MechDesigner & MotionDesigner Reference Help

USER MANUAL

PSMotion Ltd

MechDesigner & MotionDesigner Help -17.1.130

1 MechDesigner & MotionDesigner Help -17.1.130

PSM
MechDesigner
Cam - Mechanism - Motion
Design Software

Motion is a concept that you can experience or witness, but you cannot physically hold. You cannot use eBay® or Alibaba® to buy a motion!

However, to design a multi-axis machine, you must be able must and weave together the motions for all of its interacting mechanisms.

There are three ways to represent, edit, and optimize the motions for a machine:

1. **List each motion as a series of positions ...see NotePad®, Excel® , ...**
   Good luck!
2. **Plot each motion and its motion-derivatives (P, V, A, J) with a graph ... see MotionDesigner**
   Plot and edit the motion for each machine axis, over a machine-cycle.
3. **Simulate the motions with moving parts ... see MechDesigner**
   Simulate a complete machine cycle, with all of its mechanisms synchronized to the master machine axis.

When you can see all of the mechanisms in your machine interact with each other, it is much easier to see how to improve your design before you start to manufacture critical parts and build a machine.

MotionDesigner and MechDesigner ...

... together, they are a powerful combination

Mechanisms, Motions, Cams, Mechanisms, Gears, Racks, Ball-Screws, Pulleys, Belts, ...

Analyze > Scrutinize > Optimize

Note on Intel Graphics-Cards: MechDesigner will not work with ... ... Intel GPUs that are integrated with the CPU on Laptops. After you install MechDesigner, you MUST make sure you can change the system's or graphic-card's setting to force MechDesigner to use an nVidia or AMD GPU.

Reference Help

The instructions for:

MechDesigner Reference and Interface 25 - to add, edit and analyze the elements that represent the physical elements in your machines.

MotionDesigner Reference and Interface 681 - to design the motions for the mechanisms in your model.

Tutorials on the Web

You need an internet connection to connect to:

MechDesigner Tutorials

MotionDesigner Tutorials

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Text Formatting

Menu / Toolbar ; Commands - e.g. **Kinematic elements toolbar ; Add Part**

ELEMENT : objects you add to the model - e.g. 2D-CAM

ELEMENT DIALOG : the interface that we use to edit an element parameters - e.g. 2D-CAM DIALOG

DIALOG SEPARATOR : click to collapse/expand different PARAMETER groups in a dialog-box - e.g. MATERIAL PROPERTIES

PARAMETERS : values that you can edit and options you can select in an ELEMENT'S DIALOG-BOX - e.g. RADIAL-CLEARANCE

SUB-ELEMENT : elements we do not explicitly add, but are in the model - e.g. START-POINT

Derived-Name : a descriptive name we use for elements - e.g. **rotating-Part**

USER-INTERFACE : areas of the working application - e.g. PROJECT-EXPLORER

Important Word : a word in an instruction that is important - e.g. **not**

1.1 System-Requirements, Windows-Settings, ...

System Requirements

Operating System :	Windows 7, 10, 11 64-bit **only**
PC Memory :	Minimum : 4 GB of RAM Recommended : 8 GB or more
Hard Drive Space :	1GB of available space Recommended : 20 GB or more - keep your drive healthy.
Graphics Card :	High-performance Graphics Card for CAD or Gaming. OpenGL 4.5+ Minimum : 1 GB card memory Recommended : 4 GB card memory **Important Message:** **There is a graphics problem with Intel Graphic Card, particularly on laptops.** We do not have a solution to this problem. If your laptop also has a different graphics-card (e.g. nVidia or AMD), force **MechDesigner** to use the other graphics-card.

Windows Permissions

Installation :	Administrator Rights and Internet Connection.
Downloads:	Administrator Rights to download latest help 1. Right-click **MechDesigner** application start icon 2. Click **Run as Administrator** in the contextual-menu 3. Click Help menu > Download Local Help | Examples | Tutorials
General Running :	You do **not** need **Administrator Rights** to use **MechDesigner**. You do need an internet connection, as **MechDesigner** check your license with **CopyMinder** every week, approximately.

Recommended Windows Settings

Display Resolution :	Minimum : 2560 × 1440 pixels Recommended : 4K (3840 × 2160 pixels)
Windows D.P.I. :	Screen Resolution : 2560 × 1440 pixels, set Windows DPI to 100% Screen Resolution : 3840 × 2160 pixels, set Windows DPI to 150% **Note**: To change your screen settings, right-click your screen desktop, and select **Display Settings**.

Anti-Virus

PSMotion recommends that you:

- Use a trusted anti-virus product. Update it with the latest anti-virus definition/signature file.
- Add exemptions for **MechDesigner** file-types and folder locations.

Software Protection

We use **CopyMinder®** for our software protection. It uses the internet to check your license details.

- If you have a **Trial License**, you need to verify an email from **verification@copyminder.com** before you run. You do not need to know the **License-Key**.
- If you have a **Standalone License**, you need a **License-Key.** You need the **License-Key** to run **MechDesigner** the first time. Keep the **License-Key** safe.
- If you have a **Network-License** (also called a **Floating-License**), your I.T. department needs the **License-Key** to run an application on the server. They should keep the **License-Key** it safe.

Uninstall

- If you want to remove **MechDesigner** completely, then use the Windows > Uninstall utility.
- You must remove **MechDesigner** CXL, MTD, ZXL, and LXL file-types manually.

1.2 File Locations

The default paths are:

<Install Directory>: C:\Program Files\PSMotion\MDxx Pro64

<CommonAppData>: C:\ProgramData\PSMotion

<LocalAppData>: C:\users\<user-name>\AppData\Local\PSMotion

<User-name>: for example 'Adam'

File-types and File-Locations

SOLIDWORKS Type Library: yyyy = **SOLIDWORKS** release-date.	**<Install Directory>\ SW_TLByyyy_64 **
Database files: **See also:** Help menu > Edit Language Database	**<CommonAppData>\ DBase **
Local Help: **See also:** Help menu > Open Local Help / Download Latest Help	**<CommonAppData>\ Help **
Library files: **See also:** File menu > Import Library Files	**<CommonAppData>\ Library **
Theme and settings: **See also:** Edit menu > Application Settings : Save / Load buttons	**<CommonAppData> \ Style **
Example Models: **See also**: Help menu > Internet submenu > Download Example Models	**<LocalAppData> \ Examples **
MechDesigner.INI ; **MechDesigner.XML** These two files are your user-settings. If they get corrupted, **MechDesigner** can be unstable. You can delete these at any time to reset **MechDesigner** to its **factory settings.**	**<LocalAppData> \ Inifiles **
Timing Diagrams:	**<CommonAppData> \ Timing Diagram.xlsm** **<LocalAppData> \ Timing Diagram.xlsm**
Tutorials: **See also** : Help menu > Download Tutorial Videos	**<LocalAppData> \ Tutorials\ *.mp4**
CopyMinder Software Protection Text Files: Email to **PSMotion** these two files if you have problems with **CopyMinder**: **C:\ProgramData\HW\MD32_0_0\cm\mechdesigner.exe.cm.ini** **C:\ProgramData\HW\MD32_0_0\cm\mechdesigner.exe.cm.log**	

Notes:

ProgramData and **AppData** are hidden by default.

To show these paths :

1. Click **Start (Windows)** > **Documents** or **File-Explorer**

The **Documents** or **File Explorer** interface opens.

2. Click the **View tab**
3. Click the **Hidden Items** check-box in the **Show/hide** group

Be careful. Hidden files are 'hidden' to prevent you accidentally moving or deleting them and because they are important !

Other Files:

<user account>_*.memopad

The name for the **Memo** you can add to the Model and Mechanism name-tabs

1.3 Firewall, Virus-Checkers, ...

Firewalls, Virus Checkers

Occasionally, your **Virus Checker**, **Firewall**, or **Network Administrator**, may not allow you to:

- Download **MechDesigner** from our website
- Install **MechDesigner**
- Check your **License Key** and **License** with the **CopyMinder**® database

You may need to:

- Restore a **MechDesigner** file from Quarantine
- Add exception paths
- Add files to trust, to your white-list
- Add IP addresses for the **CopyMinder**® database servers to your white-list
- Run **MechDesigner** with Administrator privileges

Exception Paths

After you install **MechDesigner**,

1. Add these paths as exceptions to your Virus Checker:
    - **C:\ProgramData\PSMotion**
    - **C:\ProgramData\HW** - this is the path for **CopyMinder**® related files.
2. Add this file as an exception to your Virus Checker:
    - **C:\ProgramData\HW\MD32_0_0\CM\MechDesigner.exe.cm64.exe**

    or, for a Trial installation:

    - **C:\ProgramData\HW\MDTRL\CM\MechDesigner.exe.cm64.exe**

CopyMinder Servers

MechDesigner checks your License-Key settings on a **CopyMinder**® server* , over the internet.

There are two IP addresses for the **CopyMinder**® servers*. One is a back-up.

- **Primary Server :** 89.200.137.136
- **Secondary Server:** 92.60.122.223

1. Add these two IP addresses to your Firewall white-list.

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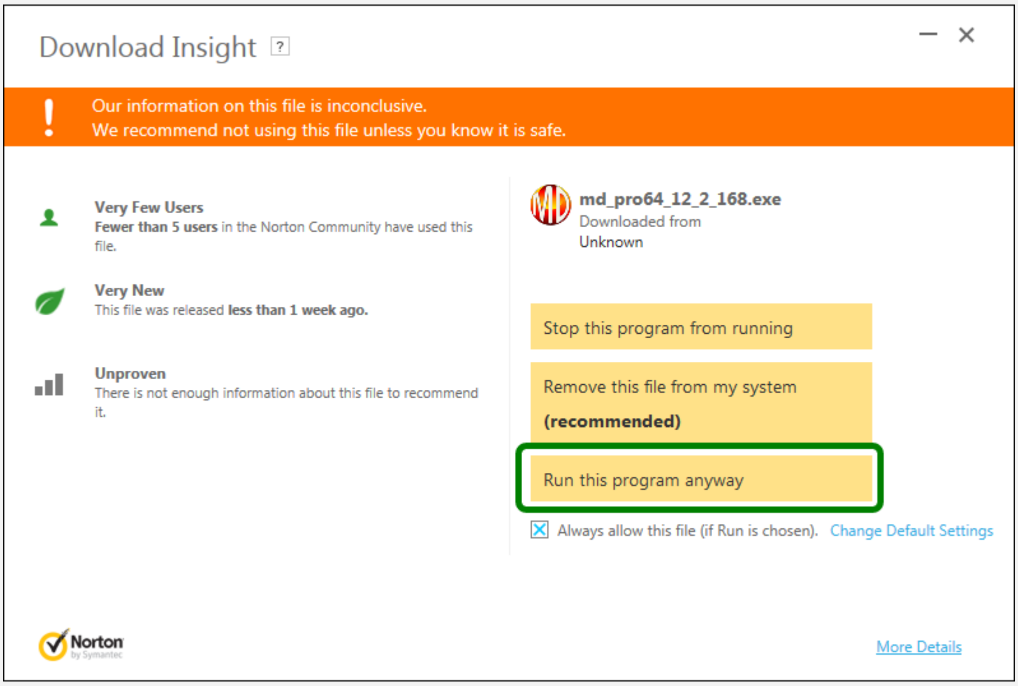
* These servers are run by Microcosm Ltd, the developer of the **CopyMinder**® software protection system.

Example Norton Notices

Download Insight

When you install **MechDesigner**, it is possible that your virus-checker, or your Windows© settings may decide that a file is a threat.

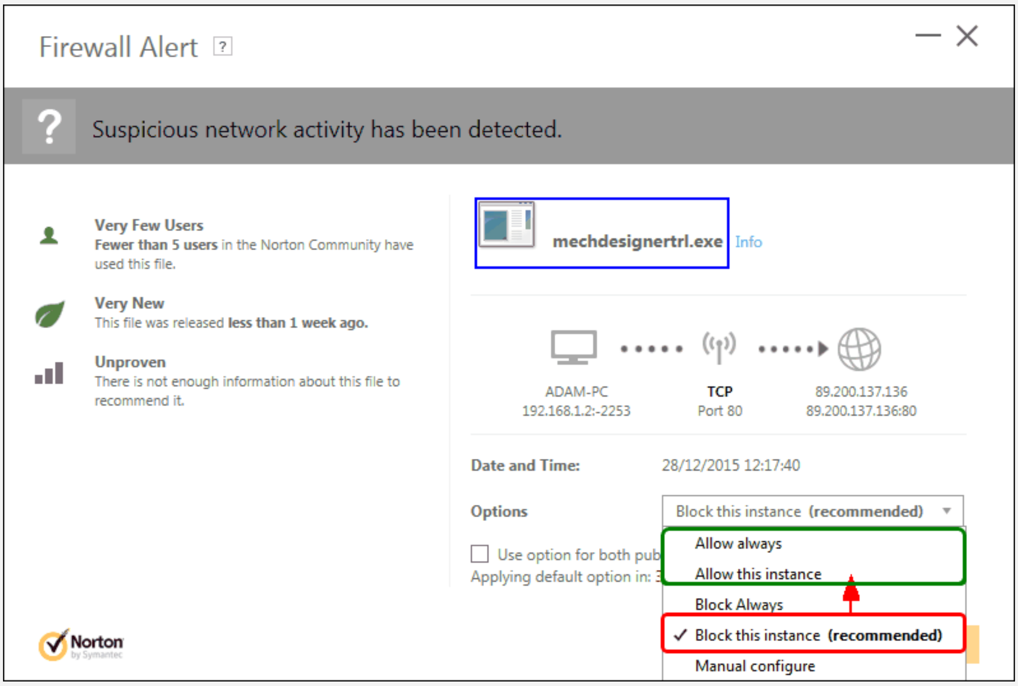
Please click **Run the program anyway**.

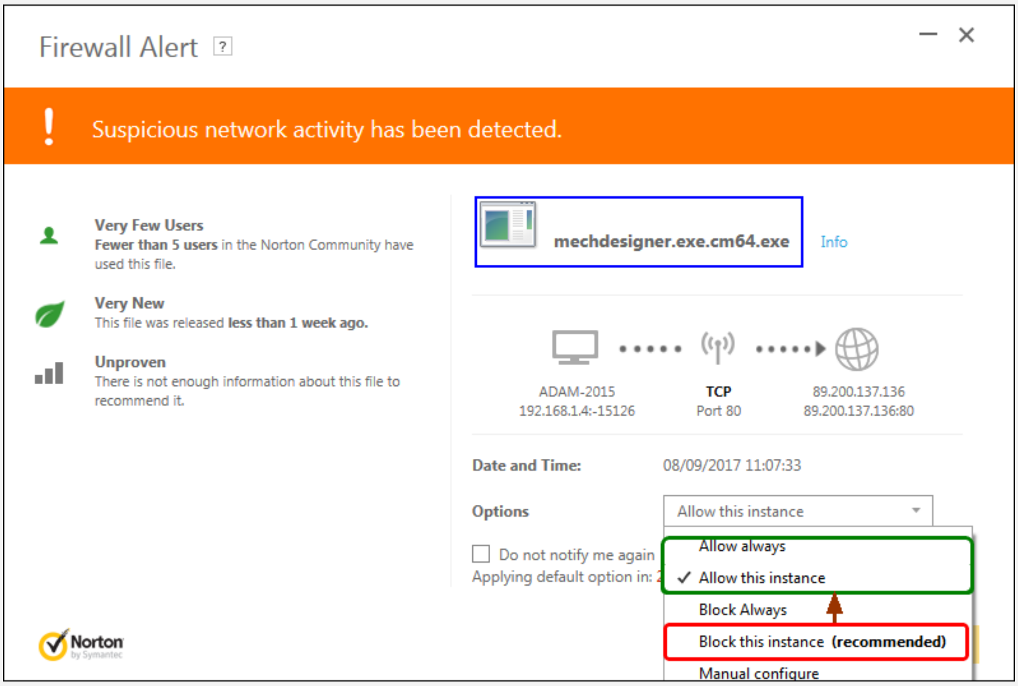


FIREWALL ALERT : Norton: Suspicious Network Activity.

- **MechDesigner.exe** may be detected as a threat
- **MechDesigner.ex.cm64.exe** maybe detected as a threat

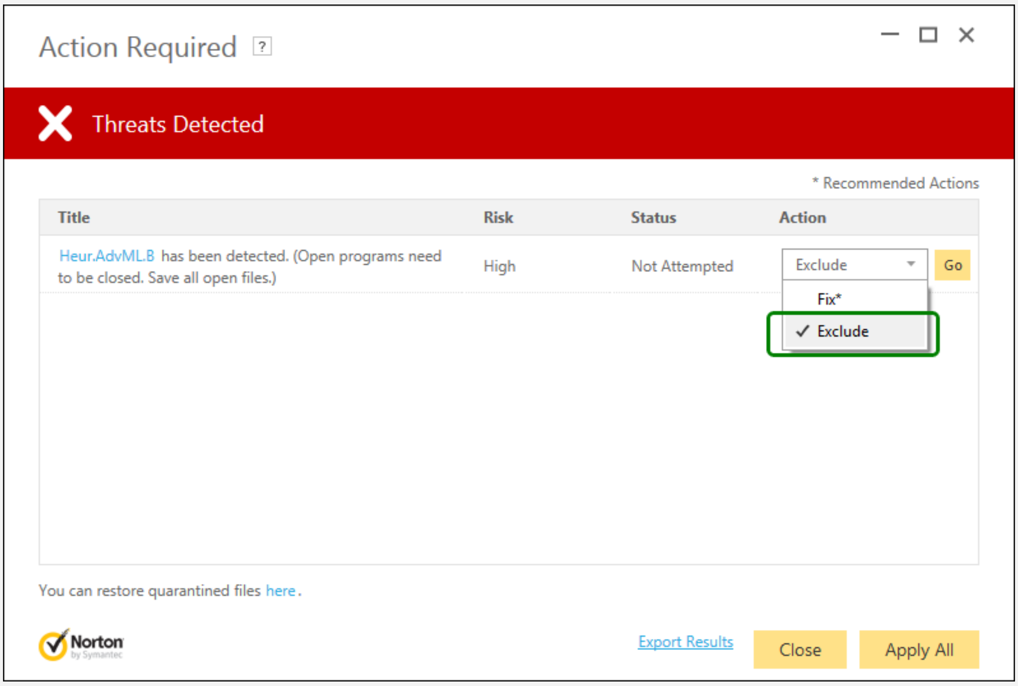
Please use **Allow Always**, or **Allow this Instances**.





ACTION REQUIRED: Threat Detected!

If this pop-up shows, then please use the 'Exclude' in the drop-down list to exclude CopyMinder as a threat.



Norton 'How to restore MechDesigner from Quarantine'

Norton:

1. Open your Norton product
2. On the main window click **Tasks** on the Security History option
3. On the opened window click on the menu and select Quarantine
4. On the list, find the file you want to restore - **MechDesigner.xxx**

5. Click on **More Details**
6. On the new window click on **Options** (bottom)
7. Click on **Restore file**
8. Check the **Do not detect it again** option during the restore
9. Close the windows

1.4 Known bugs after latest release

16.1.338

Laptop with some Intel Graphic-Cards

When does it happen? 1. When you start to add elements after you start MD.
Result Everything is selected all of the time. You cannot model anything! Or, You cannot add a new element after the first few. 1. Look in Help > About | Graphics-Card tab. If the graphics-card you are using is the Intel GPU, you must change it to an nVidia or an AMD graphics-card.
You must re-direct your settings, so that it does NOT use the Intel graphics Card. For example: 1. Start the NVIDIA or AMD graphics-card control panel (or other high performance graphic-card control panel) 2. Change the **Preferred graphics processor** from '**Auto Select**' to, for example, "**High-performance NVIDIA processor.**"
No other solution.

16.1.336

MechDesigner hangs after you open a Library model.

When does it happen? 1. Open a Library file with **File toolbar > Import Library Model**
Result You cannot select anything with your mouse. The model seems to hang.
Temporary Solution: 1. Press the **ALT+C** keyboard combination, to cycle the model. 2. Press **ALT+C** again to stop the model.
Version when corrected: Corrected in 16-1-342+

16.1.328

Lighting - Ambient increases to the Maximum

When does it happen? 1. Add a **PROFILE** 2. Enable **Show Solids in Mechanism-Editors** 3. Disable **Show Solids in Mechanism-Editors**
Result The Ambient Lighting increases to a maximum
Solution: 1. Save the model if not already saved 2. Click the **MODEL** element at the top of the Assembly-Tree 3. Right-click the **MODEL** element The **MODEL-OPTIONS DIALOG** is now open 4. Drag the **AMBIENT LIGHTING SLIDER** to almost the minimum.
Version when corrected: Not yet corrected.

16-1-230

Crash if you drag a FB past a Kinematic-Vector

Release :	**16-1-230**
Corrected :	**16-1-264**
Release Date :	15-July-2022
Bug :	Drag a Function-Block over a Velocity or Accelera-tion-Vector and the FB flies along the Vector!
Result :	Angry modeller.
Corrected 16.1.250	

16-1-146

Blurry elements

Release :	**16-1-146**
Release Date :	**22-March-2022**
Bug :	Blurry, Smokey Elements?
Details :	Especially if you load a Library File. The elements look 'washed-out', or blurred. The **Ambient Lighting** is set to zero.
To correct the Bug:	1. Save the Model

	2. Right-Click the Model element at the top of the Assembly-Tree 3. In the Model Options dialog-box > Lighting tab, increase the **Ambient Lighting** by sliding its slider to the right.

16-1-102

Known Bug 1

Release :	16-1-102
Release Date :	04-02-2022
Bug :	Blend-Curve Drag-Handles reset Blend-Curve to defaults when you lock the Drag-Handle
Details :	After you lock a Drag-Handle (double-click to edit, double-click again to lock), the Blend-Curve Resets to its default shape.
To correct the Bug:	Do not use Drag-Handles, use dialog-box only Double-Click Blend-Curve to edit and open the dialog.

15-1-58

Known Bug 1 - corrected 16-1-120

Release :	15-1-50
Release Date :	10-October-2021
Bug :	Theme - not saved after you run MD the first time ever.
Details :	When you run MechDesigner the first time, you are asked: Do you want to use the Dark theme? If you answer Yes, you will see the Charcoal Dark Slate theme, which is the Dark theme. However, the next time you run MechDesigner, you will actually see the Windows10 theme, which is a Light theme.
To correct the Bug:	Do : 1. Edit menu > Application-Settings > General tab > Themes 2. Select the **Charcoal Dark Slate** theme in the drop-down box 3. Restart ***MechDesigner***.

Known Bug 2

Release :	15-1-50
Release Date :	10-October-2021
Bug :	Solids are active the first time you run MechDesigner
Details :	When you Add a Mechanism-Editor, a Plane hides the axes of the Base-Part. The Planes show when Visibility toolbar > Show Solids in Mechanisms is active.
To correct the Bug:	Do : **1.** Add a **MECHANISM-EDITOR** **2.** **Deselect Visibility toolbar > Show Solids in Mechanisms** **3.** Save the model with **File menu > Save as** **4.** Restart ***MechDesigner***.

Known Bug 3

Release :	15-1-50
Release Date :	10-October-2021
Bug :	Display menu > Show / Hide elements
Details :	After you use Display toolbar > Hide 'element' Toggle Switches to Hide elements, they do not show when you click the same button to Show the element again.
To correct the Bug:	Do : If the elements do not show again: **1.** Click the **MODEL NAME-TAB** **2.** Click the Mechanism name-tab again. OR **3.** Start the **PART-EDITOR** **4.** Exit the **PART-EDITOR**

Known Bug 4 - corrected 16-1-100

Release :	15-1-50
Release Date :	10-October-2021
Bug :	Delete a Joint will also delete Motion-Dimension FB, even though the joint is not associated with the Motion-Dimension FB

Details :	Delete a Joint (from a Line) that is not associated with a Motion-Dimension FB, the Motion-Dimension FB is also deleted!
To correct the Bug:	No way out! Add the Motion-Dimension FB again - sorry. This should be corrected in the next release - Corrected in MD16.

Known Bug 5

Release :	15-1-50
Release Date :	10-October-2021
Bug :	If a Plane references a Line, and you edit the Position of the Line, the Plane does not move to the new location of the Line.
Details :	To build 3D models, you will often want to add a Plane to a Line. If, later, you want to move the Line and the Plane, the Plane does not move.
To correct the Bug:	1. Edit the **PLANE** element that references the **LINE**. The **PLANE DIALOG-BOX** is now open. 2. Edit one angle from **ROTATE THE X, Y, OR Z-AXIS** parameters 3. Immediately return the X, Y or Z-axis to its original angle 4. Click ✅ to close the **PLANE DIALOG-BOX** This bug should be corrected in the next release

1.5 MechDesigner Reference & User Interface

User Interface - Visual Reference

① **Menus and Toolbars**

1 **NEW - Shortcut Menu:** commands and toggles that you may use many times.

Menus- with the commands in a pseudo-ribbon, at the top of the application window.

Toolbars - above, below, left, and right of the workspace ②.

The active **Menus** and **Toolbars** are also contextual to the active editor.

Notes: You can show the Menus only, Toolbars only, or both - see Application-Settings > Accessibility tab >

② **Workspace**

The workspace is the **graphics-area** with its **name-tab**.

There are three editors. Each editor has the same workspace.

- Model-Editor 79
- Mechanism-Editor 88
- Part-Editor 257

You add different elements to each editor, to build your model.

③ **Project-Explorer** is to the left of the graphics-area.

It is a summary of the element in your model.

See more: Project-Explorer 308

④ **Feedback-Area** is below the graphics-area.

	It provides messages, hints, Slider to move your model to different positions in the machine cycle. **See more:** Feedback-Area 326
⑤	**MotionDesigner** is docked (default) to the right of the graphics-area. **See more:** MotionDesigner 329
	Memo : a memo opens when you start **MechDesigner** the first time. To turn the **Memo** off, deselect the OPEN AUTOMATICALLY AT START check-box at the bottom and left of the memo form. **See more:** Memo 331

1.5.1 Keyboard-Shortcuts

Keyboard Shortcuts

ZOOM	SCROLL-WHEEL
Zoom-In : Zoom-Out :	
	The center of the Zoom is at your mouse-pointer.
PAN	
If I want to move PAN - say to the right - I place my mouse-pointer to the right, Zoom-Out with my Scroll-Wheel, then move my mouse-pointer to the middle and Zoom-In again with my Scroll-Wheel - this is frequently easier.	
Pan :	CTRL + Drag
PAN Left or Right :	CTRL +  (scroll wheel)
PAN up or down :	SHIFT +  (scroll wheel)
SPIN	
Free-Spin :	SHIFT + Drag
10º spin :	[<] , [>] , [Λ] or [V]
30º spin :	CTRL + [<] , [>] , [Λ] or [V]
90º spin :	SHIFT + [<] , [>] , [Λ] or [V]

Mouse-Button Shortcuts

Double-Click :	... an ELEMENT, if the element has a dialog, open its dialog, and edit its parameters, .
Click :	... an ELEMENT, to show the element in the SELECTION-WINDOW.

CTRL + Click :	... an ELEMENT, to show the kinematic and dynamic properties of the element in the ELEMENT-PROPERTIES DIALOG.
Alt + Click :	... in the graphics-area, to show a bulls-eye target of concentric rings. It has a scale to approximate the distance between elements - to a minimum of 0.1mm - if you look closer than 0.1 mm you should always check the actual dimension with a MEASUREMENT FB
Right-Click :	... an ELEMENT, to see the shortcut menu that is contextual to the ELEMENT
Right-Click :	... an ELEMENT, to complete the active command in the COMMAND-MANAGER
Right-Click :	... the graphics-area, to cancel the active command, or complete the command if there are ELEMENTS are in all **Selection-Boxes** in the COMMAND-MANAGER
Right-click :	... the graphics-area, to see the shortcut menu for each editor-type.

Keyboard Shortcuts

F1 :	Hover over a toolbar icon, then press the **F1 key** (**FN+F1** on a laptop) to read the help for the command. **See also Help menu > Download Latest Help**
INSERT :	Press to start the **Add Part** command
ALT+C :	**Continuous Cycle**
ALT+F :	One Machine-Step Forward 58
ALT+B :	One Machine-Step Backward 58 .
ALT+H :	**Stop Continuous Cycle and** move the **MASTER-MACHINE-ANGLE** to 0º.
CTRL + Z :	**Undo** - This is quite powerful
ESC :	Cancel the active command

1.5.2 Known-Bugs

16.1.386

Spin-Boxes in MotionDesigner

When does it happen?

When you open the Segment Editor or the Blend-Point Editor, the Spin-Box tool does not show in the Motion-Value data-boxes

Result

Nothing

Solution:

In each data-box that does not show the Spin-Box tool:

1. Double-click, and
2. Double-click, again.

Version when corrected:

It is weird, and we are not sure why this happens.

16.1.386

Continuous Crank Fails if the motion ...

When does it happen?

If the Motion of the Tool-Part has a dwell that is not at the maximum or minimum of its motion-range, then the **CONTINUOUS-CRANK FB** will not work as expected.

Result

The Crank changes to the incorrect length.

Temporary Solution:

None

Version when corrected:

Coming Soon

16.1.336

Hangs after Importing Library Model

When does it happen?

1. Open a Library file with **File toolbar > Import Library Model**

Result

You cannot select anything with your mouse.

The model seems to hang.

Temporary Solution:

1. Press the **ALT+C** keyboard combination to Cycle the model.
2. Press **ALT+C** again to stop the model cycling.

Version when corrected:

16.1.342

16.1.336

SOLIDWORKS 2018.

When does it happen?

Help about > Type Libraries are SOLIDWORKS 2018 - and all good to go.

1. Start SOLIDWORKS 2018, and open a Part document.
2. In MD: Edit a **CAD-LINE**
3. Import SOLIDWORKS document...crash

Result

Will not open a SW2018 document - my 16-1-336 tries to activate SOLIDWORKS 2020!

Temporary Solution:

None - can you use a different release of SOLIDWORKS?

Version when corrected:

16-1-342 - not yet released.

16.1.328

Lighting - Ambient increases to the Maximum

When does it happen?

1. Add a **PROFILE**
2. Enable **Show Solids in Mechanism-Editors**
3. Disable **Show Solids in Mechanism-Editors**

Result

The Ambient Lighting increases to a maximum

Solution:

1. Save the model if not already saved
2. Click the **MODEL** element at the top of the Assembly-Tree
3. Right-click the **MODEL** element

The **MODEL-OPTIONS DIALOG** is now open

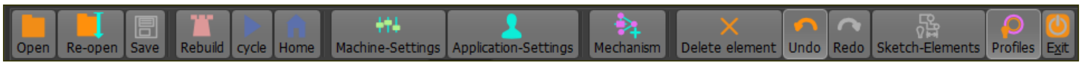
4. Drag the **AMBIENT LIGHTING SLIDER** to almost the minimum.

Version when corrected:

Not yet corrected.

1.5.3 1: Menu bar and General Toolbars

1 NEW in MD17 - Quick Access Tools



NEW (MD17) Quick Access menu for frequently-used commands

NEW (MD17+): The Quick Access toolbar are above the menu bar. It shows always.

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① Menu bar and/or Toolbars

New options in MD17+:

You can choose to show :

- **Menu bar only (MD17 style)** - an icon and short hint for each command in a pseudo ribbon

  OR

- **Toolbars only (MD16 style)** - an icon for each command in a toolbar that you can expand and collapse

  OR

- **Menu bar (MD17 style) AND Toolbars (MD16 style)**

See Application-Settings > Accessibility tab[57] .

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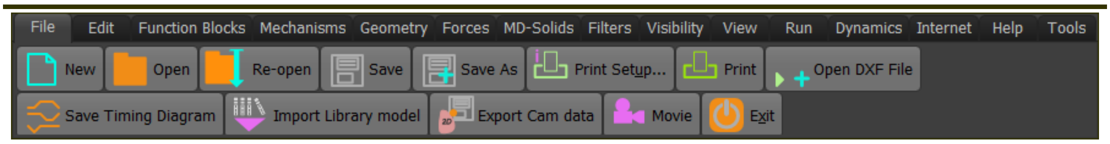
① Menu bar



Menu bar and File commands

If you show the menu bar,

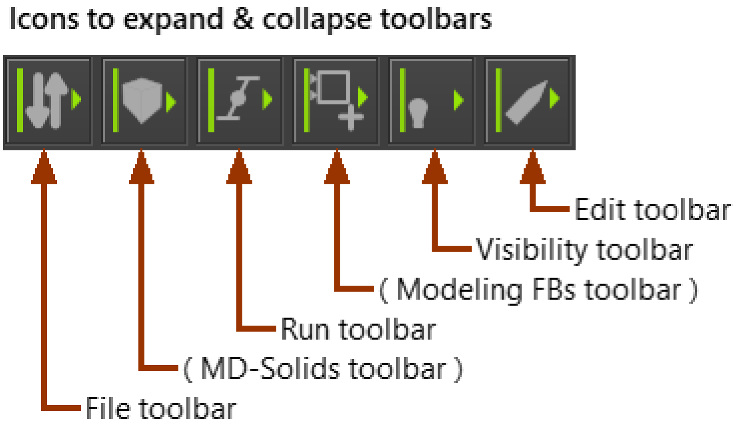
- the commands in **File, Edit, Filters, View, Internet**, and **Help** are common to most CAD applications.
- the commands in Function-Blocks[165] , Mechanism[90] , Geometry[257] , Forces[226] , MD-Solids[239] , Visibility[60] , Run[58] are those that you use to build and cycle your **MechDesigner** model.
- the menus that are active are a function of the **editor-type**.

General toolbars

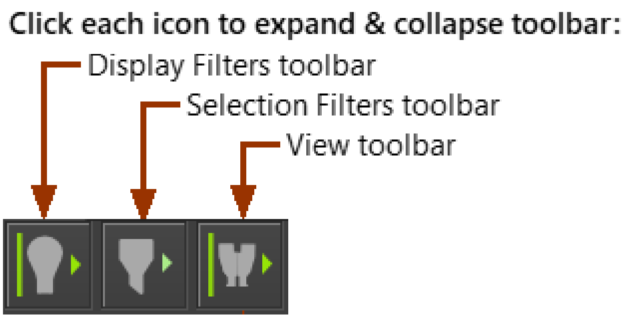
If you show toolbars:

- the **General toolbars** are directly **above** and **below** the graphics-area.
- the **toolbars** are collapsed when you start **MechDesigner**.

General toolbars ABOVE the graphics-area



General toolbars BELOW the graphics-area



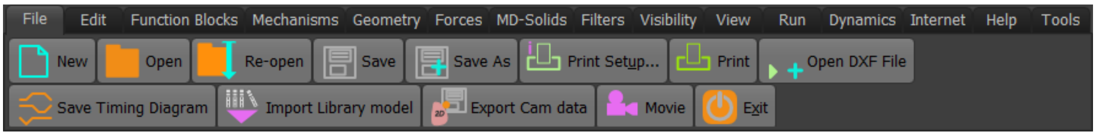
1.5.3.1 File

File

The **File** menu and toolbar provide the tools to manage your model files.

File menu

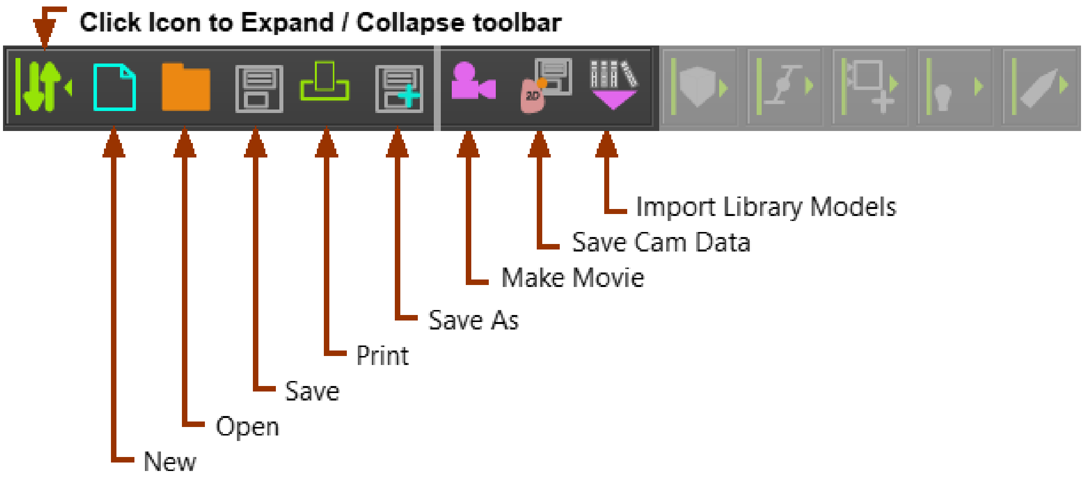
If you show menus:



MD17 - File menu

File toolbar

If you show toolbars, the **File toolbar** is **ABOVE** the graphics-area.

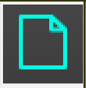


File toolbar

1.5.3.1.1 File | New

File > New

Start a new model.

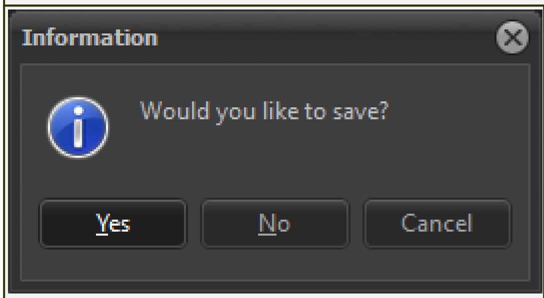
	File menu > New File toolbar > New

Notes:

Shortcut:

CTRL+N

If the active model is different from the model on your hard drive, you must decide what to do before you start the new model.

	**Yes**: Save the active model and start a new model **No**: Do not save the active model and start a new model **Cancel**: Do not save the active model and do not start a new model

1.5.3.1.2 File | Open

File > Open

Open a model that is on your hard-drive.

	File menu > Open File toolbar > Open

When you enable Auto-Save[341], we save your model after 10 commands (default).

To make sure you do not overwrite an important model, either

- Disable Auto-Save, or
- Save the model to a **new** file-name.

Open these file-types:

CXL

The **CXL** is the file-type for the **MechDesigner** model.

The **MTD** is the file-type for the **MotionDesigner** motions.

The **CXL** and the **MTD** file-types should be in the same-path.

OLD MODELS: **MechDesigner** may find a sketch-element that is over-constrained.

A pop-up asks you if we can delete for you the constraint so that we can solve the sketch. Click **YES** if you want to open the file! Check important sketches after you open the model, then save the model again.

See also: Why so many CXL and MTD files?[638]

LXL

LXL - the file-type for a **Library file**.

There are three options when you open a Library file.

- **Preselect a Plane** - the Library file adds a new **MECHANISM-EDITOR**. The model in the Library file opens on the XY-Plane of the new **MECHANISM-EDITOR**.
- **Preselect a Part** - the Library file opens on the **PART**. The Library file is a child to the **PART**.
- **Preselect nothing** - the Library file is opened and merged with the active **MECHANISM-EDITOR**.

See more: Open LXL File[35]
See also: Save as > LXL file-type[39]

ZXL

ZXL - the file-type for a **MechDesigner** ZIP file **- see** Save as > ZXL[40]

The file-types that may be in a ZXL file are:

- **CXL** and **MTD**
- **STL**, **SLDPRT**, **SLDASM**
- **DXF**

Note:

You can choose the path to which you want to extract ZXL file-types:

See: Application Settings | General tab | [341] FILE OPTIONS > Extract ZXL files to [341]:

- ⦿ CREATE SUB-DIRECTORY AUTOMATICALLY - All files extract to a sub-directory to the ZXL file.
- ⦿ SPECIFY ZXL OUTPUT DIRECTORY - enter the path for the files.

I prefer SPECIFY ZXL OUTPUT DIRECTORY. I usually extract the files the same path as that of the ZXL file itself. You can also select or make a new path.

See more: File menu > Save as > ZXL file-type. [39]

DXF

When you open a file of the **DXF file-type** you add a DXF-ELEMENT to the ASSEMBLY-TREE as a child to the MODEL. The DXF ELEMENT is a **container** for one **DXF-Drawing**.

MD17+ :The name of the DXF-ELEMENT in the ASSEMBLY-TREE in now the name of the **DXF-Drawing**.

You must link the DXF-ELEMENT to a CAD-LINE to show the **DXF-Drawing** in the graphics-area. Thus, to show the **DXF-Drawing**, do:

STEP 1. **File** > **Open** > **DXF file-**type to add a DXF-ELEMENT to the ASSEMBLY-TREE.

STEP 2. Edit a CAD-LINE (that is a child to a PART) to open the CAD-LINE DIALOG

STEP 3. In the CAD-LINE DIALOG > **DXF tab**, select the DXF-ELEMENT

The **DXF-Drawing** shows in the graphics-area.

See more: CAD-Line dialog > DXF tab [371]

MEC [Camlinks]

MEC is a Camlinks file-type.

See more: Open MEC files [37]

1.5.3.1.2.1 Open LXL file-type

File > Open > LXL file-type

See also Save as Library File[39] .

See also > NEW in MD16 Import Library File[45]

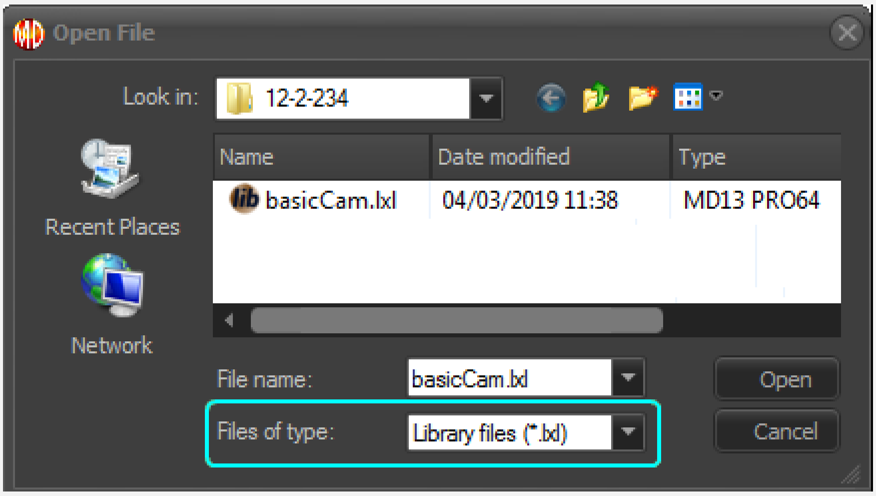
To open a Library File with File > Open

1. Click to select a PLANE, a PART; or select Nothing:

   If you:

   - ~~Select a Plane - the Library file opens onto a new Mechanism-Editor as a child to the Plane~~
   - Select a PART - the **Library fie** opens onto the PART as a child to the PART.
   - Select **nothing** - the **Library fie** opens and merges with the active MECHANISM-EDITOR.
2. Click **File > Open**

   The **Windows® File Open** interface starts.
3. In the **Files of type** drop-down, select **Library files (*.LXL)**



4. Select, a **Library File**
5. Click the **Open** button

You should now see the **Library file** as a new MECHANISM-EDITOR, as a child to a PART, or merged with the active MECHANISM-EDITOR.

1.5.3.1.2.2 Open DXF File

File > Open > DXF file-type

Do **File menu** > **Open** > **DXF** file of type to add a **DXF-ELEMENT** to the ASSEMBLY-TREE.

The **DXF-ELEMENT** in the **ASSEMBLY-TREE** is the container for the **DXF-Drawing**.

The **DXF-ELEMENT** does not show the **DXF-Drawing** in the graphics-area.

To show the **DXF-Drawing**, you must edit a **CAD-LINE** and, in the **CAD-LINE DIALOG** > **DXF tab**, link the **DXF-ELEMENT** and **DXF-Drawing** to the **CAD-LINE**.

See CAD-Line dialog > DXF tab (371)

To show/display a DXF-Drawing:

STEP 1 : File menu > Open > DXF file-type

1. Click **File menu (or toolbar) > Open**

   Make sure the **File of type** filter is .DXF
2. Browse to a DXF file-type
3. Click the Open button

A **DXF-ELEMENT** shows in the **ASSEMBLY-TREE**.

The element-name of the **DXF-ELEMENT** is the file-name of the **DXF-Drawing**.

STEP 2 : Show the DXF-Drawing

1. Edit a **CAD-LINE** to open its **CAD-LINE DIALOG**
2. Select the **DXF** tab
3. Select the DXF-element

See CAD-Line dialog > DXF tab (371)

Options

Edit the **DXF-ELEMENT** in the **ASSEMBLY-TREE** to:

- Link the **DXF-ELEMENT** with a different **DXF-Drawing** file
- Select the units of the **DXF-Drawing**. Usually, select the units of the original **DXF-Drawing**.

See also: DXF-Element dialog (354)

Top-Tips

In your original CAD software, before you save the **DXF-Drawing**:

- Use (or equivalent): **Remove Hidden Lines**
- Use (or equivalent): **Hide Tangent Edges, Remove Tangent Edges**

Finally:

- Save the **DXF-Drawing** as **Release 12** or as early as possible.

1.5.3.1.2.3 Open MEC file-type

Why we recommend that you re-build Camlinks models in **MechDesigner**.

- You will remember your design decisions.
- We must add elements from the Camlinks model that you do not need in the MechDesigner model.
- We cannot support you with your Camlinks models.
- We want to help you use **MechDesigner.**
- We can guarantee **MechDesigner** will run with Windows® 10, 11, ...
- We **cannot** guarantee that the **MechDesigner** will represent the Camlinks model in every respect.
- We continue to improve **MechDesigner** in many new ways.

IMPORTANT: LOCKED-POINTS: After you open a .MEC file, Points in the model you import are **LOCKED**.

To edit the Position of a Locked-Point:

1. Double-click the Locked-Point to open the POINT PROPERTIES DIALOG 543
2. Click **PART COORDINATES (READ-WRITE)** and
3. Edit the x and y values

To add and edit dimensions to edit the Position of the a Point:

1. Double-click the **LOCKED-POINT** to open the POINT PROPERTIES DIALOG 543
2. Click **PART COORDINATES (READ-WRITE)**
3. Click **EDIT IN PART-EDITOR** radio-button
4. Click ✅ to close the dialog.
5. Edit the **PART** in the **PART-EDITOR** in the normal way.

History Note for Camlinks, and Camlinks Import Limitations.

MOTION: Camlinks4 vs Camlinks3

1. 'Camlinks4': Mechanisms and motions are a MEC file-type. The motions were defined with segment and motion parameters. Open a 'MEC' file in MechDesigner to recreate the motions with motion segments in **MotionDesigner**.
2. 'Camlinks3': Mechanisms and motions use also a MEC file-type. However, motions were defined with a list of numbers. Open a 'MEC' file in MechDesigner to recreate the motion, but with a **Z Raw Data** List Segment-Type in **MotionDesigner**.
3. To help you recreate the motion design (with segments), save the **Z Raw Data** List Segment-Type, and use the Overlay Motion tool to design a new motion MotionDesigner: Overlay Trace.

Throw Motion-Law

These are available in Camlinks but not imported into **MotionDesigner**. However, it is possible to design the **Throw Motion-Law** with two(2) segments and the correct Blend-point Control Button conditions. We can give a Video on request.

Auto-Adjust

Auto-Adjust is not recreated. However, we have a better tool, which we call Magnetic-Joint[99].

View Outline On/Off as a Function of the Master Machine Angle

MechDesigner uses the Pattern Element - Release 7+

Camlinks Outlines

Camlinks Outlines are DXF-Drawings that you have imported onto Parts in Camlinks. The lines and arcs in the DXF-Drawing were converted to 'Camlinks Outlines'. They were 'dumb'. You could not edit them in Camlinks.

When you open a Camlinks file with 'Outlines' in MechDesigner, you have three options available. See below[37].

SSR

We do not import these dyads.

You can design the SSR and SSP dyads in **MechDesigner.**

RamR and RamP Dyads

We do not import these dyads. If you use these dyads, MechDesigner will crash (23-03-2013).

Forces, Forcebars, Torquebars

Use **MechDesigner** to add and show forces and torques in your kinematic-chains.

Cams

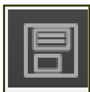
When a Follower-Roller has 0mm diameter in Camlinks – to define the Pitch-Center of the Cam – **MechDesigner** will re-define it as 0.1mm, not as 0.0mm.

You must edit the 0.1mm dimension to make it equal to the real Follower Radius. Then, to show the Pitch-Curve, use the Pitch-Circle-Path check-box in the 2D-Cam dialog[401].

1.5.3.1.3 File | Save

File > Save

Save your model to your hard-drive.



File menu > Save

File toolbar > Save

If the model does not have a file-name, the **Save as dialog**[39] opens.

Notes:

Keyboard Shortcut:

CTRL+S

We always save two files:

- **CXL** - for the **MechDesigner** model
- **MTD** - for the **MotionDesigner** motions

Note:

Auto-save starts **only** when the model has a file-name.

MOTIONDESIGNER.

You can save motions with:

MotionDesigner > **File toolbar** > **Save Active Motion**, or **Save all Motions**, or **Save as.**

See also:

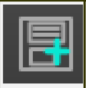
File menu > Save as [39]

Edit menu > Application-Settings > General Tab > File Options: Auto-Save [341]

1.5.3.1.4 File | Save as

File > Save as

Save your model to your hard-drive with a new file-name and/or file-type.



File menu > **Save as**

File toolbar > **Save as**

Save as:

CXL

We always save two files:

- **CXL** file-type for the model in **MechDesigner**.
- **MTD** file-type for the motions in **MotionDesigner**.

LXL

See also: Open Library File [35], Import Library File [45] and **User-Library Directory**

The **LXL** file-type is a **Library File**.

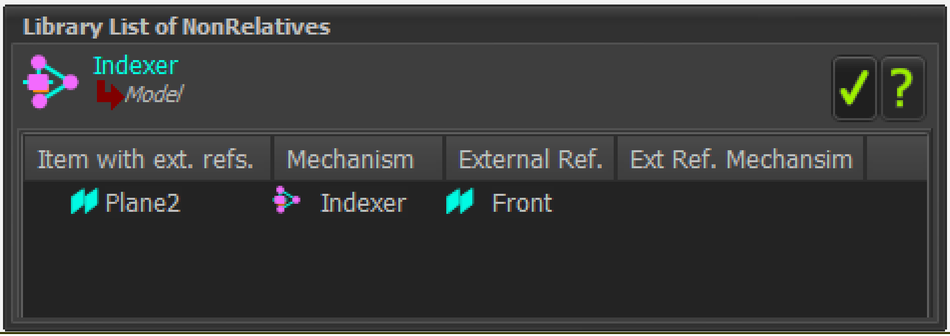
In the **Save as** dialog:

1. Browse to a path - typically the **User-Library Directory.**
2. Select **Save as Type: Library Files (.lxl)**
3. Enter a file-name

Note:

You cannot save the model in the active MECHANISM-EDITOR to an LXL file if the active MECHANISM-EDITOR has a child MECHANISM-EDITOR

The **Library List of Non-relatives** dialog shows when you cannot save the **LXL file**.



ZXL

IMPORTANT - save any **SOLIDWORKS** documents that you have imported onto a **CAD-LINE** and exit **SOLIDWORKS** before you do **File > Save as** a **ZXL** file-type.

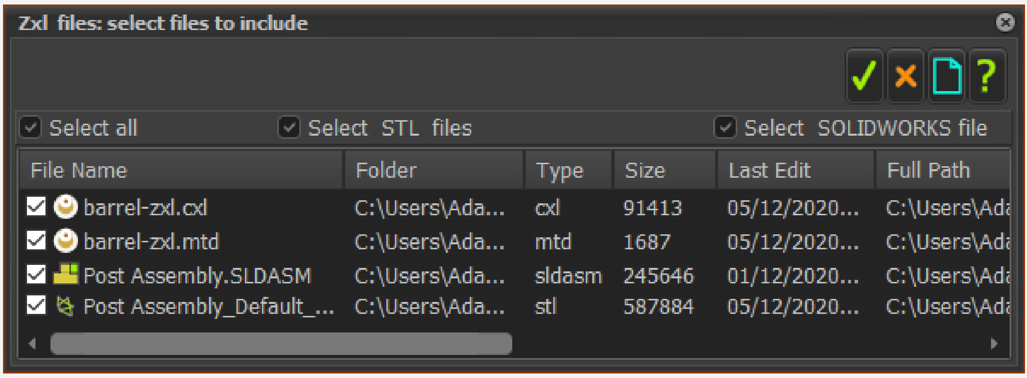
Note:

You can also use **Win-Zip**® to un-zip a **ZXL** file.

You should save the model as a **CXL** file-type before you save it with the **ZXL** file-type.

We add these file-types to the **ZXL** file when they are in the model:

- **SLDPRT***
- **SLDASM***
- **STL**
- **DXF**
- **TXT** (used with a Point-Cloud).



Save as ZXL file-type - to include SOLIDWORKS documents

When the **ZXL** save interface opens, you can choose to select:

☑ Select all

☑ Select STL files

☑ Select **SOLIDWORKS** files

Click ✓ to close the interface and save the ZXL file.

DXF

The **DXF** file we save for you has the **CAD-LINES**, **LINES**, **ARCS**, and **PART-AXES**.

Save these elements in one **PART** or all **PARTS** in a **MECHANISM-EDITOR**:

1. Click, in the **ASSEMBLY-TREE**, a **MECHANISM ELEMENT** OR a **PART ELEMENT**

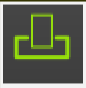
   The **MECHANISM** or **PART** element **must** show in the **SELECTION-WINDOW**.

2. Click **File menu > Save as**
3. Select **DXF** as the **File of type**
4. Enter a file name.

1.5.3.1.5 File | Print

File > Print

See also : Printer Setup 42

 	Click **File toolbar > Print** **OR** Click **File menu > Print**

Use to:

- Print a screenshot of the graphics-area.
- Save a screenshot of the graphics-area as a JPG, BMP, PNG, or GIF file-type.

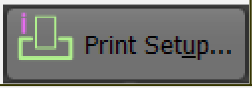
The screenshot is a 1:1 scale of the graphics-area.

Re-size the graphics-area to increase or decrease the area of the screenshot.

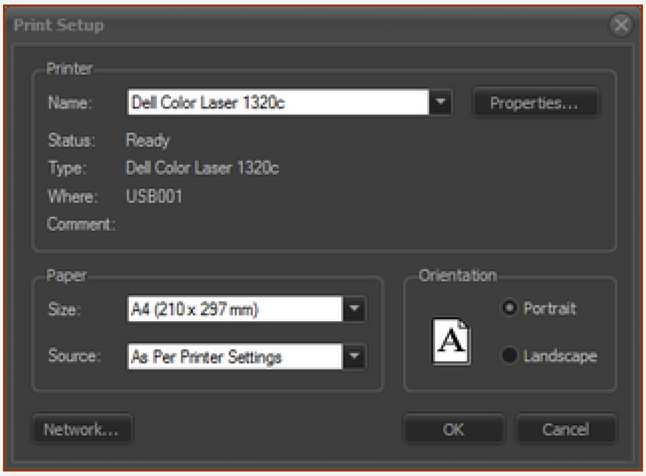
1.5.3.1.6 File | Printer Setup

File > Printer Setup

See also: Print 42

	Click **File menu > Print Setup**

Use the Windows® dialog to select the Printer name, and other Printer properties.



Print Setup dialog

1.5.3.1.7 File | Movie

File > Movie

See also Movie dialog 605

	Click **File toolbar > Movie**

	OR Click **File menu** > **Movie**
The movie dialog opens immediately. **See** Movie dialog 605	

Notes:

Use the **MOVIE DIALOG** to:

- edit the size, position, and number-of-frames to record as a movie
- browse to a path and enter a file-name for the movie

You can record and save:

- a movie as a GIF file-type

OR

- a sequence of images as JPEG, JPG, PNG, and BMP file-types

We append for you a number to each image. The numbers are 000, 001, 002, ...

OR

- save one image as a snapshot of the model.

Notes:

The GIF format produces a large file when the size and the number of frames are large.

Top-Tip - **Before** you start the **Movie** command, move the **Master-Machine-Angle** to zero(0).

1. **Run menu** > **Home**

OR

1. Use the **ALT+H** keyboard shortcut.

1.5.3.1.8 File | Save Timing Diagram

File menu > Save Timing Diagram

When you save a Timing Diagram:

- Each motion has a Motion name-tab
- The graphs are above each other.
- There is a straight-line between the position values of each **BLEND-POINT**.lines between the position values of each **BLEND-POINT** in the Motion.

How to export and show a Timing Diagram in Excel

STEP 1: MechDesigner - Save the Timing-Diagram.

A: Do: **File menu** > **Save Timing Diagram**

We save for you a CSV file-type with the data to display a timing diagram with the Excel® workbook: **Timing Diagram.xlsm** - **see STEP 2, below**

We save the:

- MOTION NAME
- BLEND-POINT: **X-axis** and **Y-axis** position values

We do not save the:

- Motion-Law (Cam-Law)
- Motion derivative data

STEP 2: Microsoft Excel

A. Open the **Excel Macro-Enabled Worksheet: Timing-Diagram.xlsm**

Timing Diagram.xlsm is located in:

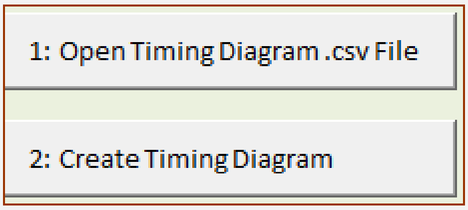
<LocalAppData> \ TimingDiagram.xlsm

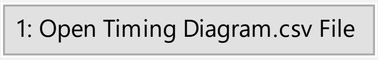
and

<CommonAppData> \ Timing Diagram.xlsm

B. If necessary, enable macros

There are two buttons on the **Motion data** worksheet.



C. Press button 

Find, and open, the CSV file you have saved to your hard drive with MechDesigner : File menu > Save Timing Diagram - **see STEP 1, above**

NOTE - reformatting maybe required:

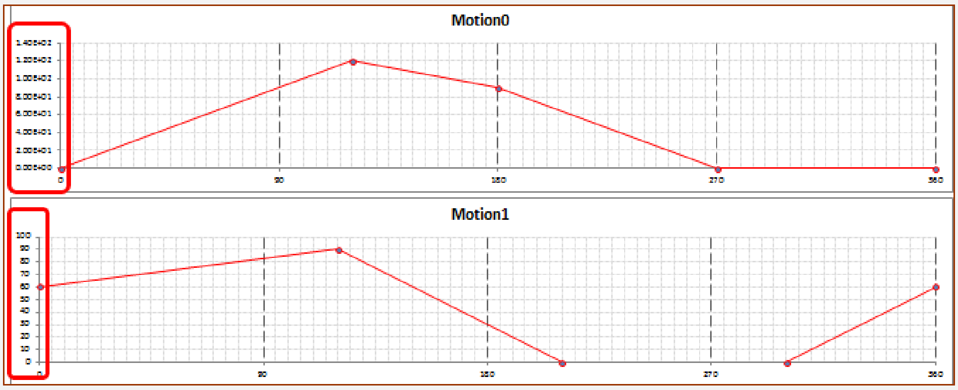
The format of the **Y-axis** of **Motion0** moves the plot of the Timing-Diagram slightly to the right.

Change the format of all numbers with **Excel** > **Home tab** > **General group** > **Format drop-down box** to "**GENERAL**".

D. Press button 

E. Look at the worksheet Timing Diagram to see the timing diagram for each motion.

See Note in "**C.**" if the format of the **Y-axis** of **Motion0** is not correct.



Typical Timing Diagram with 2 Motions

1.5.3.1.9 File | Import Library Model

File menu > Import Library File

A **Library-File** is a model to import as a new **MECHANISM-EDITOR**, or merge with the active **MECHANISM-EDITOR**.

A **Library-File** has the **LXL** file-extension.

Use the **Import Library File** interface to review the **Library File** before you import it.

See also:

File menu > Open > file of type .LXL [32]

File menu > Save as > Save as type .LXL [39]

Warnings

Warning 1: You **cannot undo** **Import Library File**.

Warning 2: If you import a Library file as a new model, Auto-save [38] **only** starts after you save the model to your hard-drive.

To Import a Library File:

STEP 1: Click to select the Model-Editor, or Mechanism-Editor, or edit a Part

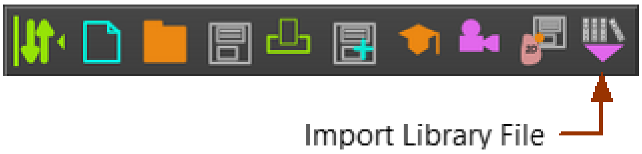
Model-Editor: To add the **Library File** to a new **MECHANISM-EDITOR** on the **Front** **PLANE**.

Mechanism-Editor: To merge the **Library File** with the active **MECHANISM-EDITOR**.

Remember, you can add a **MECHANISM-EDITOR** to a **PLANE** that references a moving **LINE** in a **PART** - see Add Plane to Line [92]

Part: If the **Library File** is Geometry ONLY, then edit a **PART** to import the Geometry onto the **PART**.

STEP 2: File menu or toolbar > Import Library-File



The Import Library File interface[46] opens.

STEP 3: Use the Import Library File interface (see below) to open a Library file:

Standard Library - PSMotion provides these Library files.

When you select a **Library file** from the **Standard Library**, you see:

- an image that is a preview of the **Library-File**

- a note that describes the function of the **Library File** and which dimensions or parameters to edit.

User Library - to open a Library-File that you have saved to your User Library Path

To edit your **User Library Path**, see Application-Settings > General tab > File Options[341] .

See also: File menu > Save as > library-file .lxl[39]

STEP 4: Click the LOAD button

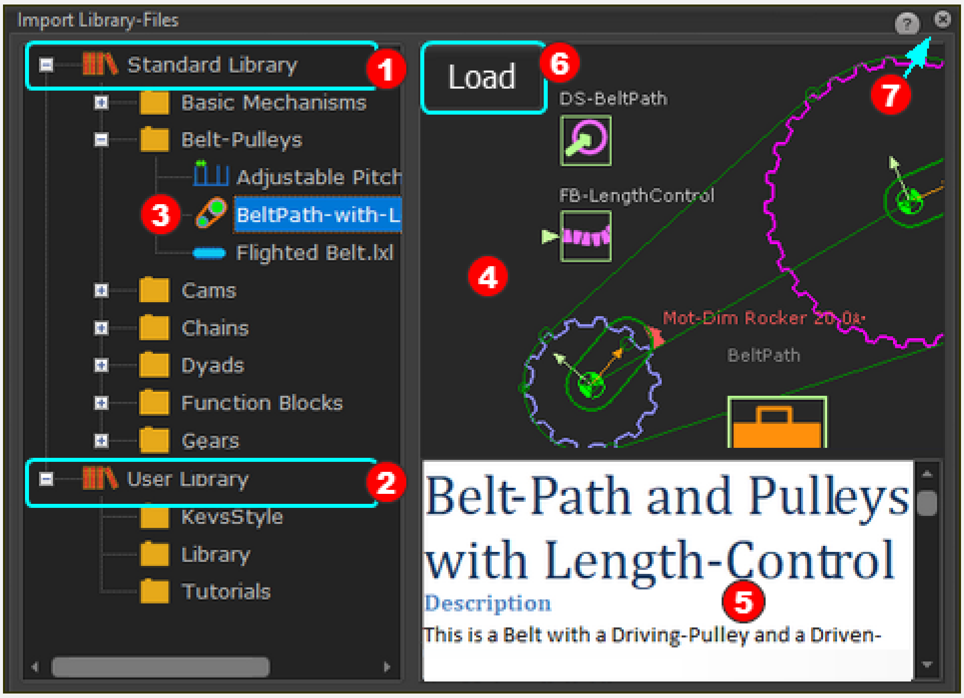
The Load button is at the upper left of the Image window.

We load the Library File immediately into the Mechanism-Editor or Part - see **STEP 1**

STEP 5: Click ⊗ to close the dialog

Click ⊗ at the top right of the dialog

Import Library-File interface and User Library Files



Import Library File interface

User Library Files:

❷ **User Library -** Library files that you save to your **User Library Path** or its sub-paths, with **File menu > Save as > file-of-type .LXL**.

When your Library file needs a motion, save the motion from **MotionDesigner > File toolbar > Save Active Motion** to the same path as the Library file

Optional - but very helpful:

To get the maximum use from your **User Library** and the **Import Library-File** interface, add these files to your **User Library Path** or sub-path:

❹ **LibraryFilename.PNG** - an image - ideal size is 480 x 360 that is a snapshot of the model in the Library file.

To save a 480×360 image, use File menu > Movie[42] : **File-type**: PNG ; **File-path**: User Library Path ; **Frame Size: 430 × 360** ; Press SINGLE SHOT button.

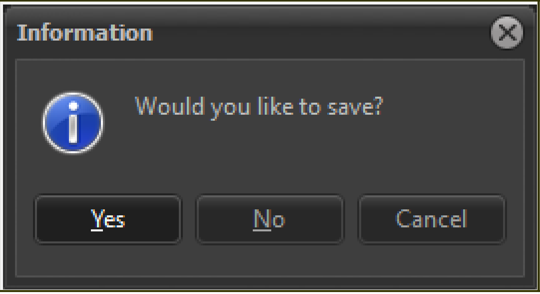
❺ **LibraryFilename.RTF** - typically, use Word® to describe the function of the model, and what to edit with a Design-Set[217]

❸ **LibraryFilename24.PNG** - an icon that is to the left of each Library-File

Use an image-editor to make an image that has **exactly** 24x24 pixels, with a transparent background.

1.5.3.1.10 File | Exit

File > Exit

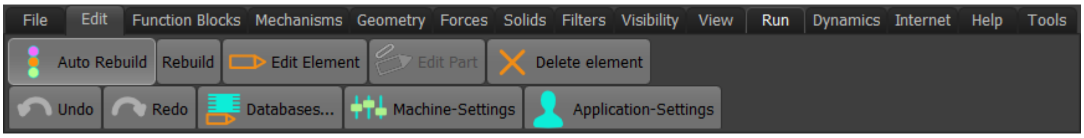
<table>
<tr><td colspan="2">To close MechDesigner.
If the model has changed since you last saved it, the Information box shows:</td></tr>
<tr><td>
</td><td>Click:
Yes: Save the active model.
No: Do not save the active model.
Cancel: Do not save the active model and do not exit.</td></tr>
</table>

1.5.3.2 Edit

Edit

The **Edit** menu and the toolbar provide the tools to manage settings, elements, and the status of your model.

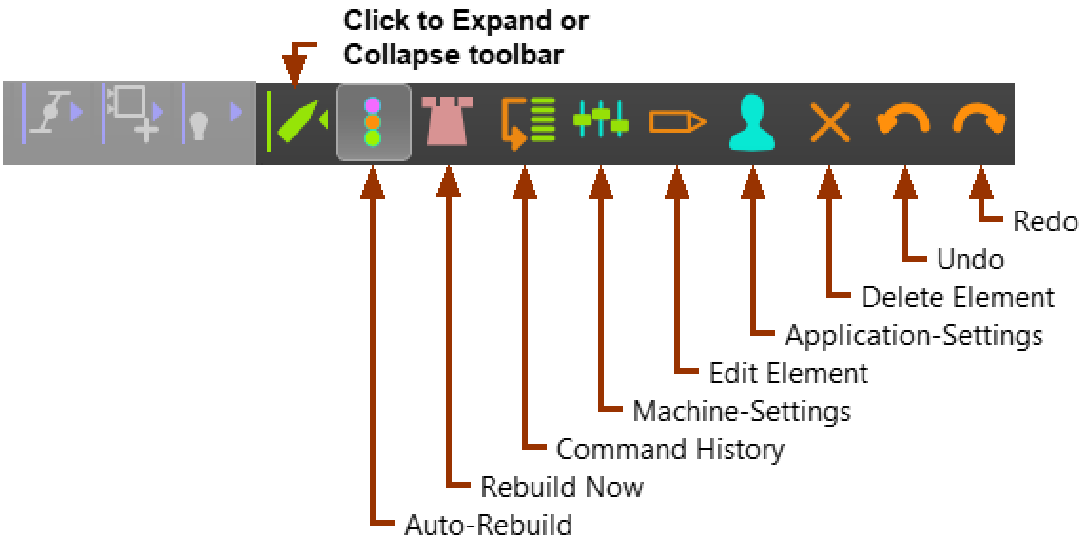
Edit menu



Edit menu - MD17

Edit toolbar

The **Edit toolbar** is **ABOVE** the graphics-area.



Edit Toolbar

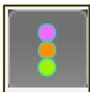
1.5.3.2.1 Edit | Auto Rebuild

Edit > Auto Rebuild

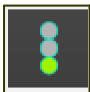
See also Rebuild Now 50

Auto Rebuild is a toggle button.

Auto-Rebuild - enabled

	The model **should** be up-to date - see also **Top-Tip** below. However, it is slower to add new elements when the model is large or complex.

Auto-Rebuild - disabled

	The model **will not** be up-to-date. It **will not** rebuild with all commands - see also **Top-Tip** below However, it is faster to add new elements

Top-Tip

To make sure a complex model is up-to-date:

1. Click Rebuild Now[50].
2. If enabled, click to disable **Auto Rebuild**, and then click again to enable **Auto-Rebuild**.
3. Move the **Master-Machine-Angle** to 0. Do **ALT+H** or **Run menu > Home**.
4. Edit a PART, then exit the **PART-EDITOR**. This also rebuilds the model.
5. If there is a 2D-CAM in the model, edit the 2D-CAM, then close the 2D-CAM DIALOG.
6. Click Rebuild Now[50] again.

1.5.3.2.2 Edit | Rebuild Now

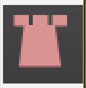
Edit > Rebuild Now

See also Auto Rebuild[49]

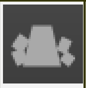
The **Rebuild Now** button has two states.

The two states of the **Rebuild Now** button are:

Model is up-to-date

	The state of the **Rebuild Now** button (and the "fort" icon) when the model is up-to-date.

Model is not up-to-date

	The state of the **Rebuild Now** button (and the "fort" icon) when the model is not up-to-date. 1. Click **Rebuild Now** to rebuild the model (and the fort).

Top-Tip

To make sure a complex model is up-to-date:

1. Click **Rebuild Now**
2. If enabled, click to disable Auto Rebuild[49], and then click again to enable **Auto-Rebuild**.
3. Move the **Master-Machine-Angle** to 0. Do **ALT+H** or **Run menu > Home**.
4. Edit a PART, then exit the **PART-EDITOR**. This also rebuilds the model.
5. If there is a 2D-CAM in the model, edit the 2D-CAM, then close the 2D-CAM DIALOG.
6. Click **Rebuild Now** again.

1.5.3.2.3 Edit | Command History

Edit > Command-History

Use the **Command-History dialog** to undo or to redo more than one command at a time.

To open the **Command-History dialog:**

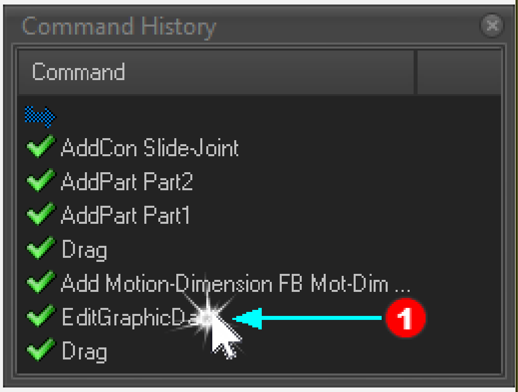
	1. Click **Edit toolbar > Command History**
or 1. Click **Edit menu > Command History**	

The **Command-History dialog** is now open.

See also:

Undo 55
Redo 55

Command-History dialog

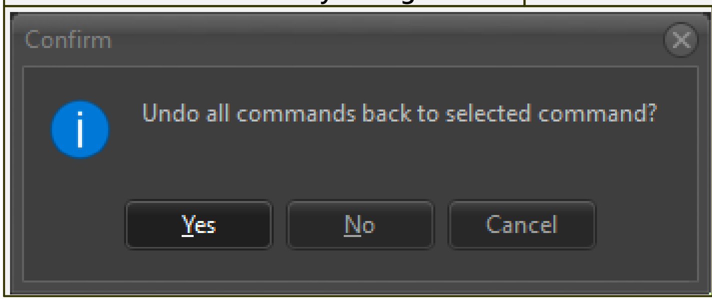


Command-History dialog

The most recent command is at the top of the list.

To Undo commands:

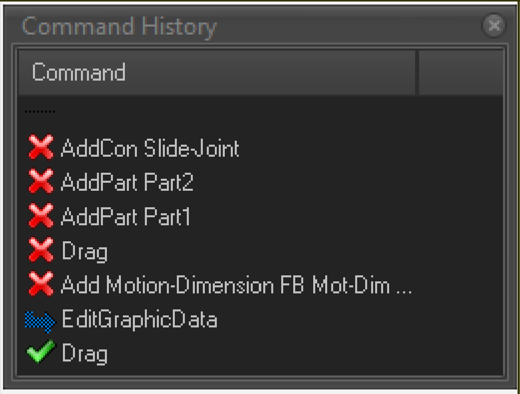
1. Select a command in the list ❶



2. Click YES to confirm you want to undo the commands.

   Wait until we undo the commands.

<table>
<tr>
<td>



Command History dialog

</td>
<td>

To Redo commands:

1. Select a command in the list of undone commands

Wait until we redo the commands.

Warning:

If you do a new command before you **Redo** command, the new command will be at the top of the list.

Then, you cannot redo the original commands.

</td>
</tr>
</table>

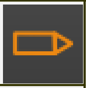
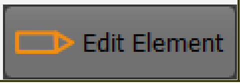
1.5.3.2.4 Edit | Edit Element

Edit > Edit element

Note: You cannot edit all element-types - for example, you cannot edit a **LINE**.

To edit an element:

1. Click the **ELEMENT** in:
   - the graphics-area, or
   - the **ASSEMBLY-TREE**, or
   - the SELECTION-WINDOW [310]

	2. Click **Edit toolbar** > **Edit Element**
	OR
	2. Click **Edit menu** > **Edit Element**

When it is possible to edit the element-type, the dialog to edit the **ELEMENT** is now open.

See also:

Delete element [54]

Rename element [335]

How to open a dialog [627]

1.5.3.2.5 Edit | Delete Element

Edit > Delete Element

Delete element commands:

Delete element	Click **Edit toolbar > Delete element** OR Click **Edit menu > Delete element**

You can also use the **Delete** key on your keyboard.

How to use the Delete element command.

To delete elements with **Edit menu > Delete element**:

1. Click one or more elements in the graphics-area

OR

2. Click one element in the **ASSEMBLY-TREE**

One or more elements are now in the **SELECTION-WINDOW**.

To delete **ALL** of the elements that are in the **SELECTION-WINDOW**:

2. Click **Edit toolbar > Delete Element**

If there are dependent elements, the Delete Dependent elements[617] opens.

Be careful! Only click ✓ in the **Delete Dependent element** form if you are sure.

To delete **ONE** of the elements that is in the **SELECTION-WINDOW**:

2. Click in the SELECTION-WINDOW[310] the element that you want to delete.
3. Click **Edit toolbar > Delete Element**

If there are dependent elements, the **Delete Dependent elements** opens.

Be careful! Only click ✓ in the **Delete Dependent element** form if you are sure.

Notes:

- You **cannot** delete an element that is in a DESIGN-SET[217]. You must remove the element from the **DESIGN-SET** before you can delete it from the model.
- You **cannot** delete a **2D-CAM** after you add to it a **POLYLINE**. You must edit the **Cam-Part** to delete the **POLYLINE**, then you can delete the **2D-CAM** from the model.

1.5.3.2.6 Edit | Undo

Edit > Undo

To **undo** commands:

	Click **Edit toolbar > Undo** OR Click **Edit menu > Undo**

The most recent command is now undone.

Click **Undo** again to undo another command.

See also:

Command History[51] , **Redo**[55]

Notes:

- Keyboard shortcut: **CTRL+Z**
- To redo[55] a command, do **not** do a new command.

1.5.3.2.7 Edit | Redo

Edit > Redo

To **redo** commands you have undone:

	Click **Edit toolbar > Redo** OR Click **Edit menu > Redo**

The command that you have **undone** is now **redone**.

See also:

Command History[51] , **Undo**[55]

Notes:

- Keyboard shortcut: **CTRL+R**
- To redo[55] a command you have undone, do **not** do a new command.

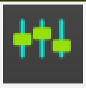
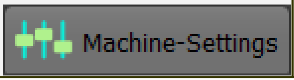
1.5.3.2.8 Edit | Machine-Settings

Edit > Machine-Settings

Machine-Settings: MACHINE-SPEED (RPM), NUMBER-OF-STEPS in a Machine-Cycle, and the ENGINEERING UNITS.

See Machine Settings dialog [351]

To open the Machine-Settings dialog:

 	Click **Edit toolbar > Machine-Settings** **OR** Click **Edit menu > Machine-Settings**

The **MACHINE-SETTINGS DIALOG** is now open.

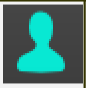
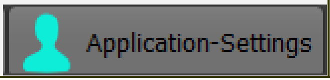
1.5.3.2.9 Edit | Application-Settings

Edit > Application Settings

Application Settings: colors, number-formats, element sizes, ... and many more settings.

See **Application-Settings dialog**[341]

To open the Application-Setting dialog:

	Click **Edit toolbar > Application-Settings**
	OR
	Click **Edit menu > Application-Settings**

The **APPLICATION-SETTINGS DIALOG** is now open

Notes:

When you exit **MechDesigner**, we save your **Application-Settings** automatic-ally in these files:

- **<LocalAppData>\IniFiles\MechDesigner.INI**
- **<LocalAppData>\IniFiles\ MechDesigner.XML**

Delete these two files to revert to factory-settings.

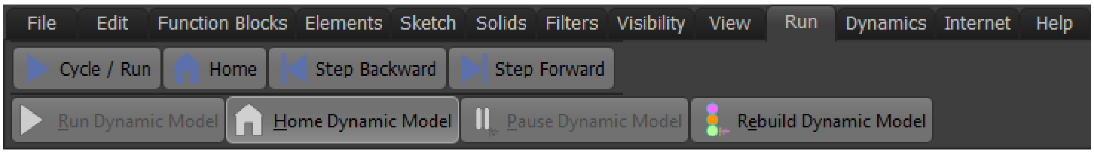
1.5.3.3 Run

Run

The **Run** menu and toolbar provide the commands to run or pause, step, and reset the machine-angle and Revs (Revolutions) o to zero.

Run menu

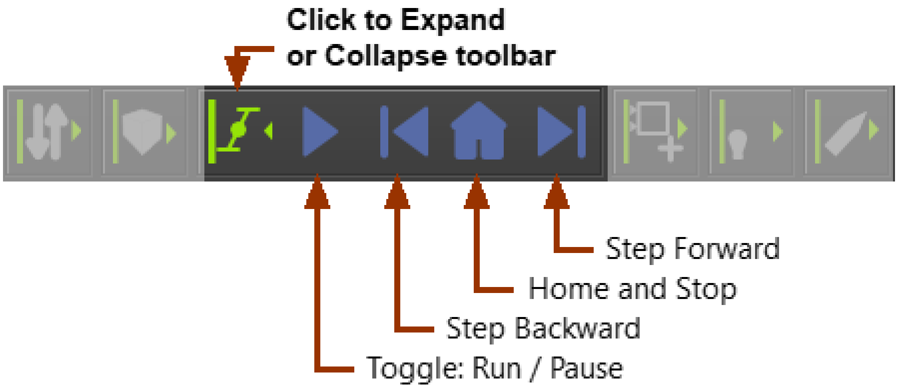
If you show menus, the **Run** menu is at the top.



MD17 - Run menu

Run toolbar

The **Run toolbar** is **ABOVE** the graphics-area.



Run toolbar

Run menu: Commands and shortcuts

ICON	COMMAND	SHORTCUT
	**Toggle: Run / Pause** Toggle on to continuously cycle the model at a constant-rate - see Machine-Settings > Cycle/Minute 351 Toggle off to pause the model at the **Master Machine-Angle**.	ALT+C
	**Step Forward** Click to increase the **MMA** by **360 / Number-of-Steps**	CTRL+ALT+F
	**Step Backward** Click o decrease the **MMA** by **360/ Number-of-Steps**	ALT+B
	**Home (Reset)**	“Home” key on your keyboard

ICON	COMMAND	SHORTCUT
	Click to move the **MMA** and **Revs** to **Zero**, and to stop the model.	
To edit the **MMA**, approximately or exactly, **see Master-Machine-Angle (MMA)**.		

1.5.3.4 Visibility

Visibility

The **Visibility** menu and toolbars toggle on and off the display of different element-types that represent the solid and kinematic element in the graphics-area.

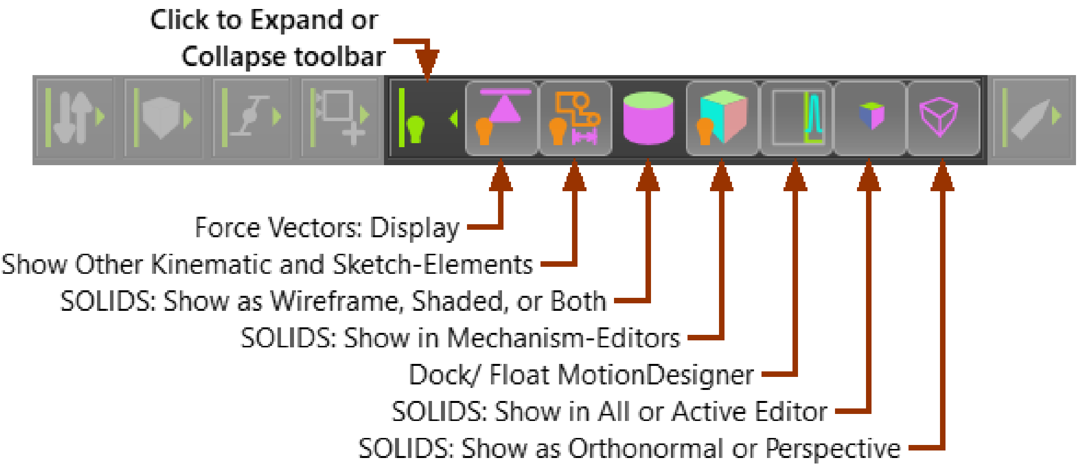
You can also dock or float **MotionDesigner**.

Visibility toolbar

When you show toolbars, the **Visibility toolbar** is **above** the graphics-area.

Toggle the icons in the toolbar to show or hide kinematic and solid element-types.

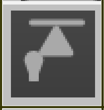
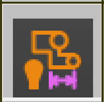
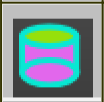
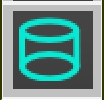
You can also dock or float **MotionDesigner**.

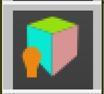
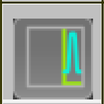
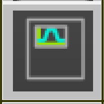
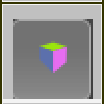
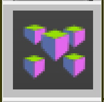
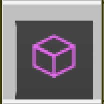
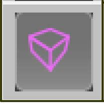


Visibility toolbar

Visibility toolbar - more details

Visibility controls for SOLIDS

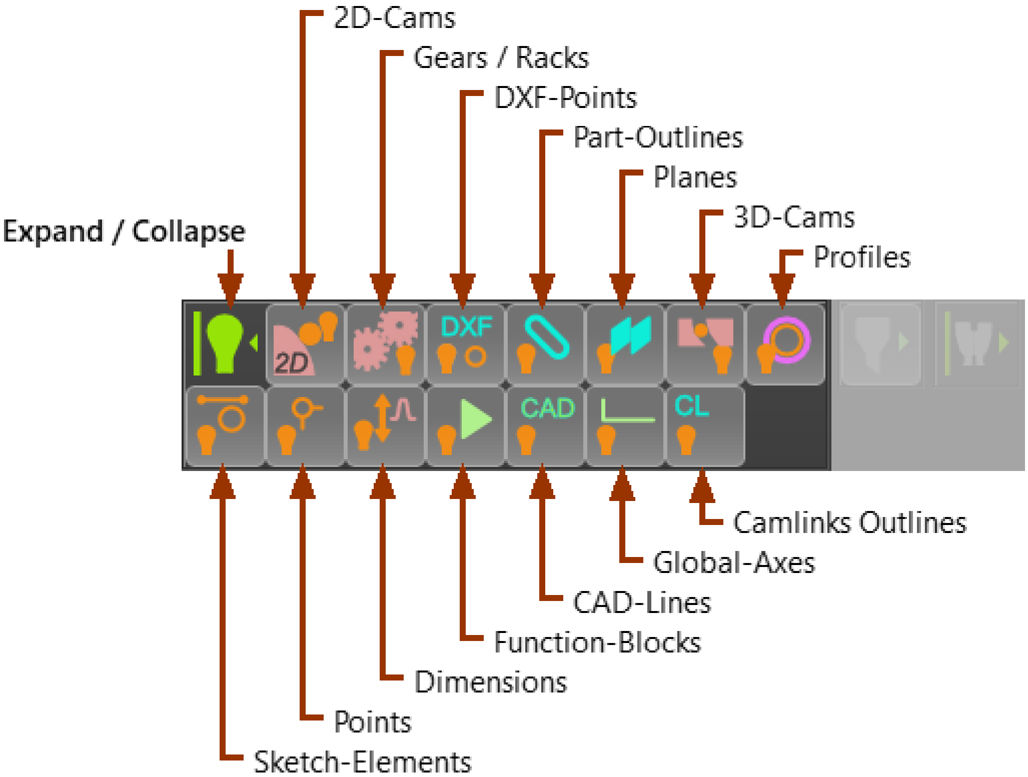
	- Enable "Force-Vectors: Display" - See More 237
	- Disable: "Force-Vectors: Display"
	- Enable "Show other Kinematic and Sketch elements" - See More 63
	- Disable "Show other Kinematic and Sketch elements"
	- Solids as "Shaded AND Wireframe edges" - See More 65
	- Solids as "Wireframe"

	- Solids as “Shaded”
	- Enable “Show Solids in Mechanism-Editor” - See More[66]
	- Disable “Show Solids in Mechanism-Editor”
	- MotionDesigner is “Docked” : See More[66]
	- MotionDesigner is “Floating”
	- “Solids in ACTIVE Mechanism-Editor ONLY” - See More[66]
	- “Solids in ALL Mechanism-Editors”
	- “Orthonormal View” - See More
	- “Perspective View"

Element-Visibility toolbar

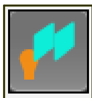
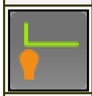
When you show toolbars, the **Element-Visibility toolbar** is **BELOW** the graphics-area.

Toggle the icons in the toolbar to show or hide different element-types.



Display Filters toolbar
[Default: All Filters Selected to Display ALL element-types]

Element Visibility toolbar - more details

	Show or Hide PLANES from the graphics-area. **Note**: An active MECHANISM-EDITOR shows only those PLANES that are its 'children'.
	Show or Hide MODEL AXES from the graphics-area.
	Show or Hide PART-OUTLINES and Joints from the graphics-area.
	Show or Hide POINTS from the graphics-area.
	Show or Hide SKETCH-ELEMENTS AND PART-AXES from the graphics-area.
	Show or Hide PROFILES from the graphics-area.
	Click to hide CAD-Lines, all DXF Outlines and CAD-SOLIDS from the graphics-area.
	Show or Hide DXF POINTS in **DXF-Drawings** from the graphics-area. Other **DXF Entities** stay in the graphics-area. **DXF Points** show at the ends of DXF Entities in a **DXF-Drawing** that you import. If there are many **DXF Points**, they can hide the **DXF-Drawing**.

	Show or Hide **CAMLINKS OUTLINES** from the graphics-area. **CAMLINKS** was a 2D kinematics software package.
	Show or Hide **FUNCTION-BLOCKS** from the graphics-area.
	Show or Hide: • **MOTION-DIMENSIONS** and **MOTION-DIMENSION FBS** • **DIMENSIONS**
	Show or Hide **GEAR-PAIRS**
	Show or Hide **2D CAM**
	Show or Hide **3D-CAMS**

1.5.3.4.1 Display Force-Vectors

Visibility > Force-Vectors: Display

See Force toolbar > Force-Vectors: Display [237]

1.5.3.4.2 Show Other Kinematic and Sketch elements

Visibility > Show "other Kinematic and Sketch elements" (Global Switch)

Control the visibility of **Kinematic elements** and **Sketch elements** in the graphics-area.

Use this "**Global Switch**" together with the "**Local Switch**" Light-Bulb [63] in each **Mechanism name-tab**.

> When you enable **Visibility toolbar > Show "other kinematic and sketch-elements"**, you can see:
>
> ... all **Kinematic elements** and **Sketch elements** that in the **ACTIVE MECHANISM-EDITOR** when you edit a **PART**
>
> AND
>
> ... those **Kinematic elements** and **Sketch elements** that are in **OTHER MECHANISM-EDITORS** that have their **Light-Bulbs** **ON**

Global Switch

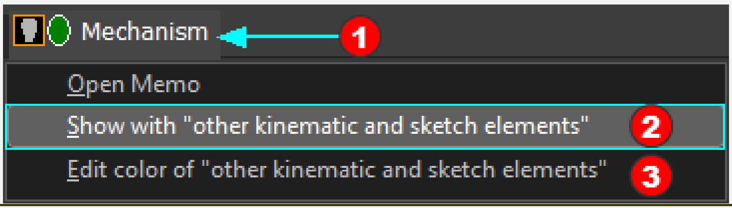
	Visibility toolbar > Show other Kinematic and Sketch elements
	Visibility toolbar > Hide other Kinematic and Sketch elements

Local Switch for each Mechanism-Editor : Light-Bulb

There is a **Light-bulb** in each **Mechanism name-tab**.

The **Light-bulb** must be **ON** to show from other **MECHANISM-EDITORS** those kinematic and sketch-elements that are in this **MECHANISM-EDITOR**.

	Mechanism name-tab : Light-bulb switch is ON
	Mechanism name-tab : Light-bulb switch is OFF



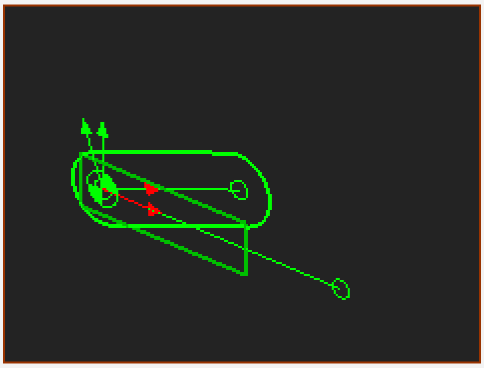
To turn a Light-bulb switch to on  :

1. Right-click the **Mechanism name-tab**❶ of any **MECHANISM-EDITOR**
2. Click **Show with "other kinematic and sketch elements"**❷.

Note: You can also **Edit color of "other kinematic and sketch-elements**❸" in each **MECHANISM-EDITOR**.

Example

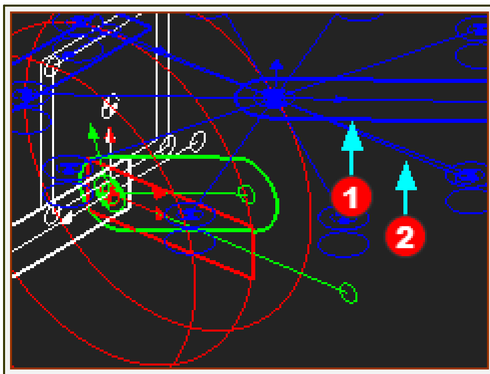
Visibility when Global-Switch is OFF



Kinematic and sketch-elements in active Mechanism-Editor ONLY.

Visibility toolbar (or menu) > Show "other Kinematic and Sketch elements" is OFF

Visibility when Global-Switch is ON



Kinematic and sketch-elements in active and other Mechanism-Editors.

Thee Kinematic and Sketch-Elements of other Mechanism-Editors when their Light-Bulb is also ON.

Visibility toolbar (or menu) > Show "other kinematic and sketch elements" is ON

❶ A PART-OUTLINE symbol in a different MECHANISM-EDITOR that also has its **Light-Bulb ON**

❷ A LINE or CAD-LINE in a different MECHANISM-EDITOR that also has its **Light-Bulb ON**

You can control the color of the elements if you right-click the **Mechanism name-tab**.

In the image there are three colors.

- Green is the color of elements that are kinematically-defined in the active MECHANISM-EDITOR
- Blue / Red are the colors of elements that are in other MECHANISM-EDITORS

TOP-TIP :

When you **show other kinematic and sketch-elements** in other MECHANISM-EDITORS, you can use you mouse-point to:

Identify Parts

- Single-Click a PART-OUTLINE (or JOINT, or CAD-LINE) to identify in the SELECTION-WINDOW and ASSEMBLY-TREE the name of the PART (or JOINT, or CAD-LINE) and the MECHANISM-EDITOR to which it is a child.
- Single-Click a **sketch-element** to identify, in the SELECTION-WINDOW, the name of the sketch-element and the PART to which the sketch-element is a child.

Jump to a different Mechanism-Editor

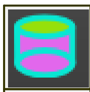
- Double-Click a PART-OUTLINE or sketch-element to jump to the MECHANISM-EDITOR in which the PART or sketch-element is a child.

1.5.3.4.3 Solids Display Mode

Visibility > SOLIDS Display Mode

To change how you view **SOLIDS**.

This switch has three states.

	Visibility toolbar > Solids as Shaded AND Wire-Frame
	Visibility toolbar > Solids as Wire-Frame ONLY (hidden lines visible)
	Visibility toolbar > Solids as Shaded ONLY
MUST also be enabled:	

- Visibility toolbar> Show Solids in Mechanisms [66]

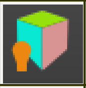
OPTIONS:

- Visibility toolbar > Show Solids in Active or All Mechanisms [66]
- Visibility toolbar > Show Solids as Orthonormal or as a Projection View

1.5.3.4.4 Show Solids in Mechanisms

Visibility > Solids in Mechanisms

This command is a toggle between Show and Hide **Solids in Mechanism-Editors**.

	Visibility toolbar > Solids in Mechanisms - Enabled
	Visibility toolbar > Solids in Mechanisms - Disabled

PLANES also show when you show **Solids in Mechanisms**, which can be inconvenient.

To hide PLANES, use:

- Element-Visibility toolbar > Show or Hide Planes

Use Solids in Mechanisms with:

Visibility menu > Show Solids in Active or All Mechanism-Editors [66]

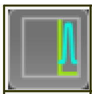
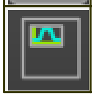
Visibility menu > Solids Display Mode [65]

Visibility menu > Show Solids as Orthonormal or Projection View

1.5.3.4.5 Dock or Float MotionDesigner

Visibility > Dock / Float MotionDesigner

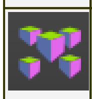
This command has two(2) states:

	Visibility toolbar > MotionDesigner is Docked
	Visibility toolbar > MotionDesigner is Floating

1.5.3.4.6 Solids In Active or All Mechanisms

Visibility > Show Solids in Active or All Mechanism-Editors

This command relates to SOLID and PLANE elements.

	Visibility toolbar > Show Solids that are in the active Mechanism-Editor ONLY
	Visibility toolbar > Show Solids that are in all of the Mechanism-Editors

To see the SOLIDS, you must also enable:

- Visibility toolbar> Solids in Mechanisms [66]

OPTIONS:

- Visibility toolbar > Solids Display Mode: 65 Shaded, Wire-Frame, or Shaded AND Wire-Frame 65
- View toolbar > Orthonormal or Perspective View

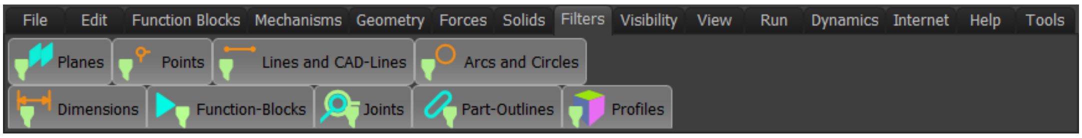
1.5.3.5 Filters

Filters

Selection Filters help you to select different types of elements in the graphics-area. For example, select the filter for **POINTS** so that you can select only **POINTS**.

Filter menu

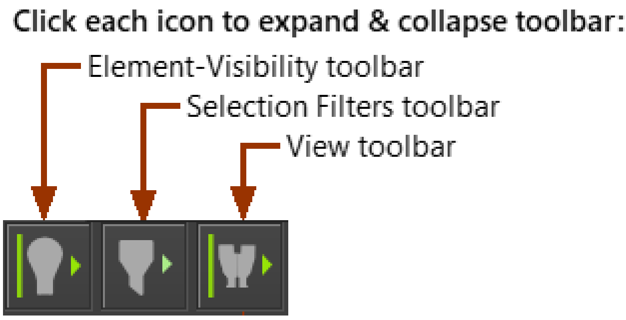
When you show menus, use Filters to help you select different element-types.



MD17 - Filter menu

Filter toolbar (+Element-Visibility and View toolbars)

When you show toolbars, the **Selection Filters toolbars** are **BELOW** the graphics-area.



Display Filters & Selection Filters (and View) toolbars - collapsed

1.5.3.5.1 Selection-Filters

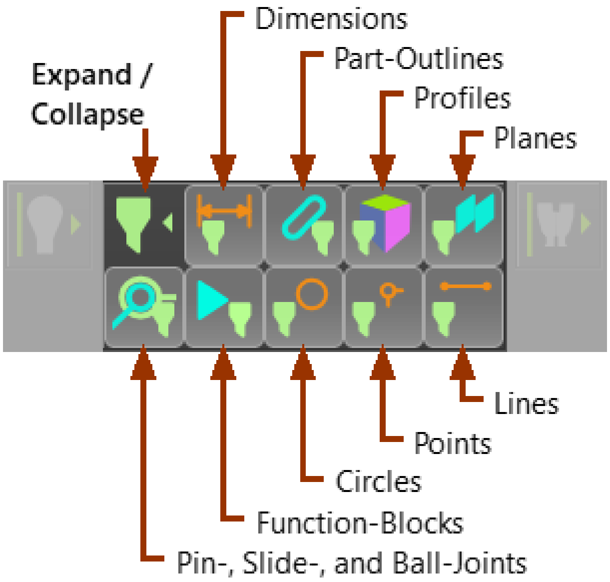
Filters menu and Selection Filters toolbar

The Selection Filters toolbar is BELOW the graphics-area.

When you toggle an icon to ON, you can:

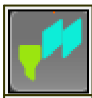
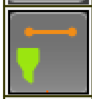
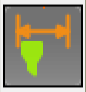
- select that type of element in the graphics-area
- select and edit the type of element from the **ASSEMBLY-TREE**

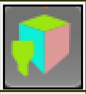
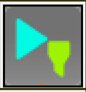
Special Case and default: Disable OR Enable ALL Filters to select ALL element-types.



Selection Filters toolbar
[All filter elements selected]

Selection Filter icons

	Filter for PLANES
	Filter for **PART-OUTLINES** (to select a PART).
	Filter for **POINTS**
	Filter for **LINES**, **CAD-LINES**, **X-axes**, and **Y-axes** of a PART.
	Filter for CIRCLES and ARCS
	Filter for Dimensions: • DIMENSIONS[269] in the **PART-EDITOR** • MEASUREMENT DIMENSIONS[193] and MEASUREMENT FBs • MOTION-DIMENSIONS[174] and MOTION-DIMENSION FBs

	Filter for **PROFILES**
	Filter for **FUNCTION-BLOCKS**
	Filter for **PIN-JOINTS** , **SLIDE-JOINTS** and **BALL-JOINTS.**

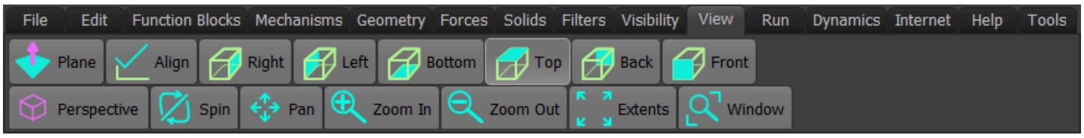
1.5.3.6 View

View

Use the **View** menu and toolbar to manipulate and control how to display the graphics area.

View menu

When you show menus, use the View menu to help you manipulate and control how to display the graphics area.



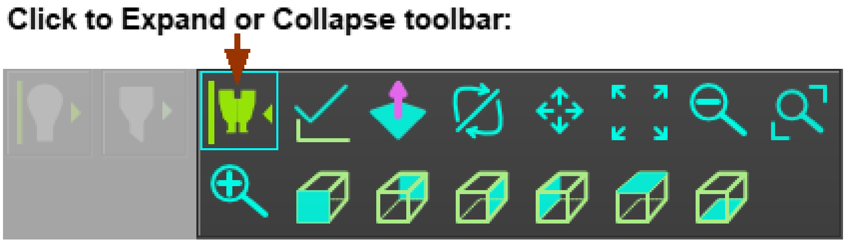
View menu - MD17

View toolbar

When you show toolbars, the **View toolbar** is **above** the graphics-area.

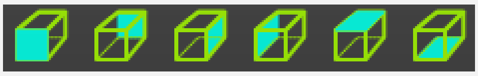
Use the buttons to control how to display the graphics area.

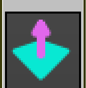
The **View toolbar** is **BELOW** the graphics-area.



View toolbar

View toolbar - more details

<table>
<tr><td colspan="2">
View from the: Front ; Back ; Left ; Right ; Top ; Bottom

Front-View is the XY-Plane of the active MECHANISM-EDITOR
Press F3 on your keyboard as the short-cut key for the Front-View.</td></tr>
<tr><td></td><td>View Align
PART-EDITOR : Click View Align to rotate the Part so that the X-axis is horizontal
MECHANISM-EDITOR : Click View Align to rotate the BASE-PART so that the X-axis is horizontal.</td></tr>
<tr><td></td><td>View Normal to a Plane
To make the view normal(⊥) to a PLANE:
Click View Normal to Plane
Click a PLANE
Click ✅ in the COMMAND-MANAGER</td></tr>
</table>

	SPIN **Spin button + Drag in the graphics-area** **Shortcut** **SHIFT + Drag in the graphics-area** **Shortcuts and keyboard arrow-keys** **10º Spin** : **LEFT / RIGHT and UP / DOWN** keyboard arrow-keys **30º Spin** : **CTRL + LEFT / RIGHT and UP / DOWN** keyboard arrow-keys **90º Spin** : **SHIFT + LEFT / RIGHT and UP / DOWN** keyboard arrows-keys **Note**: Make sure your mouse-pointer does not hover above an element before you drag your mouse.
	PAN **Pan button + Drag in the graphics-area** **Shortcut:** **CTRL + Drag in the graphics-area** **Note**: Make sure your mouse-pointer does not hover above an element before you drag your mouse.
	Zoom Extents To display the complete model. If the complete model does not show, do **Front-View(F3),** then **Zoom-Extents**.
	Zoom In SHORTCUT: Mouse Wheel: Zoom in/out at your mouse position.
	Zoom Out SHORTCUT: Mouse-Wheel: Zoom in/out at your mouse position.
	Zoom Windows With your mouse, drag a window as the extents of the new model view.

1.5.3.7 Help

Help

The **Help menu** (no toolbar) has the tools to find different help formats.

Help menu - MD17

Help menu - MD17

Help menu commands

Open Local Help

We put the **Local Help** in **<CommonAppData>\ Help ** - when you install **MechDesigner**.

To get contextual help:

- Click **Help menu > Open Local Help**, **AND/OR**
- Click the icon in a dialog[332], **AND/OR**
- Press the **F1** key when you move your mouse over a command button.

On-line Help

You need an Internet connection.

We open for you the **MechDesigner's Help** Welcome Page.

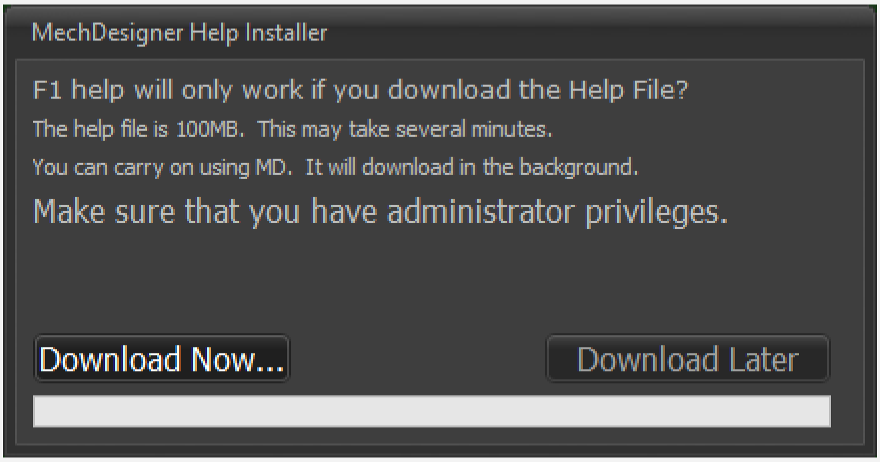
The On-Line help has many tutorials.

Download Latest Help...

You MUST start MechDesigner with Administrator Rights

Download the Local Help to make sure you have the latest version.

1. Click **Help menu > Download Latest Help...**



2. Click **Download Now** button

Download Example Models

1. Click a model from the list of Examples

Wait for the model to download.

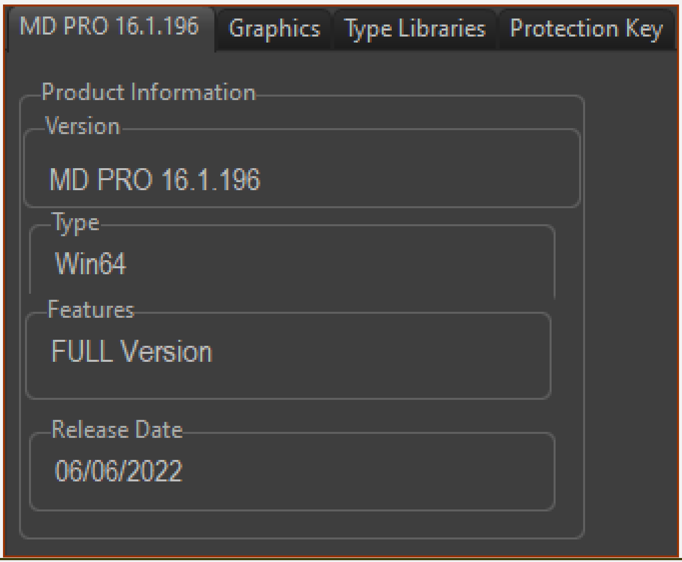
	Some models are large. Please be patient to make sure the file downloads. To show **MD-SOLIDS** and any **CAD-SOLIDS**, click: • Edit toolbar > Auto Update / Rebuild [49] • Visibility toolbar > Show Model in Mechanisms [66] to show SOLIDS • **Element-Visibility toolbar > Show/Hide Planes** to hide **PLANES** that may hide other elements in the model.
	Toggle Hints Use to show tool-tips next to your mouse-pointer. 1. Click to **Toggle Off** (You may need to click this two(2) times) 2. Click again to **Toggle On** **See also** Application Settings [347]
	MechDesigner YouTube 1. Click to see the **MechDesigner YouTube** channel.
Internet sub-menu [76] >	
	About dialog tabs: **MechDesigner E.g.: 17.1.54:** (Release.Version.Build) **Graphics** - your Graphics Card Supplier, OpenGL Version, Graphics Card Model, OpenGL Extensions **Type-Libraries: Last used** version of **SOLIDWORKS** and installed version of **SOLIDWORKS** Type-Libraries **Protection Key** - Your License Settings **See** About dialog [74]

1.5.3.7.1 About

Help > About dialog

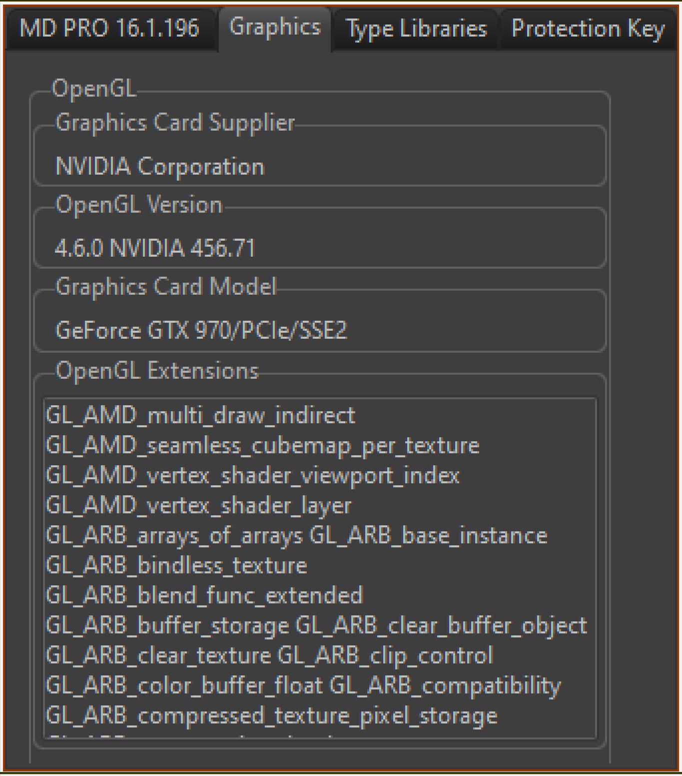
There are four tabs:

MD XXX V-R-B tab



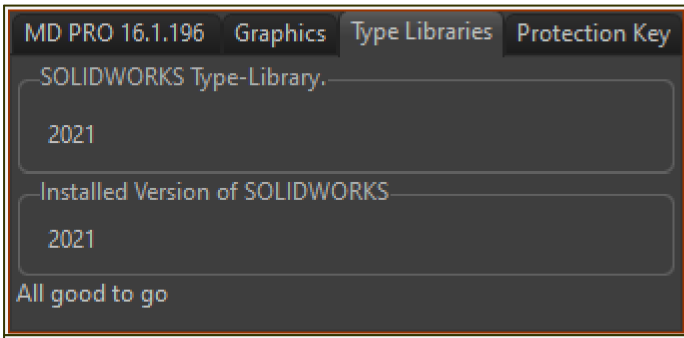
Version: MechDesigner XXX V.R.B	
XXX = PRO - Professional ; STD = Standard ; TRL = Trial	
V. R . B : Version - Release - Build	
Type :	Win64
Features:	FULL Version
Release Date:	dd-mm-yyyy

Graphics tab



Graphics Card Supplier:	For example: NVIDIA Corporation
OpenGL Version:	For example: 4.5.0 NVIDIA 361.91
Graphics Card Model	For example: GeForce GTX 970/PCIe/SSE2
OpenGL Extension	For example: GL...AMD_multi_draw_indirect, GL_AMD,_.... and others.

Type Library tab



SOLIDWORKS® Type-Libraries / Installed Version of SOLIDWORKS

Each version of **SOLIDWORKS** uses a different Type Library file.

In the image :

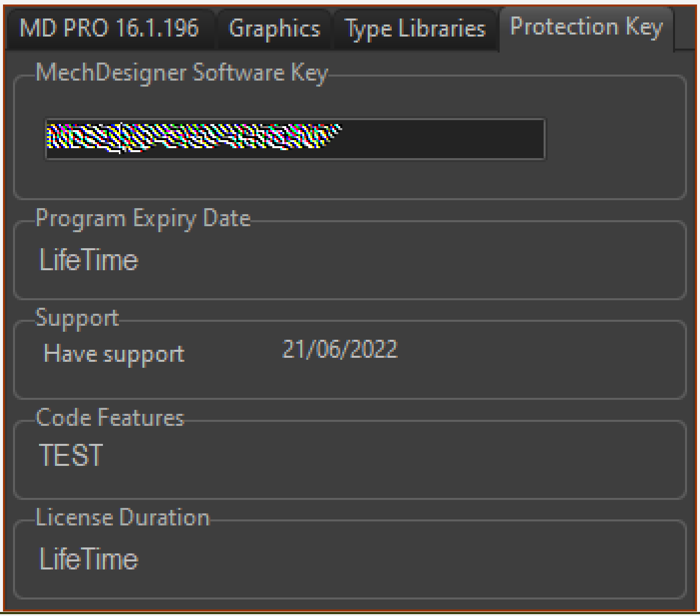
- **SOLIDWORKS Type Library:** 2021
- **Installed Version of SOLIDWORKS**: 2021

When the year is the same, you are **All good to go**.

If the versions are not the same, then **Run as Administrator** when you start **MechDesigner**, and check again.

Note: From MD15 - the correct Type Libraries are installed automatically with your installation, and it checks which version of **SOLIDWORKS** you are using each time you start **MechDesigner**.

Protection Key



MechDesigner Software Key	Mdxx_x_x-xxxx-xxxx-xx
Program Expiry Date	Lifetime / Expiry Date
Support	Have Support + Expiry date / Without Support
Code Features	PREM, STAN, LITE (TEST (code testing only))
License Duration	Lifetime / Annual

1.5.3.8 Internet

Internet

The **Internet menu** (no toolbar) provides some ways to download help, email us, and download example models. You need an internet connection.

PSMotion Home Page

A link to: **psmotion** dot **com** in your web-browser

Send Mail

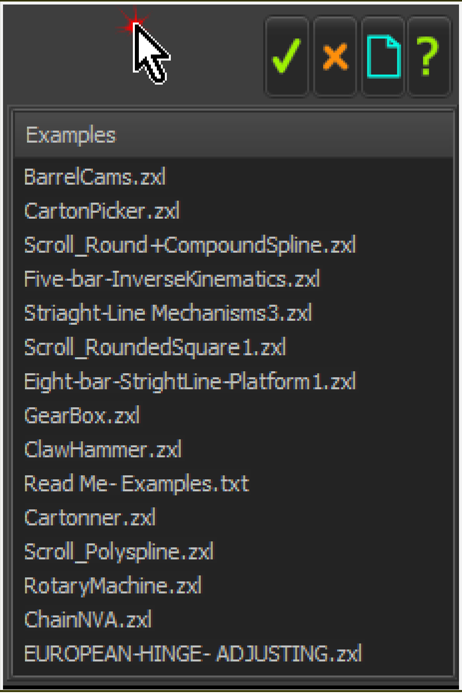
Report Bug / Feature Request

Please send all Bugs and Feature Requests to **support at psmotion dot com**

General Mail

Send emails to **sales at psmotion dot com**

Download Example Models



MechDesigner YouTube

1. Click to see the **MechDesigner YouTube** channel.

1.5.4 2.1 Model-Editor

② Model-Editor

What is the Model-Editor?

The **MODEL-EDITOR** shows the **SOLID** and **PLANE** elements in your model. You can cycle the model continuously or position it at any machine angle.

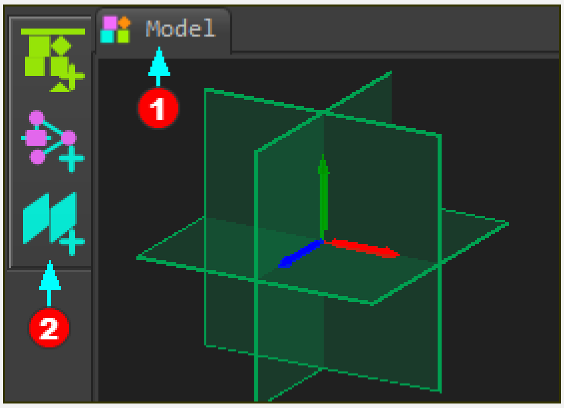
In the **MODEL-EDITOR**, you can:

- add **PLANES** to **PLANES**
- add **MECHANISM-EDITORS** to **PLANES***
- edit **SOLID** elements

* You **MUST** use the **MODEL-EDITOR** to add a minimum of one **MECHANISM-EDITOR** to a **PLANE**.

See Model elements > Add Mechanism [85]

Model-Editor workspace



Model-Editor: Reference Triad and fixed Planes

Graphics-area :

The **Reference Triad** shows the directions of the **Global XYZ-axes**.

The direction of each axis uses the **right-hand rule**.

The elements in the **MODEL-EDITOR** are:

- Three fixed **PLANES**:
  - **Front PLANE**, which is co-planar with the **Global** XY-axes
  - **Top PLANE**, which is co-planar with the **Global** ZX-axes
  - **Right PLANE**, which is co-planar with the **Global** YZ-axes
- Other **PLANES** you may have added
- **SOLIDS** that you have added to **PARTS**

Name-tab ❶ :

The default element name of the **MODEL-EDITOR** and name-tab is **Model**

Menu and Toolbar

Menu - the commands that you can use in the **MODEL-EDITOR** are in the Mechanism menu 90

Toolbar - the commands that you can use in the **MODEL-EDITOR** are in the **Model elements toolbar** 81 .

See also:

Model Options dialog 337

1.5.4.1 Model elements

Model element commands

There are only two commands in the **Mechanism menu** that you can use in the **MODEL-EDITOR**. The two commands arrange the basic layout of your machine.

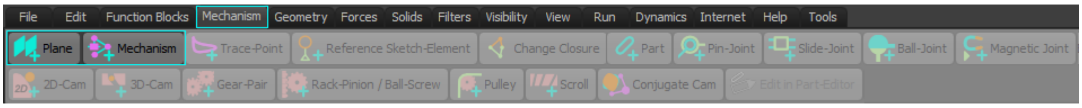
The two commands are:

- Add Plane 82
- Add Mechanism 85 *

* You **MUST** do Add Mechanism 85 to add a minimum of one **MECHANISM-EDITOR**.

The two commands are in the **Mechanism menu** and the **Model elements toolbar**.

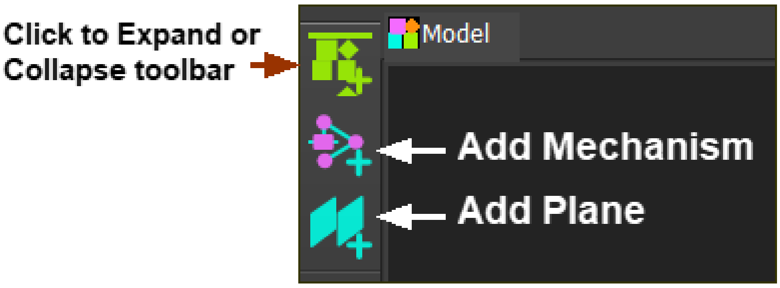
Mechanism menu > Model elements



Mechanism menu > Model elements (MD17)

Model elements toolbar

The **Model elements toolbar** is to **left** of the graphics-area.



Model elements toolbar

1.5.4.1.1 Add Plane in Model-Editor

What is a Plane?

A PLANE is a flat surface, defined by its Local XYZ-axes. The PLANE is coincident with the XY axes. The Z-axis follows the usual Right-Hand-Rule.

You add PLANES to arrange the layout of your machine.

You add **MECHANISM-EDITORS** to PLANES.

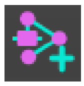
Add Plane (Model-Editor)

In the **MODEL-EDITOR**, you offset a new PLANE along the **Z-axis** of a PLANE you select.

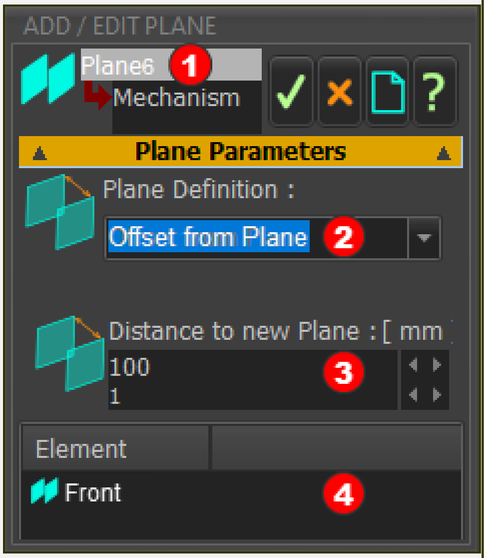
STEP 1: Start the Add Mechanism command:

1. Click Mechanism menu > Add Plane

OR



1. Click [Model elements toolbar](81) > Add Plane



Add Plane dialog:
FORMAT 1: Add Plane to Plane

The ADD PLANE DIALOG opens, immediately.

If you have not pre-selected a PLANE, we select for you the **FRONT** PLANE as the default reference element.

In the **MODEL-EDITOR**, the format of the ADD PLANE DIALOG is:

❶ **Name** - of new PLANE, and the Parent element (MECHANISM in the dialog)

PLANE PARAMETERS

❷ **Plane Definition :**

OFFSET FROM PLANE (always in the **MODEL-EDITOR**)

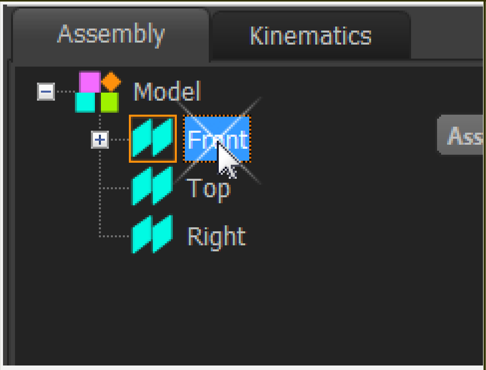
❸ **Parameter to define the new Plane :**

DISTANCE TO NEW PLANE [mm]

The distance from the reference element, PLANE.

❹ **Element box** - the reference PLANE for new PLANE (default **Front**)

STEP 2: Select a Plane



Click a Plane in the Assembly-Tree

1. Click a PLANE in the graphics-area

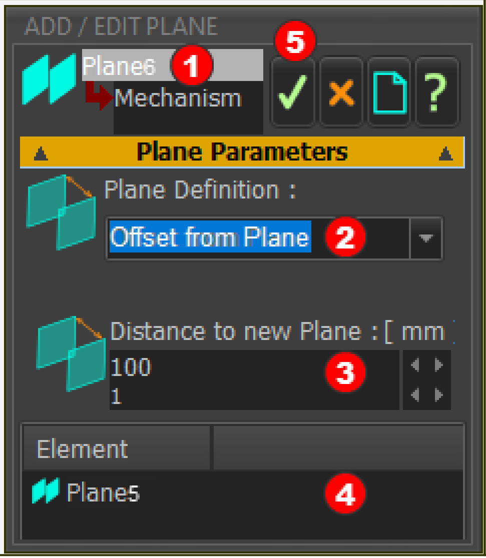
OR

1. Click a PLANE in the ASSEMBLY-TREE

When you click a PLANE, it shows in the **Element box**❹ of the ADD PLANE DIALOG

A preview of the new PLANE is also in the graphics-area.

STEP 3: Edit the Parameter

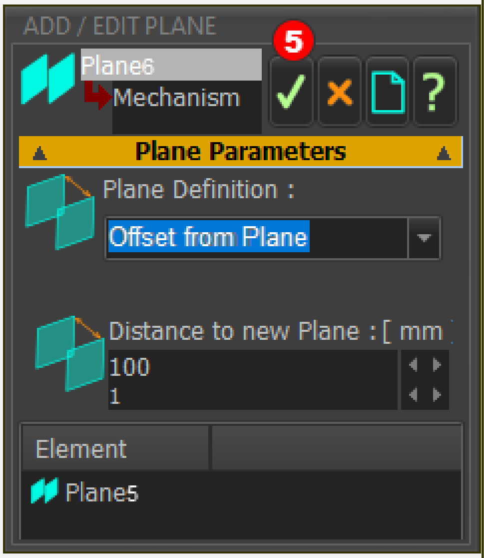


There is one parameter to edit:

Edit the DISTANCE TO NEW PLANE❸

The DISTANCE TO NEW PLANE is from the reference PLANE in the **Element-box**❹.

STEP 4: Complete the Command

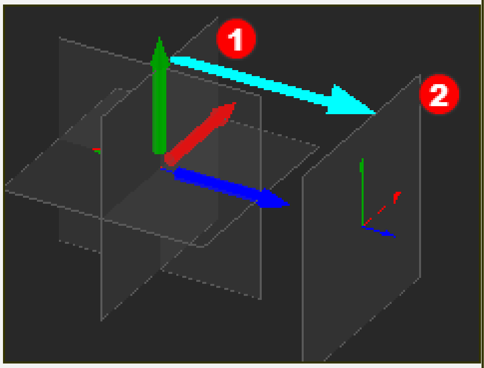


New Plane in the Graphics-Area

To complete the command:

Click ✓ ❺in the **ADD-PLANE DIALOG**

RESULT



New Plane in the Graphics-Area

RESULT

The new **PLANE**❷ is in the graphics-area and the **ASSEMBLY-TREE**.

The The new **PLANE** has shows its **XYZ-axes**.

The **XY-axes** are coplanar with the new **PLANE**.

Note:

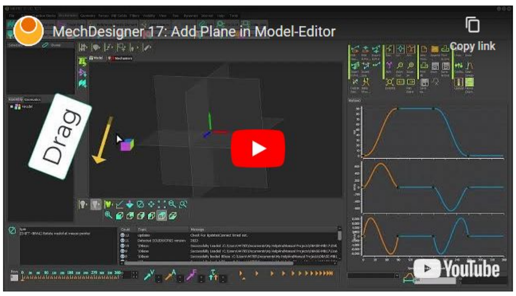
If you cannot see the new **PLANE** try:

View menu > Zoom-Out 70 (or use your mouse scroll wheel)

View menu > Spin model 70 (or use the keyboard arrow keys)

View menu (or Display toolbar) > Display Planes 67

Videos (YouTube): Double-click to watch Video



Add Plane in Model-Editor

1.5.4.1.2 Add Mechanism in Model-Editor

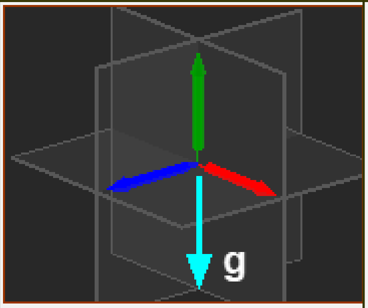
Mechanism and Mechanism-Editor?

What is a MECHANISM and a MECHANISM-EDITOR?- See here[88] .

Why add a MECHANISM? - See here[88] .

Important - Read if this Is this the first Mechanism-Editor.

Gravitational Vector (g = 9.81665 m/s/s)



You **cannot edit the direction** or the magnitude of the **Gravity Vector**.

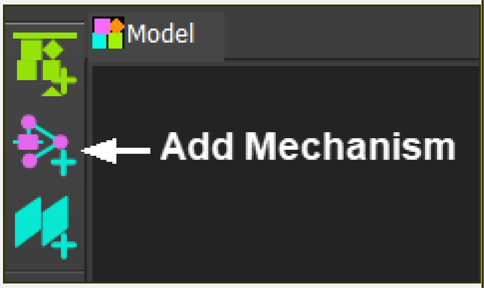
Therefore, add the first MECHANISM-EDITOR to a PLANE that represents the layout of your machine.

GRAVITY VECTOR - its direction is in the "global" negative Y-axis direction

For example, if your machine is a horizontal, rotating table, you should add the first **MECHANISM-EDITOR** for the table to the **TOP** PLANE, or a PLANE that is parallel to the **TOP** PLANE.

Add Mechanism

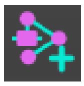
STEP 1: Start the Add Mechanism command:



Model elements toolbar

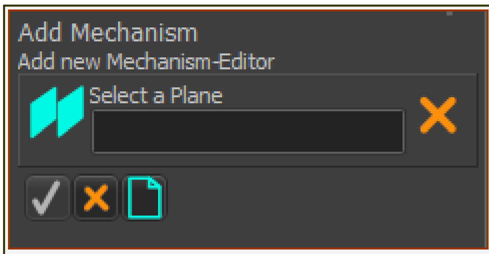
1. Click Mechanism menu > Mechanism

OR



1. Click Model elements toolbar[81] > Add Mechanism

STEP 2: Select a Plane



Command-Manager

The COMMAND-MANAGER (left of graphics-area) has one selection-box.

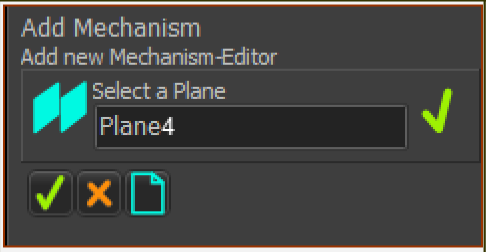
You must select a PLANE.

1. Click a PLANE in the graphics-area

OR

1. Click a PLANE in the ASSEMBLY-TREE

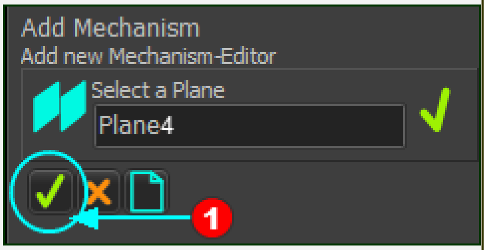
The PLANE is now in the selection-box in the COMMAND-MANAGER.



Command-Manager - Plane element

To see **PLANES**: Enable Show Solids in Mechanisms[66]. Enable: Visibility menu > Display Planes.

STEP 3: Complete the command



Command-Manager - 'OK'

You must click the 'tick' to complete the command.

In the **COMMAND-MANAGER**:

1. Click the ✓ below the selection-box.

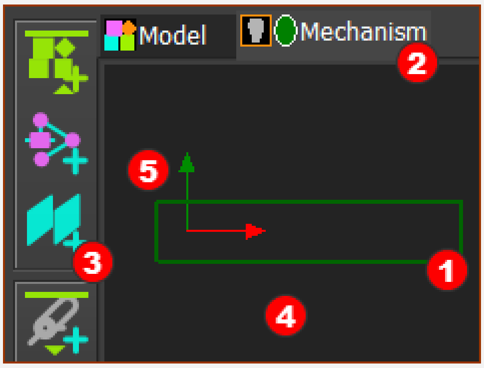
RESULTS

1. The **COMMAND-MANAGER** closes.
2. You **jump** immediately to a new **MECHANISM-EDITOR** workspace - with a Mechanism tab, graphics-area, **BASE-PART**, and toolbars.
3. There is a new **MECHANISM** element in the **ASSEMBLY-TREE**.

   The **MECHANISM** element is a child to the **PLANE** you select.

See also: The Base-Part does not show correctly![659]

RESULT: Workspace



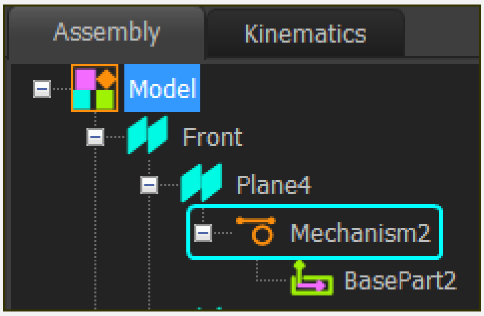
Mechanism-Editor workspace

The new **MECHANISM-EDITOR**:

❶ **BASE-PART WITH A RECTANGULAR PART-OUTLINE**
❷ **Mechanism name-tab**
❸ **Toolbars** (left and right of the graphics-area)
❹ **Graphics-area**
❺ **Local XY-axes** of the **MECHANISM-EDITOR** and **BASE-PART**

The **XY-Plane** of the **PLANE** you select, the new **MECHANISM** element, and the **BASE-PART** are coplanar and coincident.

RESULT: Assembly-Tree



Hieratchy of new Mechanism in Assembly-Tree

The hierarchy of the new Mechanism element

PLANE4 - that you selected to add the MECHANISM element:

(New) MECHANISM2 - is a child to PLANE4, and coplanar with the **XY axes** of PLANE4.

(New) BASEPART2 - is the name the PART that you edit to add sketch-element. It is the machine-frame of MECHANISM2.

The **XYZ-axes** of PLANE4, MECHANISM2, and the BASE-PART2 are all coincident.

Video


Add Mechanism-Editor in the Model-Editor

1.5.5 2.2 Mechanism-Editor

Mechanism-Editor

What is a Mechanism-Editor?

To do **Add Mechanism** you must select a **PLANE**.

When you do **Add Mechanism**, we add for you a:

- **MECHANISM** element to the **ASSEMBLY-TREE** as a child to the **PLANE** you select,

and a

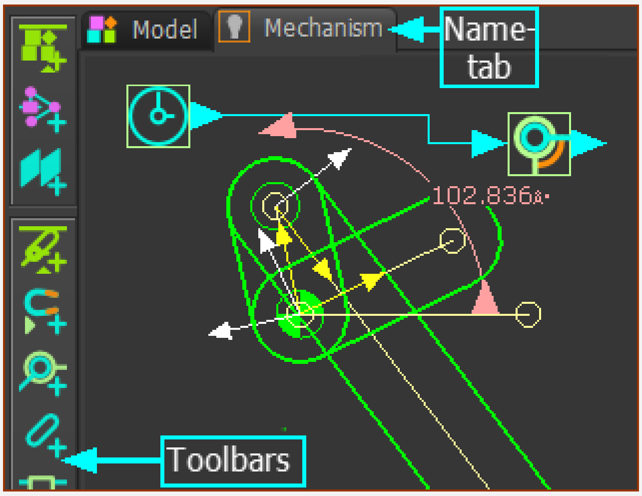
- **MECHANISM-EDITOR** workspace with its name-tab, graphics-area, XY-axes, and a **BASE-PART**.

Why add a Mechanism-Editor?

You build you model in the **MECHANISM-EDITOR** workspace with kinematic elements 98, Solid elements, Function-Blocks, ...

You must add a minimum of one **MECHANISM-EDITOR**.

Mechanism-Editor workspace



Mechanism-Editor- Example

The Mechanism-Editor workspace:

Graphics-area : to which you add Kinematic and Machine elements, Kinematic and Modeling Function-Blocks, Solid elements, Force elements, and other elements.

Name-tabs : each **MECHANISM-EDITOR** has a name tab.

The **BASE-PART** (not shown in the image above) is a child to the **MECHANISM-EDITOR**. It represents the frame, or the stationary part, of the Mechanism workspace. The XYZ-axes of the **BASE-PART** are coincident with the XYZ-axes of the **PLANE** you select when you add the **MECHANISM-EDITOR**.

Menus and Toolbars

The commands in the toolbars are also in the **Mechanism menu**, **Function-Blocks menu**, **Forces menu**, and **MD-Solids menu.**

Mechanism menu 90

Model elements toolbar 91 - left of the graphics-area - add **PLANES** and add **MECHANISM-EDITORS** to **PLANES**

Kinematic elements toolbar 90 - left of the graphics-area - add the basic kinematic elements to build kinematic-chains

Machine elements toolbar 127 - left of the graphics-area - add more complex elements

Function-Blocks menu 165 :

Kinematic Function-Blocks toolbar 169 - right of the graphics-area - plan and measure the motion of each kinematic-chain, analyze and calculate cam-coordinates

Modeling Function-Blocks toolbar 206 - above the graphics-area - tools to help you do more complex modeling

Forces menu

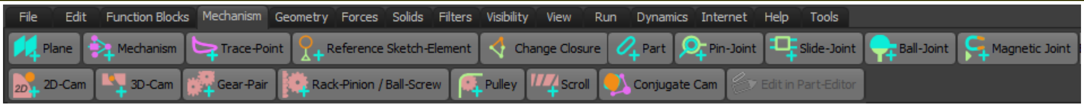
Force elements toolbar 226 - right of the graphics-area - measure force, torque, and power that is required to drive each kinematic-chain

MD-Solids menu

MD-Solids toolbar 239 - above the graphics-area - extrude Solids from sketch-loops, add Holes, add extrusions to all or one **PART**

1.5.5.1 Mechanisms

Mechanism menu



The **Mechanism menu** combines the commands from three toolbars. The three toolbars are to left of the graphics-area.

Model elements[91] - to add elements that arrange the layout of your machine.

Kinematic elements[98] **-** to add the elements that represent the moving parts on your machines. E.g. Parts, Joints, ...

Machine elements[127] - to add elements that represent the hardware components you frequently find on industrial machines. E.g. Cams, Gears, Pulleys, ...

1.5.5.1.1 Model elements

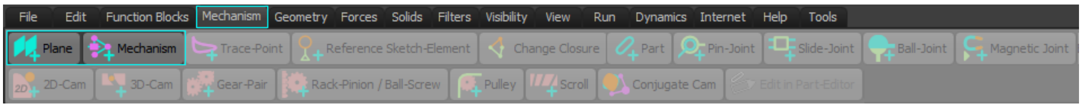
Model elements

Model elements arrange the layout of your machine.

There are only two commands - **Add Mechanism-Editor** and **Add Plane**.

The two commands are in the **Mechanism menu** and the **Model elements toolbar**.

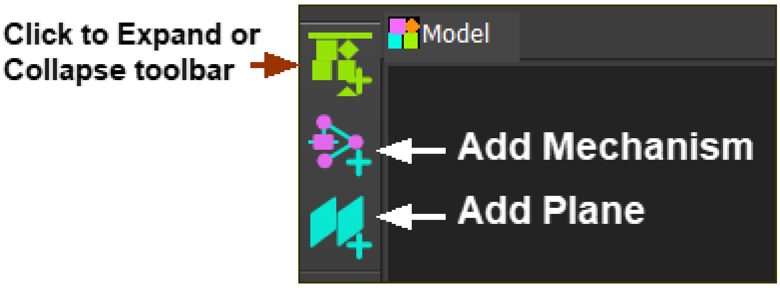
MD17 : Mechanism menu > Model elements



Mechanism menu > Model elements (MD17)

Model elements toolbar

The **Model elements toolbar** is to left of the graphics-area.



Model elements toolbar

1.5.5.1.1.1 Add Plane in Mechanism-Editor

What is a Plane?

A **PLANE** is a flat surface, defined by its Local XYZ-axes. The XY axes are co-planar with the **PLANE**. The **Z-axis** follows the usual Right-Hand-Rule.

Use Visibility toolbar > Show Solids in Mechanisms[66] to see **PLANES** in **MECHANISM-EDITORS**.

See also: Add Plane - Model-Editor[82]

Add Plane (Mechanism-Editor)

In a **MECHANISM-EDITOR**, you can add a new **PLANE**:

- that is parallel to a **PLANE** you select. You can control the distance from the reference **PLANE** - see **FORMAT 1**
- whose origin is at the **START-POINT** of a **LINE*** and the **PLANE** to which the **LINE** is descendant. You can rotate the new **PLANE** about the XYZ axes of the **PLANE** - **FORMAT 2**

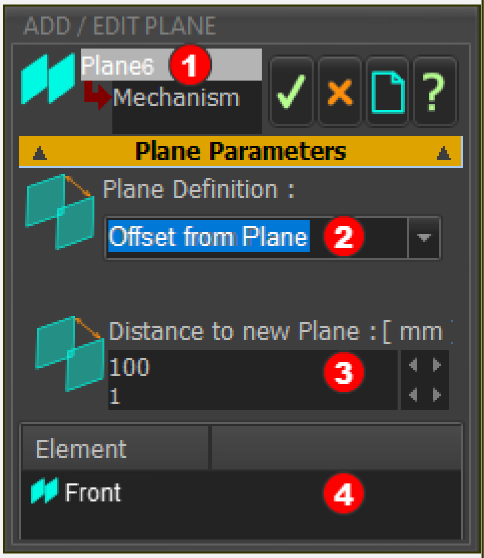
FORMAT 1: Add Plane to a Plane

STEP 1: Start the Add Plane command

Mechanism menu > Plane

OR

Model elements toolbar[91] > Add Plane



FORMAT 1: Add Plane to Plane

The Add Plane dialog opens, immediately

In the **MECHANISM-EDITOR**, the default format is:

❶ **New Plane Name** - **PLANE6**

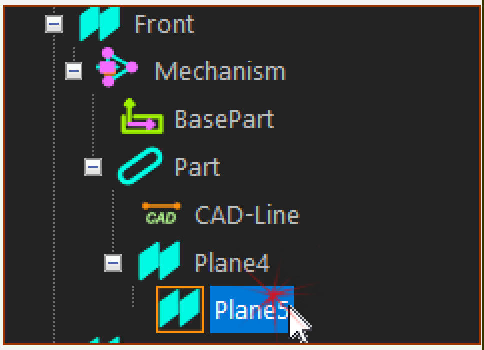
PLANE PARAMETERS

❷ **Plane Definition -** (default format)

OFFSET FROM PLANE (default definition)

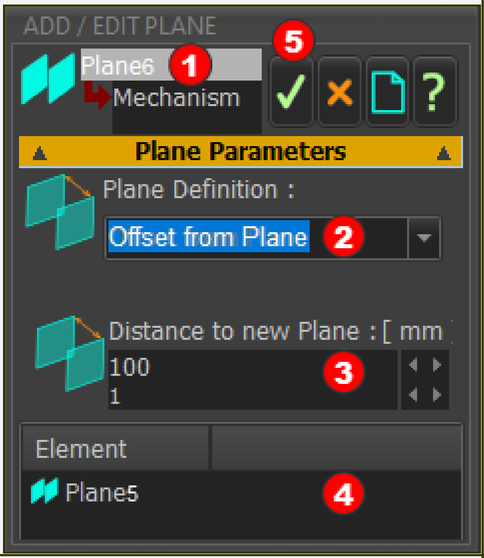
❸ **Parameter to define the new Plane :**

DISTANCE TO NEW PLANE

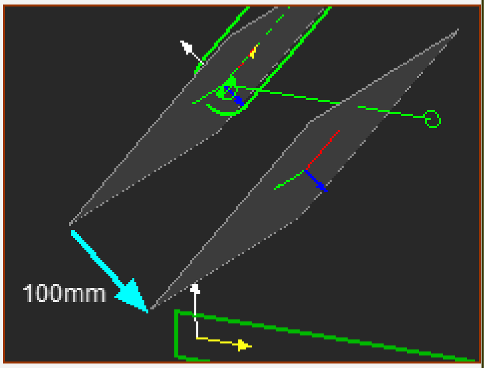
<table>
<tr><td></td><td>❹ Element box - the name of the element(s) that are referenced by the new PLANE.</td></tr>
<tr><td>
</td><td>STEP 2: Click a Plane.

Click a PLANE in the graphics-area or the ASSEMBLY-TREE.

When you click a PLANE, it shows in the Element box❹ of the ADD PLANE DIALOG.

A preview of the new PLANE is also in the graphics-area immediately.</td></tr>
<tr><td>
</td><td>STEP 3: Edit the Parameter❸

Edit DISTANCE TO NEW PLANE❸

DISTANCE TO NEW PLANE - to PLANE 6❶ from PLANE5❹</td></tr>
<tr><td>
</td><td>STEP 4. Complete the Add Plane command

Click ✅ in the ADD-PLANE DIALOG

RESULT

The new PLANE❷ is in the graphics-area and ASSEMBLY-TREE.

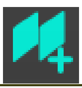
It is on Local Z-axis of the PLANE you select to add the new PLANE.

The new PLANE has its own Local XYZ-axes.</td></tr>
</table>

FORMAT 2: Add Plane to a Line (CAD-Line, Part's X-axis or Y-axis)

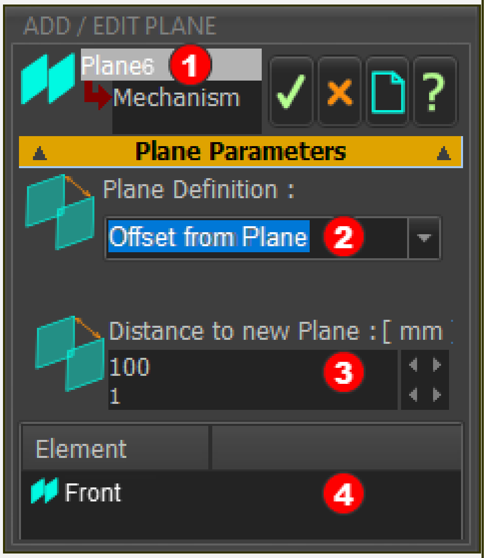
STEP 1: Start the Add Plane command

Mechanism menu > Add Plane



OR

Model elements toolbar 81 > Add Plane



FORMAT 1: Add Plane to Plane

The Add Plane dialog opens, immediately

In the **MECHANISM-EDITOR**, the default format assumes you will select a PLANE.

❶ **New Plane Name** - PLANE6

PLANE PARAMETERS

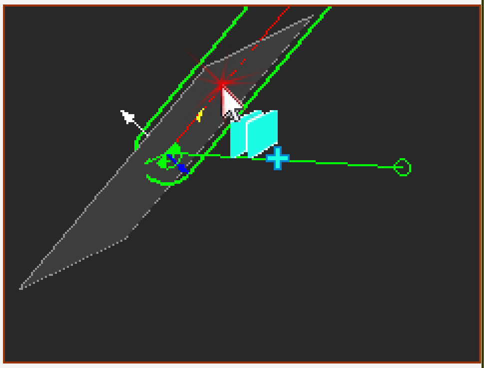
❷ **Plane Definition -** (default format)

OFFSET FROM PLANE (default definition)

❸ **Parameter to define the new Plane :**

DISTANCE TO NEW PLANE

❹ **Element box -** the name of the element(s) that the new PLANE references.



STEP 2: Click a Line*.

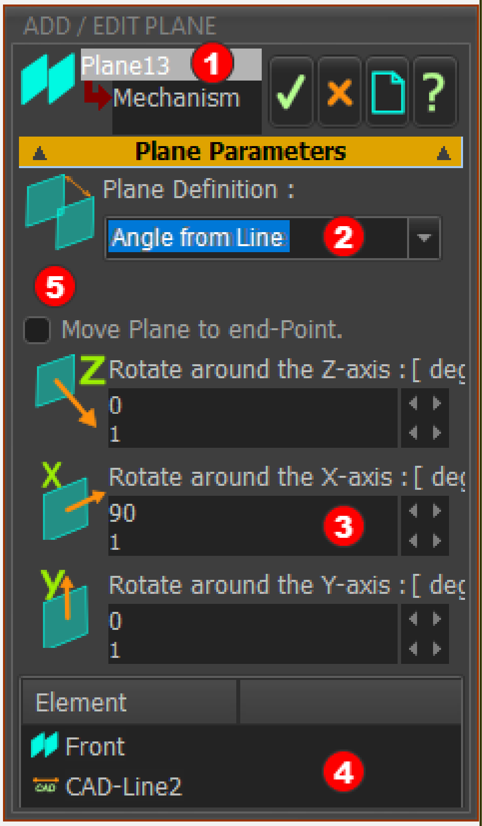
Click a LINE* in the graphics-area

* LINE, CAD-LINE, or a PART'S **X-axis** or **Y-axis**

When you click a LINE, the LINE and the PLANE (see below) to which the LINE is descendant (great-grand-child - PLANE > MECHANISM > PART > LINE) show in the **Element box**❹

There is a preview of the new PLANE in the graphics-area, immediately.

Note: Default ROTATE AROUND X-AXIS = 90.



FORMAT 2: Add Plane to Line

STEP 3. Edit the parameters ❸❺

❸ ANGLE - rotate the new PLANE around the X–AXIS

and

❸ ANGLE - rotate the new PLANE around the Y–AXIS

and

❸ ANGLE - rotate the new PLANE around the Z–AXIS

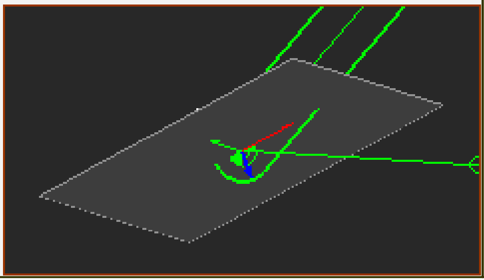
Optional (for Bevel Gearboxes)

❺ MOVE PLANE TO END-POINT - move the new PLANE to the end of the LINE in the **Element box.**

If you enable MOVE PLANE TO END-POINT, (and the ROTATE AROUND X,Y,Z parameters are zero(0)), the Local X-axis is from the **END-POINT** to the **START-POINT**, the Local Y-axis is on the new PLANE, and the Local Z-axis follows the **Right-Hand-Rule.**

STEP 4. Complete the Add Plane command

Click ✅ in the ADD-PLANE DIALOG



RESULT

The new PLANE❷ is in the graphics-area and **ASSEMBLY-TREE**.

The new PLANE shows its **XYZ-axes**.

Video: Double-click to watch Video

1.5.5.1.1.2 Add Mechanism in Mechanism-Editor

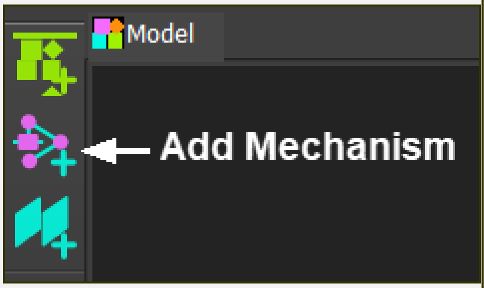
Mechanism and Mechanism-Editor?

What is a MECHANISM and a **MECHANISM-EDITOR**?- See here 88 .

Why add a MECHANISM? - See here 88 .

Add Mechanism

STEP 1: Start the Add Mechanism command:



Model elements toolbar

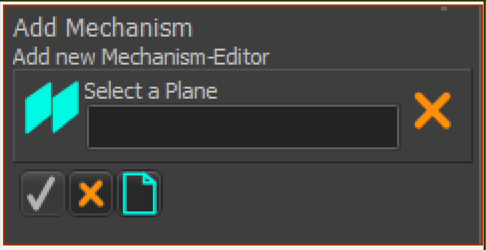
1. Click **Mechanism menu > Mechanism**

OR

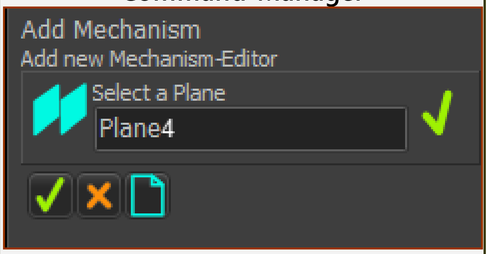
1. Click Model elements toolbar[81] > **Add Mechanism**

The **COMMAND-MANAGER** starts.

STEP 2: Select a Plane



Command-Manager



Command-Manager - Plane element

The **COMMAND-MANAGER** has one selection-box.

You must select a **PLANE**.

If you cannot see a **PLANE**: Enable Show Solids in Mechanisms[66] .

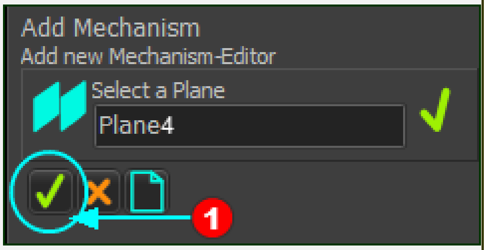
1. Click a **PLANE** in the graphics-area

OR

1. Click a **PLANE** in the **ASSEMBLY-TREE**

The **PLANE** is now in the selection-box in the **COMMAND-MANAGER**.

STEP 3: Complete the command



Command-Manager - 'OK'

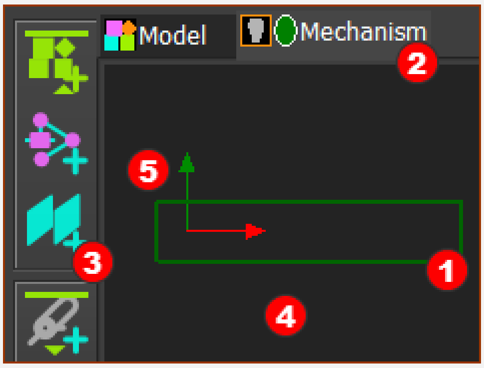
You must click the 'tick' to complete the command.

1. Click ✓ in the **COMMAND-MANAGER**

RESULT

1. The **COMMAND-MANAGER** closes.
2. You **jump** immediately to a new **Mechanism-Editor** workspace
3. The **MECHANISM** element is a new element in the **ASSEMBLY-TREE**. It is a child to the **PLANE** you select.

RESULT: Workspace



Mechanism-Editor workspace

The workspace of each **MECHANISM-EDITOR**:

❶ : **BASE-PART** with a rectangular **PART-OUTLINE**

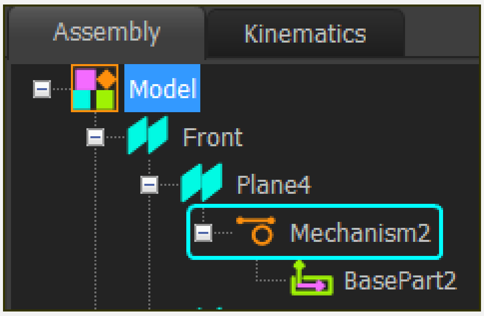
❷ : **Mechanism name-tab**

❸ : **Toolbars** (left and right of the graphics-area)

❹ : **Graphics-area**

❺ : Local **XY-axes** of the **MECHANISM-EDITOR** and **BASE-PART**

RESULT: Assembly-Tree



Hieratchy of new Mechanism in Assembly-Tree

The Mechanism element in the Assembly-Tree:

PLANE4 - that you selected to add the Mechanism element:

(New) **MECHANISM2** - is a child to **PLANE4**, and coplanar with the **XY axes** of **PLANE4**.

(New) **BASEPART2** - is the name the **PART** that you edit to add sketch-element. It is the machine-frame of **MECHANISM2**.

The **XYZ-axes** of **PLANE4**, **MECHANISM2**, and the **BASE-PART2** are all coincident.

Video: Add Mechanism

Double-click to watch 'Add Mechanism to Plane'

1.5.5.1.2 Kinematic elements

Kinematic elements

Kinematic elements are coplanar with the **XY-Plane** of the active **MECHANISM-EDITOR***.

Kinematic elements symbolically represent the moving parts in your machine. You join **PARTS** to each other to build kinematic-chains (mechanisms, linkages).

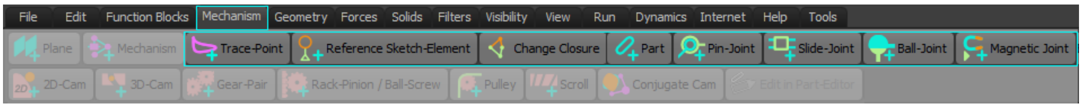
Kinematic elements are NOT solid bodies and they do NOT have shape or form**.

---

* The exception is a **PART** that has a **BALL-JOINT** at its **START-POINT** and **END-POINT**.

** To add a solid body to a **PART**, you must add a **PROFILE** to a **PART**, and/or import a **SOLIDWORKS** part/assembly document, or import an STL file from other CAD.

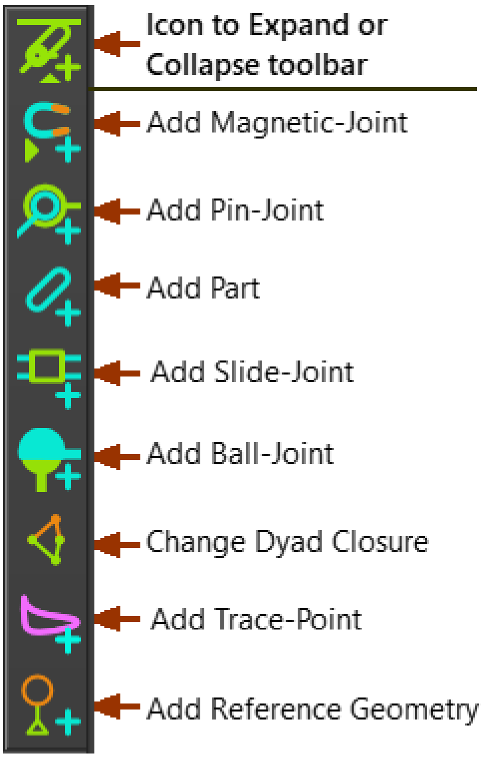
Mechanism menu > Kinematic elements



Mechanisim menu > Kinematic-elements (MD17)

Kinematics elements toolbar

The **Kinematic elements toolbar** is to the left of the graphics-area.



Kinematic elements toolbar

1.5.5.1.2.1 Add Magnetic-Joint

Magnetic-Joint

See also: Magnetic-Joint dialog 560 (**YouTube Video :** http://youtu.be/IME9Eb4mpQE)

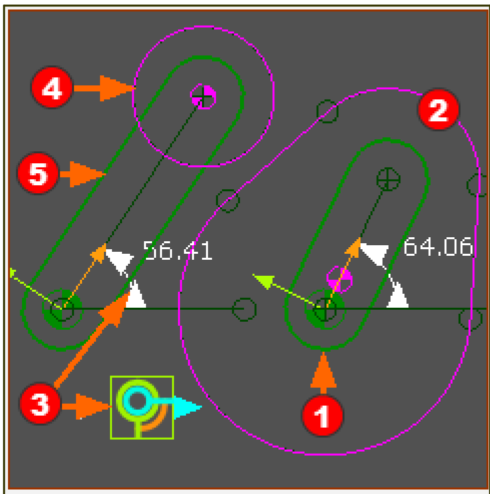
Use MAGNETIC-JOINTS ONLY for **special modeling** - for example, to reverse-engineer the motion of a Follower from the shape of an imported Cam.

MAGNETIC-JOINTS use iterative, root-finding techniques. All other kinematic joints use closed-form equations for exact and fast evaluations. Therefore, a model with a MAGNETIC-JOINT is ~100+ times slower to solve than a model with SLIDE-JOINTS, PIN-JOINTS, and/or BALL-JOINTS. Most models (99%?) do NOT need a MAGNETIC-JOINT.

Terminology

MAGNETIC-JOINT :	A MAGNETIC-JOINT pulls a **circular** PROFILE to be in continuous contact with an **irregular** PROFILE (or CURVE). The **circular** PROFILE and **irregular** PROFILE (or CURVE) are in different kinematic-chains. After you add a MAGNETIC-JOINT, the motion of the two kinematic-chains are related by the contact between the **circular** and **irregular** PROFILES (or CURVE).
Irregular Shape :	The **Irregular Shape** can be PROFILE from a sketch-loop, or a CURVE that we calculate from a **Point-Cloud**.
Point-Cloud :	X-Y or R-Θ coordinates. Use a POINT-CLOUD FB to import the **Point-Cloud** coordinates.
CURVE :	The smooth shape that we calculate for you from the **Point-Cloud** coordinates - see POINT-CLOUD DIALOG 484 .

Preparation for Add Magnetic-Joint (Typical)



The MAGNETIC-JOINT pulls a **Circular-Profile**❹ onto the outside or inside of an **Irregular-Profile**❷.

❶ A PART (and kinematic-chain) to which the **Irregular-Profile**❷ is a child.

❷ An **Irregular-Profile**, which is a

- PROFILE that you have added to a **sketch-loop**

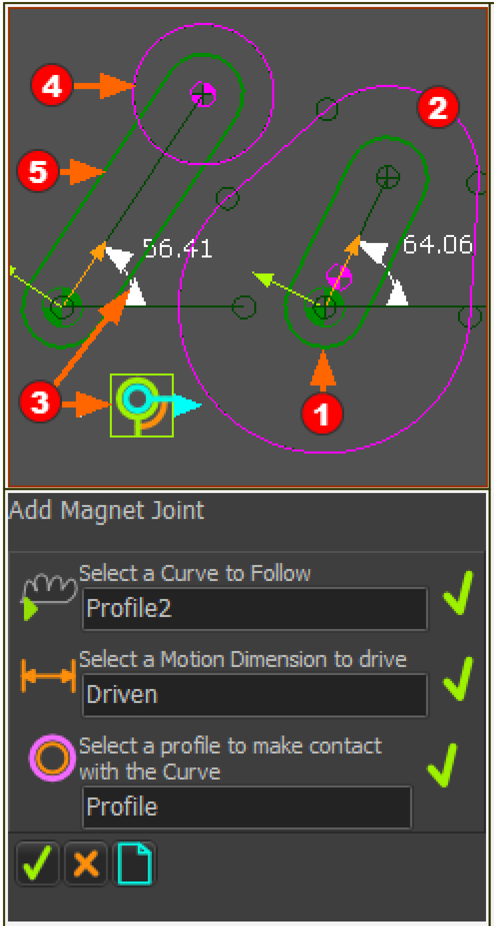
OR

- CURVE that you have fitted to a **Point-Cloud**

❺ A **PART** (and kinematic-chain) to which the **Circular Profile**❹ is a child.

❸ The **MOTION-DIMENSION FB** to drive by the action of the **MAGNETIC-JOINT**.

Add Magnetic-Joint



STEP 1: **Pre-Position the Circular Profile**

1. **HOME** the model

   Select the **Home** key, or use the **ALT+H** keyboard shortcut, or do **Run menu/toolbar** > **Home**.

2. Edit the **MOTION-DIMENSION FB** ❸ | **BASE-VALUE** so that the:

   Distance from the **Circular-Profile**❹ to the **Irregular-Profile**❷ ...

   ... < 0.5 × **Radius of Circular-Profile**❹

Note: See also Magnetic-Joint dialog > 560 ADVANCED 563

STEP 2: **Start the Add Magnetic-Joint command**

1. **Mechanism menu > Add Magnetic-Joint**

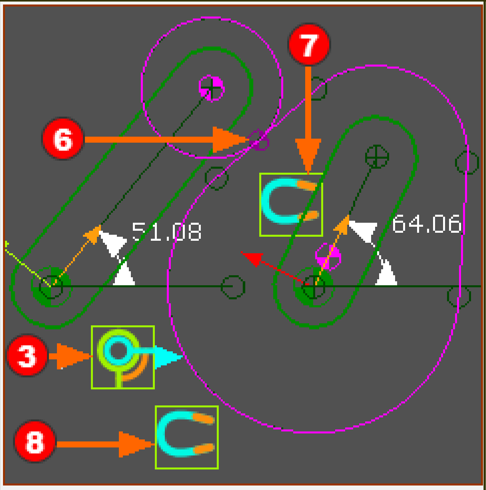
OR

1. **Kinematic elements toolbar > Add Magnetic-Joint**

STEP 3: **Select the elements:**

1. Click the **Irregular Profile**❷
2. Click the **MOTION-DIMENSION FB**❸ **that you want to 'drive' with the Magnetic-Joint.**
3. Click **Circular Profile**❹

STEP 4: **Complete the Command**

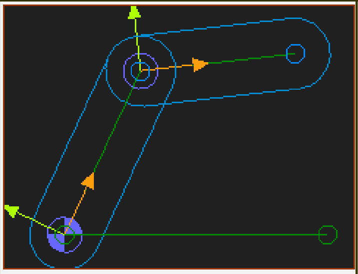
	1. COMMAND-MANAGER: Click ✓ in the COMMAND-MANAGER.
	RESULT: (usually) The MAGNETIC-JOINT pulls the **Circular-Profile**❹ to be in contact with the **Irregular-Profile**❷. A **Point Symbol**❻ is at the contact. The MAGNETIC-JOINT FB❼ is near to the **Point-Symbol**❻ There is a MAGNETIC-JOINT ICON❽ **below and right** of the MOTION-DIMENSION FB❸ that is driven by the MAGNETIC-JOINT.
	STEP 5: Open the Magnetic-Joint dialog 560

Video: Double-click to watch Video

1.5.5.1.2.2 Add Pin-Joint

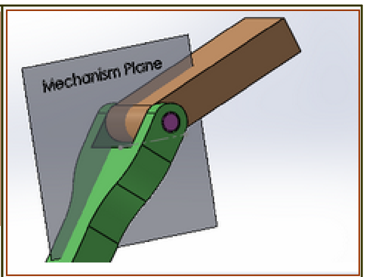
Pin-Joint

See also: Edit-Pin-Joint 592 **(Servomotor and Gearbox Sizing)**



Pin-Joints in MechDesigner

Pin Joint: Connecting-Rod and Piston

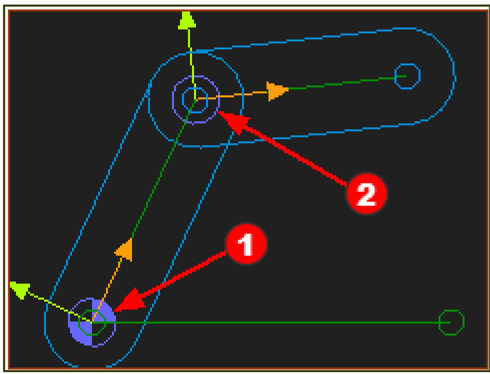


Pin-Joint in CAD model.

Terminology

PIN-JOINT :	A PIN-JOINT makes a POINT* in a PART to be coincident with a POINT* in a different PART. A PIN-JOINT allows two PARTS to rotate relative to each other. A PIN-JOINT removes two **degrees-of-freedom** from the model.
rotating-Part :	A PART that can rotate relative to a different PART.
Revolute-Joint :	The kinematic and technical term of a PIN-JOINT.
KINEMATICS-TREE :	In **Dyads**, we represent a PIN-JOINT with the letter **R**, which is from the kinematic term: **Revolute-Joint**.
* POINT, START-POINT, END-POINT, or CENTER-POINT.	

Pin-Joints in the graphics-area

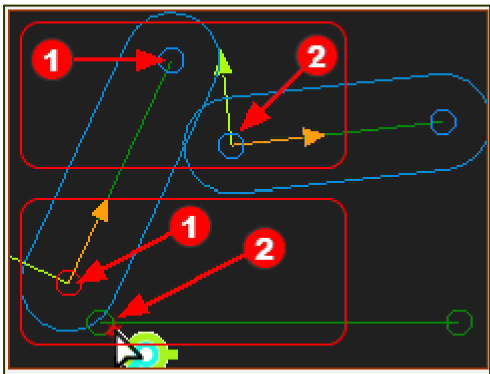


A PIN-JOINT has two symbols.

1 - a PIN-JOINT between a PART and the BASE-PART.

2 - a PIN-JOINT between two(2) added PARTS and they can move relative to the BASE-PART.

Simple Case - Add Pin-Joint

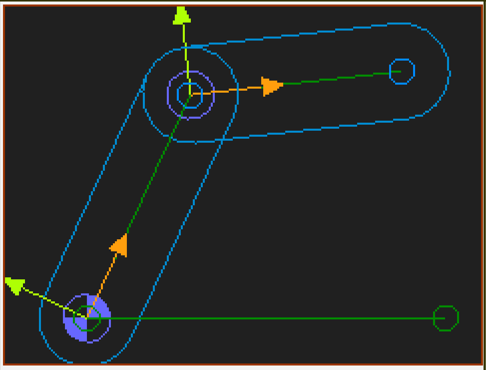


STEP 1: Start the Add Pin-Joint command

Mechanism menu > Add Pin-Joint

OR

Kinematic elements toolbar > Add Pin-Joint



Two Pin-Joints

STEP 2: Select two(2) Points:

At least one **POINT** must be in a **FREE PART**.

1. Click a **POINT❶** in a **free PART**
2. Click a **POINT❷** in a different **PART**

The two(2) **POINTS** are coincident at the **PIN-JOINT**.

If the **SELECT-ELEMENTS DIALOG** opens, see Special-Case[103] .

See also:

Add Slide-Joint[110]

Add Ball-Joint[114]

Add Motion-Dimension FB[174]

VIDEO : Add Pin-Joint - Simple-Case

DOUBLE-CLICK FOR VIDEO

Special-Case - Add two or more coincident Pin-Joints

Frequently, a design has **PIN-JOINTS** that are coincident, to join more than two **PARTS**.

Example:

You want to join **POINTS(#1,#2,#3)**, in **PARTS(#1,#2,#3)**. with **PIN-JOINTS(#1,#2).**

Say, **PIN-JOINT#1** is between **POINTS #1 and #2** (in **PARTS #1 and #2**)

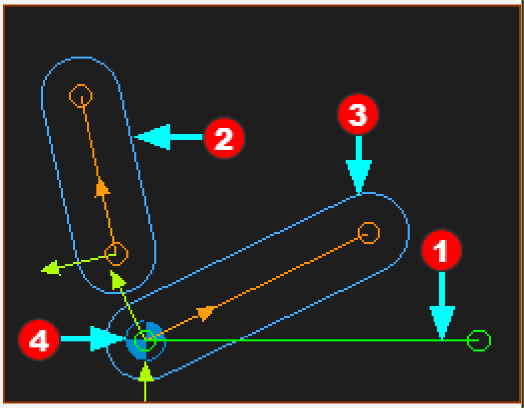
When you add **PIN-JOINT#2**, you have two(2) options:

- **Option A**: **PIN-JOINT**#2 is between **POINTS** #3 and #1 (in **PARTS** #3 and #1)

OR

- **Option B**: **PIN-JOINT**#2 is between **POINTS** #3 and #2 (in **PARTS** #3 and #2)

To select **Option A** or **Option B** is important if you also select the **PIN-JOINTS** to add **MOTION-DIMENSION FBS**[174] .



Preparation example:

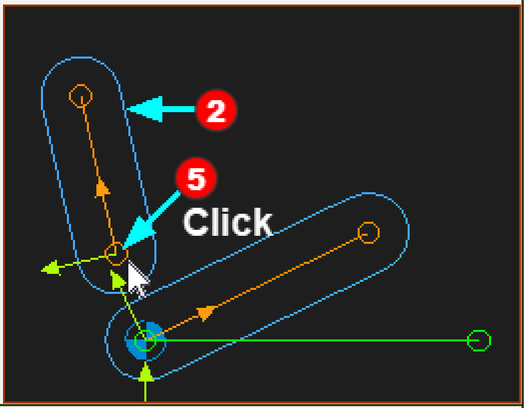
❶ LINE in the BASE-PART (any PART that is **kinematically-defined**)

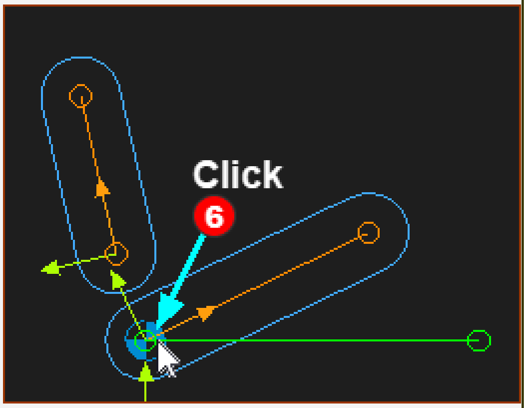
❷ Part that is completely-free

❸ Part that is free

PIN-JOINT❹ joins the START-POINT of LINE❶ to the START-POINT of PART❸

You want to join PART❷ that is **completely-free** with a PIN-JOINT that is coincident with PIN-JOINT❹.





STEP 1: Add Pin-Joint #2

1. Click **Kinematic elements toolbar > Add Pin-Joint**

1. Click POINT❺ at the end of the **Completely-Free-Part**❷
2. Click the PIN-JOINT❻ to select a POINT - see below

You have actually clicked a total of **three(3)** POINTS.

- One POINT at ❺
- Two POINTS at ❻

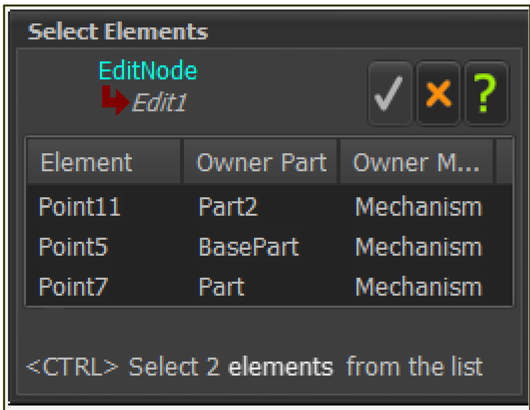
However, the PIN-JOINT is between two(2) POINTS.

Therefore, there is **ambiguity** ...

... Which two(2) POINTS, of the three(3) POINTS, do you want the PIN-JOINT to select?

Definition:

Ambiguity: we are not clear which element(s) to select to add a new element.



Select-Elements dialog

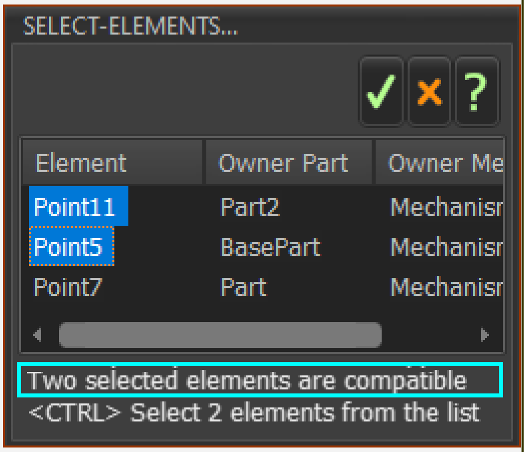
When there is **ambiguity** as to which elements you want to select, the **Select Elements dialog** opens.

In this model, there are three(3) possible POINTS from which you want to select two(2) POINTS.

- POINT11 (the START-POINT❺ of the PART❷ that is completely-free)
- POINT5 (the POINT❻ at the left of the LINE in the BASE-PART)
- POINT7 (the START-POINT❻ of the PART that is free)

TOP-TIP

The element at the top of the list is the first element you click. Therefore, if possible, click the element you know you need before you click the other elements. Then, you know you need to select the top element plus one other.



OPTION A

STEP 2: Select the Points in the Select-Elements dialog:

1. Ctrl key down
2. Click the two POINTS you want to use for the PIN-JOINT
3. Ctrl key up

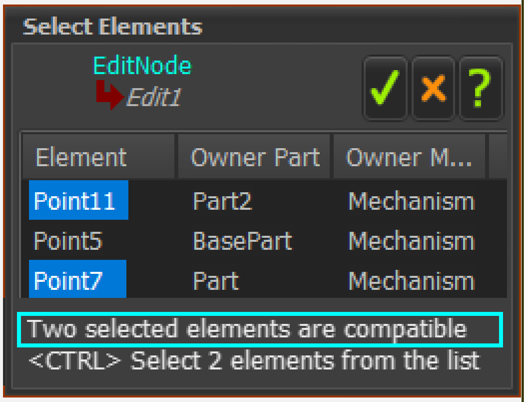
The ✓ colorizes **only** when you select the elements that are compatible .

4. Click ✓ at the top, right of the dialog

Which two POINTS do you select from the three POINTS?

There are three options to select two(2) **ELEMENTS** from three(3) elements.

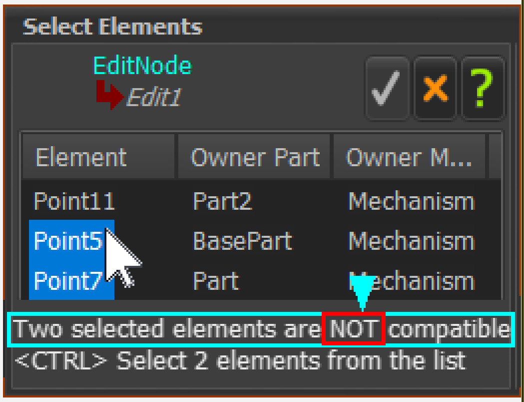
- **Option A**: Two elements are compatible or NOT compatible.
- Yes, you can select **POINT11** and **POINT5**



OPTION B

OR

- **Option B**: Yes, you can select **POINT11** and **POINT7.**



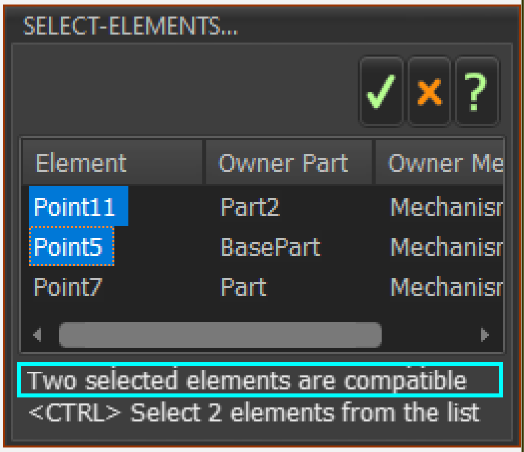
OPTION C

Option C: No, you **cannot** select **POINT5** and **POINT7**.

Why? Because **POINT5** and **POINT7** are joined with a **PIN-JOINT**, already.

Note: In the image to the left, see the word **'not'** in the message that is below the element-box

"**Two selected elements are not compatible**"



Option A

STEP 2: To confirm again, select the TWO Points:

1. 

key down
2. Click the two **POINTS** you want to use for the **PIN-JOINT**
3. 

key up

The ✓ colorizes **only** when you select the elements that are compatible .

4. Click ✓ at the top right of the dialog

	The **SELECT-ELEMENTS DIALOG** closes. The **POINTS** (and **completely free-Part**) are coincident, at the new **PIN-JOINT**.

TOP-TIP:

If the **SELECT-ELEMENTS DIALOG** opens, the **ELEMENT** you click first is at the **top** of the list.

Therefore, if I know there will be ambiguity, I click the **ELEMENT** that I know I need to select before the elements that cause the ambiguity. Then, when the **SELECT-ELEMENTS DIALOG** open, the element I click first will at the top of the list.

VIDEO - Add Pin-Joint - Special-Case:

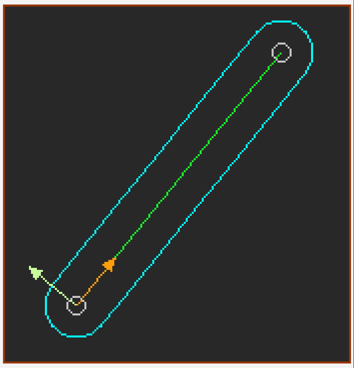
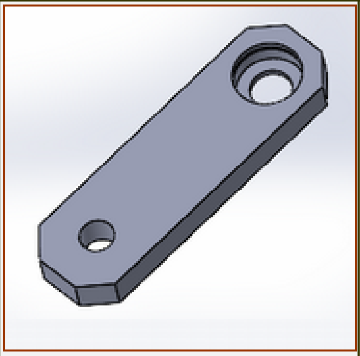
Double-click to Video

1.5.5.1.2.3 Add Part

Part

See also: Edit Part 259

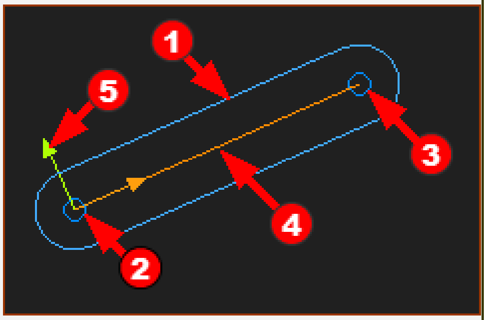
Part Images

 Part in MechDesigner	 A Part in SOLIDWORKS	 A physical part/link

Terminology

PART :	PARTS represent a fixed or moving component in a machine. Use the Part-Editor 257 to edit the length of the PART, and to add sketch-elements and constraints to the sketch-elements.
BASE-PART :	The PART we add for you. It is the fixed frame for each **Mechanism-Editor**. **Note**: a **Mechanism-Editor** can move with a PLANE that you have added to a moving PART.
Part-Outline :	The **Part-Outline** is the **symbol** you select to edit a PART. **Part-Outlines** have two shapes: • **Oval**: symbol of a PART that you add to the model • **Rectangular**: symbol of the BASE-PART
A PART has **TWO** possible **kinematic-states.**	
Not kinematically-defined :	The state of a PART when it has one or more degrees-of-freedom. Other terms: **Free-Part**, **Completely-Free Part**, a **Part that is not solved**. The **Part-Outline** is approximately Blue
kinematically-defined :	The state of a PART when its **Mobility** is Zero(0). Other term: is a **Part that is solved**. The **Part-Outline** is approximately Green
IMPORTANT: All of the PARTS in your model must be **kinematically-defined** before you can analyze kinematic (motion) and kinetostatic (force) data in your model.	

A Part in the graphics-area.



❶ **Part-Outline**: the symbol of the PART you select to edit the PART with the **PART-EDITOR**

You **cannot** edit the shape of the **PART-OUTLINE**.

❷ **START-POINT** and ❸ **END-POINT** of the PART

❹ **CAD-LINE** from the **START-POINT** to the **END-POINT**

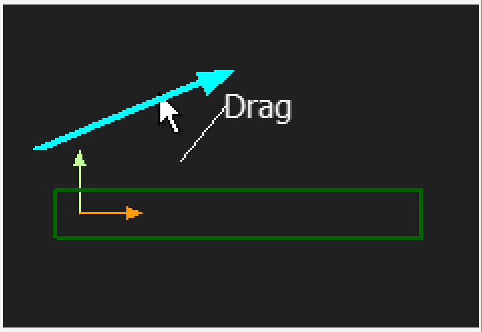
❺ **X-axis and Y-axis**: at the **START-POINT** (origin)

TOP-TIP:

You can hide **PART-OUTLINES** (Display Filters - Part-Outlines).

Select the **Y-axis** to edit the PART.

Add Part



STEP 1. Start the Add Part command

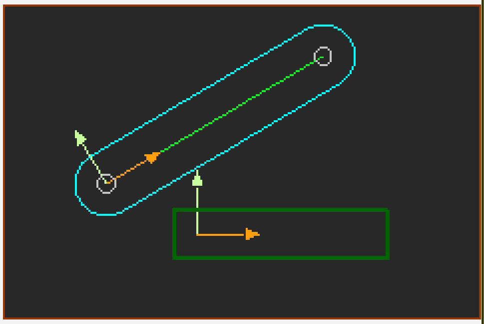
Mechanism menu > Add Part

OR

Kinematic elements toolbar > Add Part

OR

Click the **INSERT** key on your keyboard as a shortcut key



STEP 2. To add the Part

DRAG: in the graphics-area :

Mouse-button down, ... move your mouse, ... mouse-button up.

The PART is now in the graphics-area.

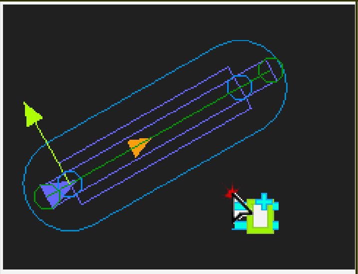
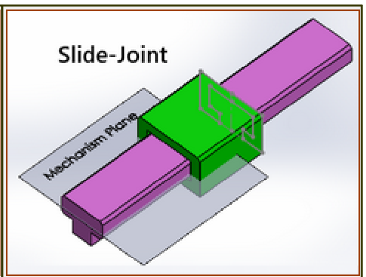
Add Part is **not** a persistent command.

Do **STEP 1** and **STEP 2** again to add a new PART.

Video: Double-click to watch Video Clip

1.5.5.1.2.4 Add Slide-Joint

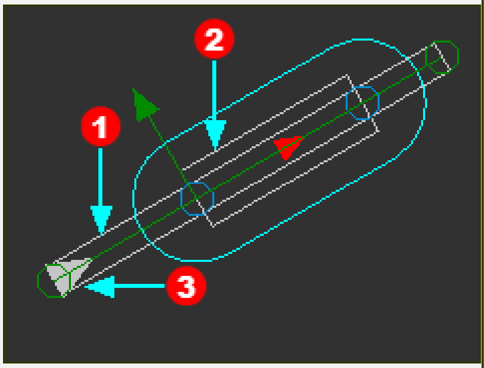
Slide-Joint

		
Slide-Joint in MechDesigner	Slide-Joint - THK	Slide-Joint in SOLIDWORKS

Terminology

SLIDE-JOINT :	A SLIDE-JOINT forces a LINE* in a PART to be collinear with a LINE* in a different PART. A SLIDE-JOINT removes two **degrees-of-freedom** from the model. A SLIDE-JOINT lets a PART move relative to a different PART with a rectilinear translation motion.
Prismatic Joint :	The kinematic and equivalent term for a SLIDE-JOINT.
KINEMATICS-TREE :	Joints in a **Dyad** use the letter **P** to represent a SLIDE-JOINT. - for example: R-R-**P** dyad
* LINE or CAD-LINE.	
Derived Names:	
sliding-Part :	a PART that you join with a SLIDE-JOINT to a different PART.

A Slide-Joint in the graphics-area



Slide-Joint

The symbol for a SLIDE-JOINT:

❶ A **Narrow Rectangle** that is equal to the length of the LINE in one of the PARTS.

❷ A **Wide Rectangle** that is equal to the length of the LINE in the other PART.

❸ An **Arrowhead** that is the **Positive-Direction*** of the SLIDE-JOINT.

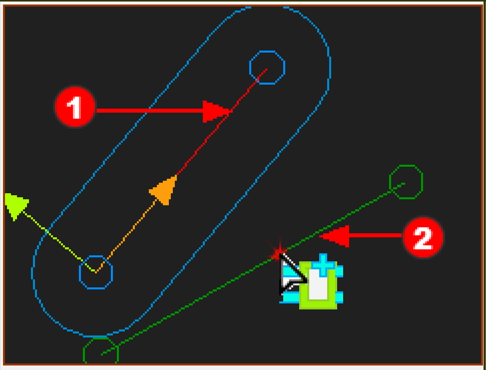
* The **Positive-Direction** is important if you want to add a MOTION-DIMENSION FB to the SLIDE-JOINT.

See Positive direction of Slide-Joints and Motion-Dimension 188 .

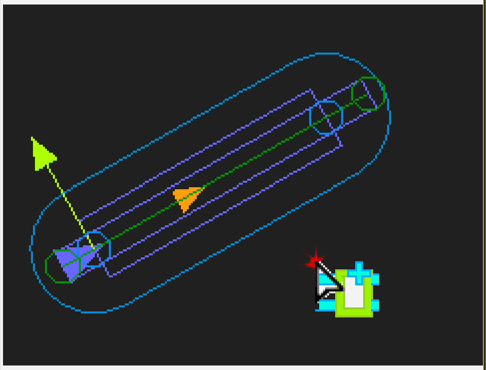
IMPORTANT: To calculate reaction FORCES on a Slide-Joint:

The **length** and **position** of the LINES should be equivalent to actual length and position of the Slide-ways and Bearings.

Add Slide-Joint:



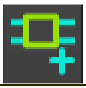
Select two Lines


A New Slide-Joint

STEP 1: Start the Add Slide-Joint command

Mechanism menu > Add Slide-Joint

OR


Kinematic elements toolbar > Add Slide-Joint

STEP 2: Click the two(2) Lines

1. Click a LINE❶ in a **free-Part**
2. Click a LINE❷ in a different PART

The two(2) LINES are collinear at the SLIDE-JOINT.

The **Positive Direction** of the SLIDE-JOINT is identified by the small arrowhead.

If the **SELECT-ELEMENTS DIALOG** opens, see Slide-Joint Special Case 111

VIDEO: Add Slide-Joint - Simple-Case

Double-click to watch: Add Slide-Joints - Simple-Case

Special Case: two(2) or more collinear Slide-Joints

Frequently, a machine design has **two(2)** collinear SLIDE-JOINTS between **three** PARTS.

You must decide which **two(2)** LINES from which of two(2) PARTS you want to select for **each** SLIDE-JOINT.

For example:

There are a total three PARTS. You must add two(2) SLIDE-JOINTS:

SLIDE-JOINT#1 - joins LINES 1 and 2 (in PARTS 1 and 2),

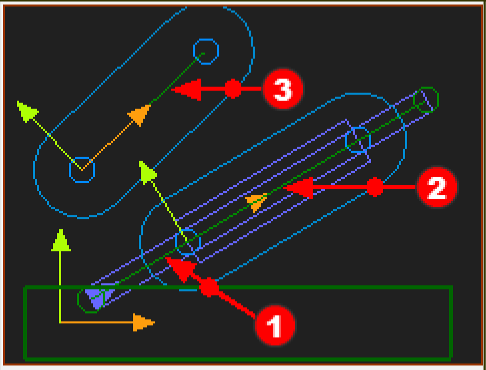
SLIDE-JOINT#2: joins

OPTION A: LINES 3 and 1 (in PARTS 3 and 1)

OR

OPTION B: LINES 3 and 2 (in PARTS 3 and 2)

OPTION A or OPTION B is important when you also add a MOTION-DIMENSION FBS 174 to control the motions of the two(2) PARTS.



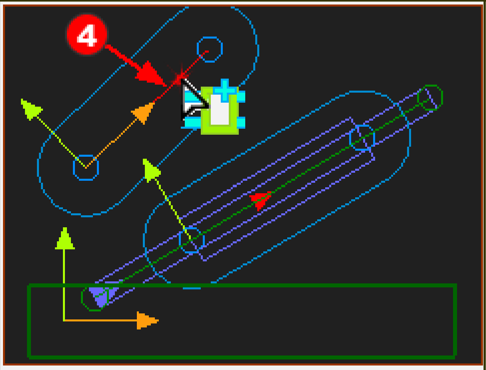
Preparation example:

❶ LINE in the BASE-PART

❷ CAD-LINE along the center of a SLIDING-PART

❸ CAD-LINE in a PART that is COMPLETELY-FREE❸

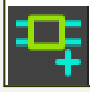
You want to join the PART that is **completely-free**❸ to be collinear with the existing SLIDE-JOINT.



STEP 1: Add Slide-Joint

Mechanism menu > Add Slide-Joint

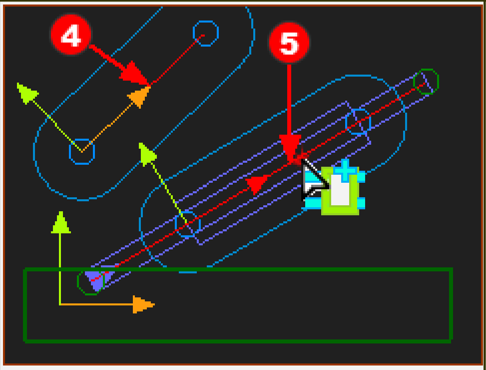
OR



Kinematic elements toolbar > Add Slide-Joint

STEP 2: Select two(2) Lines:

1. Click the CAD-LINE❹ in the COMPLETELY FREE PART.
2. Click LINES ❶❷ at ❺

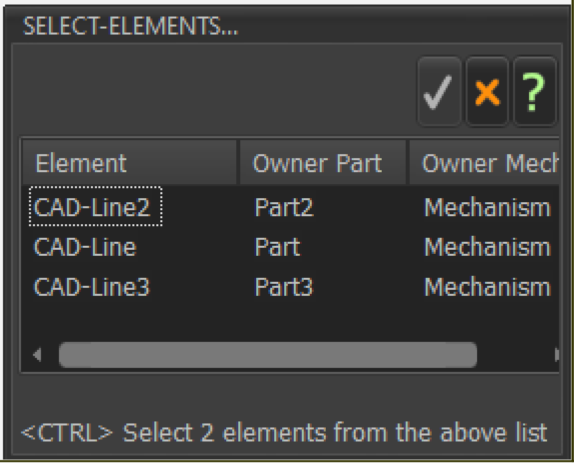


You have clicked a total of **three**(3) LINES.

However, the SLIDE-JOINT is between two(2) LINES.

Therefore, there is **AMBIGUITY**. Which two(2) LINES do you want for the SLIDE-JOINT?

“**AMBIGUITY**” : when **MechDesigner** does not know which elements you want to select.



When there is ambiguity, the SELECT ELEMENTS DIALOG opens.

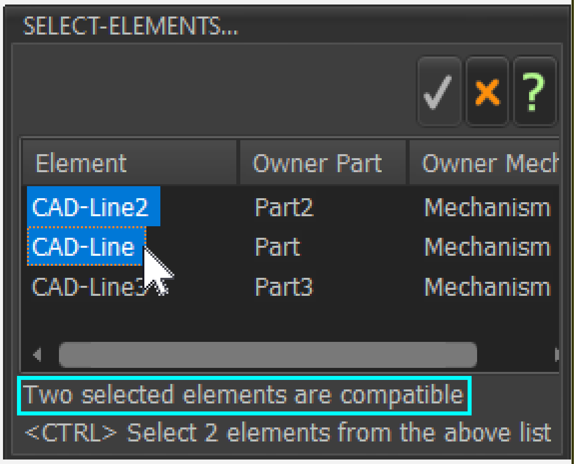
<<< SELECT-ELEMENTS DIALOG

STEP 3: Select the TWO Lines in the Select-Elements dialog

1. Click a LINE (CAD-LINE2) at the top of the Element list (CAD-LINE2)
2. Ctrl key down

AND

3. Click one other LINE in the Element list.



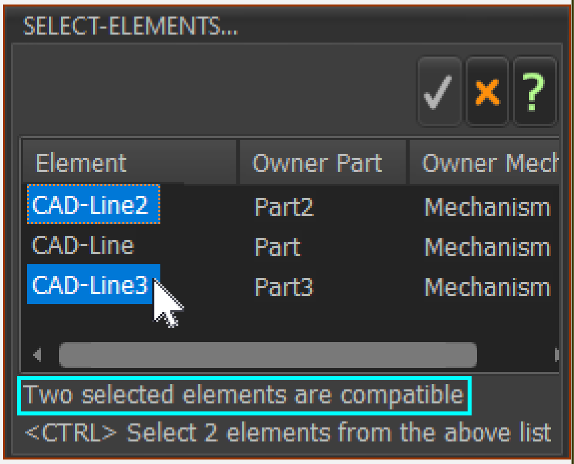
Two Lines are Compatible

You CAN select:

CAD-LINE2 AND CAD-LINE are compatible

OR

CAD-LINE2 AND CAD-LINE3 are compatible



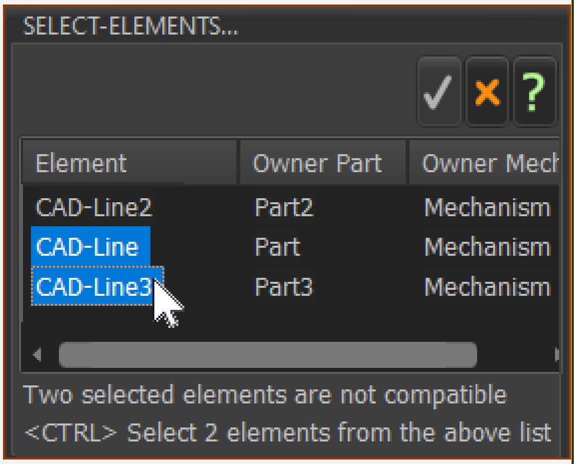
Two Lines are Compatible

You CANNOT select:

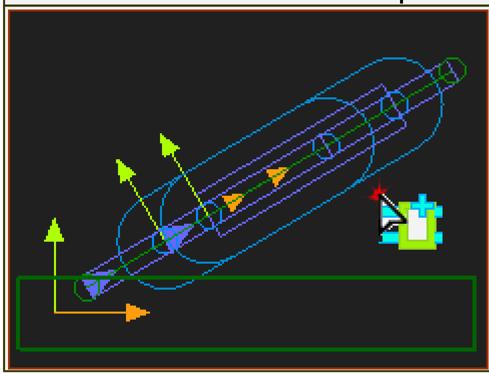
CAD-LINE and CAD-LINE3 are NOT compatible (image below)

Why not CAD-LINE and CAD-LINE3 ?

There is a SLIDE-JOINT between CAD-LINE and CAD-LINE3 already.



Two Lines are NOT Compatible



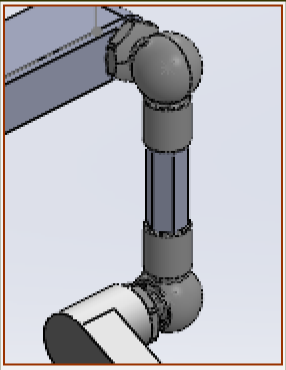
STEP 5: Close the Select-Elements dialog

SELECT-ELEMENTS DIALOG: Click ✓ to close the SELECT-ELEMENTS DIALOG.

There are now two(2) SLIDE-JOINT between three(3) LINES

1.5.5.1.2.5 Add Ball-Joint

Ball-Joint

		
2x Ball-Joints in MechDesigner	Rod-End Bearing	2 x Ball-Joint in SOLIDWORKS

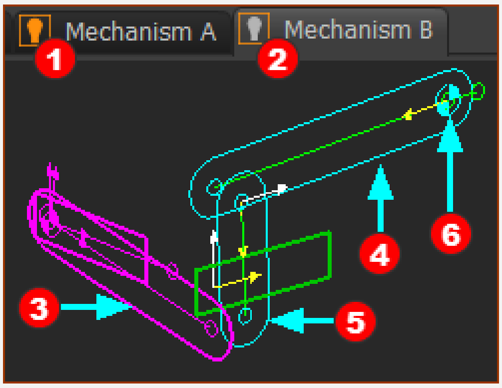
Terminology:

BALL-JOINT :	A **BALL-JOINT** makes a **POINT** in a **Connecting-Part** coincident with a **POINT** in a different **PART**. You must add a **BALL-JOINT** to each end of a **Connecting-Part** : • 1 x **BALL-JOINT** between **POINTS** in different **PARTS** that are in the active **MECHANISM-EDITOR** • 1 x **BALL-JOINT** between **POINTS** in different **PARTS** that are in different **MECHANISM-EDITORS**
Spherical-Joint :	The kinematic and equivalent term for a **BALL-JOINT**.
KINEMATICS-TREE :	**Dyads R-S-S, P-S-S** - the joints in a **dyad** use the letter **S** for a **BALL-JOINT**.
Derived Names:	
Connecting-Part :	A **PART** with a **BALL-JOINT** at its **START-POINT** and at its **END-POINT**.
Part that is Completely-Free :	A **PART** with 3 degrees-of-freedom (no joints).
Part that is Free :	A **PART** with 1 or 2 degrees-of-freedom.

See also: Ball-Joint dialog[559] , Connecting Part Length and Diameter[117] .
See also Ball-Joint configurations

Preparation

A typical preparation:



A typical prepration for Add Ball-Joint

Mechanism A

Usually, **Mechanism A** is perpendicular(⊥) to **Mechanism B**

- PART ❸ is **kinematically-defined** - in the image, PART ❸ is Pink

Mechanism B - the active MECHANISM-EDITOR

Three PARTS:

1 x PART is usually the BASE-PART - it is **kinematically-defined**.

2 × PARTS❹❺ are not **kinematically-defined**.

- PART ❹ is a PART that is **free**. It has a PIN-JOINT to join it to the BASE-PART.
- PART ❺ is a PART that is **Completely Free**. It does not have any joints before you do Add Ball-Joint.

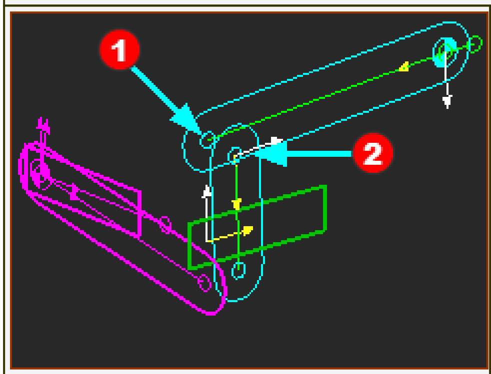
Notes:

The MECHANISM-EDITORS cannot be parallel to each other. They are usually perpendicular(⊥) to each other.

As you add the PART that is **Completely-Free**, try to estimate its length. If it is too short or too long, the BALL-JOINTS cannot join the **Completely Free** PART to PART❹ and PART❸ - you do not get the expected result.

Add Ball-Joint × two(2)

Do Add Ball-Joint two(2) times. One time to each end of the COMPLETELY FREE PART.



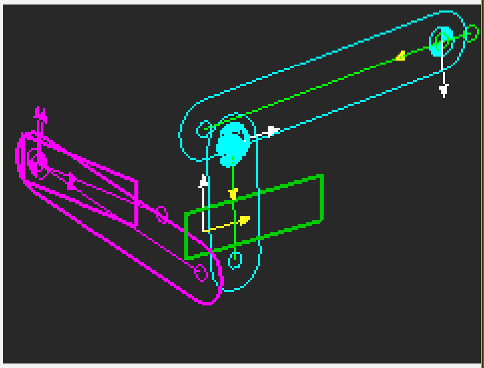
STEP 1: Start the Add Ball-Joint command

Mechanism menu > Add Ball-Joint

OR


Kinematic elements toolbar > Add Ball-Joint

STEP 2: Add Ball-Joint #1



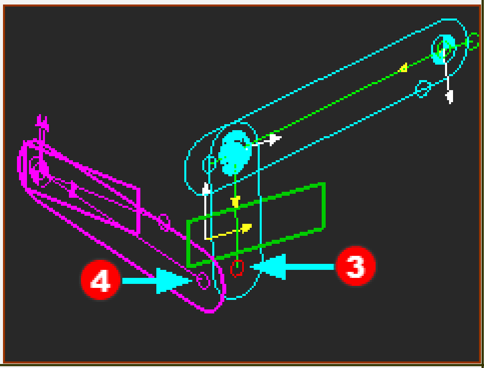
MECHANISM-EDITOR **B** is active.

1. Click POINT❶ at the end of the PART that is **Completely-Free**
2. Click POINT❷ at the end of the PART that is **Free**.

If you cannot select the POINTS to add a BALL-JOINT, disable the Auto-Update tool[49] , and try again.

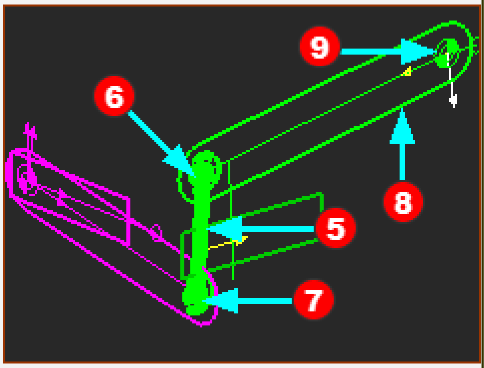
After you do **Add Ball-Joint #1** you can see the **Ball-Joint symbol**.

However, POINTS❶❷ **do not** snap together. You must do **Add Ball-Joint #2**.



STEP 3: Add Ball-Joint #2

1. Click POINT❸ at the other end of the PART that is **Completely-Free**
2. Click POINT❹ - the Pink Point - at the end of the PART that is **kinematically-defined** in MECHANISM-EDITOR(**A**)

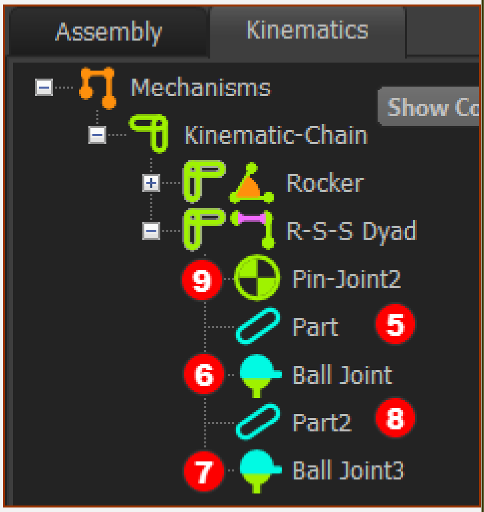


RESULT - Graphics-Area

The BALL-JOINTS❻❼ snap to the POINTS in MECHANISMS **A** and **B**.

The PARTS that were **Completely-Free** and **Free** are now **kinematically-defined**❺❽

If the arrangement of the PARTS that were **Completely-Free** and **Free** is not correct, then see Change-Dyad Closure[119]



RESULT - Kinematics-Tree

In the KINEMATICS-TREE[318] ,

There is a new **Dyad** - the **R-S-S** dyad.

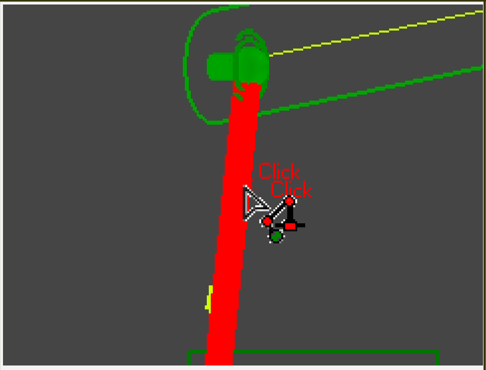
The three Joints in the **Dyad** are:

- PIN-JOINT 9 is the **R** joint - **R** is for **Revolute-Joint**
- BALL-JOINTS 6 7 are the **S** Joints - **S** is for **Spherical-Joint**

Connecting-Part: Edit Length, Rod Diameter, Ball-Diameter

Notes:

- You cannot add **SOLIDS** to **Connecting-Parts**.



To edit the LENGTH of the CONNECTING-PART

1. **MECHANISM-EDITOR**: Double-click the symbol for the **Connecting-Part**

It is now open in the **PART-EDITOR**.

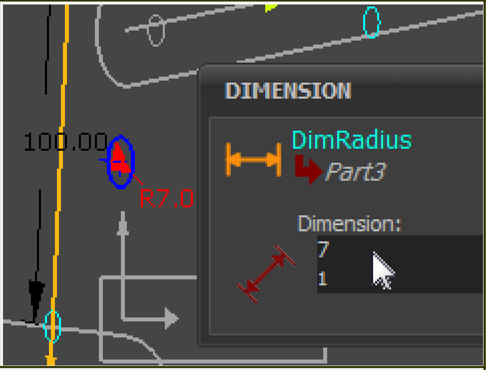
2. **PART-EDITOR:** Edit the Length dimension of the **Connecting-Part**
3. Exit the **PART-EDITOR**

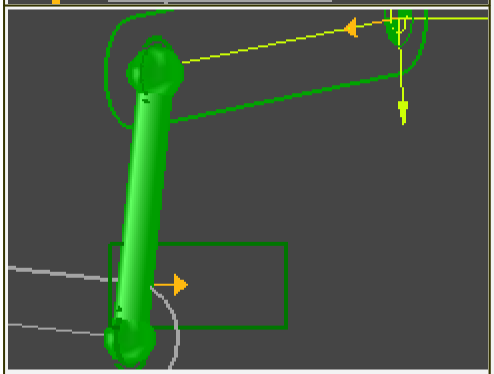
To edit the SYMBOLIC RADIUS of the CONNECTING-PART

1. **MECHANISM-EDITOR**: Double-click the symbol for the **Connecting-Part**

It is now open in the **PART-EDITOR**.

2. **PART-EDITOR:** Add a LINE or CIRCLE
3. **PART-EDITOR:** Add a dimension to the LINE or CIRCLE
4. Exit the **PART-EDITOR**





The dimension of the LINE or CIRCLE is the Radius of the **Con-necting-Part**.

To edit the symbolic diameter of the BALL-JOINT - see Ball-Joint dialog 559

Notes:

In the **PART-EDITOR**, when the view is not the **Front View**, the CAD-LINE, **Axes**, sketch-elements and dimensions may show in unusual places! If you cannot add or edit a dimension: do **View toolbar > Front Plane (F3)**

To see the symbol of the BALL-JOINT: enable **Visibility toolbar > Show Solids in Mechanisms** 66

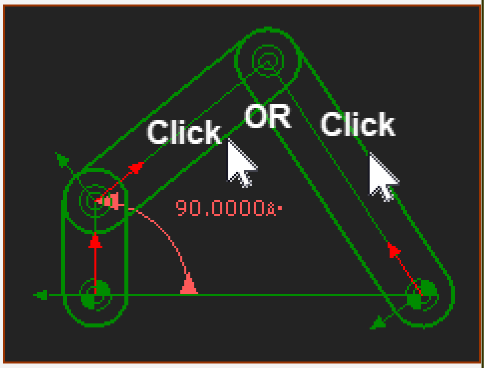
1.5.5.1.2.6 Change Dyad Closure

Change Dyad Closure / Change Configuration Assembly of a Dyad

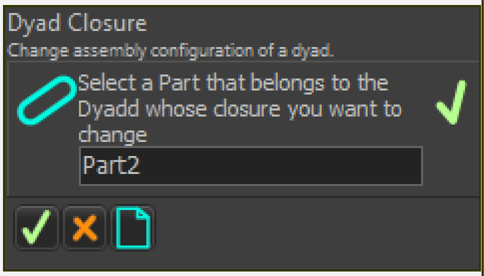
Terminology

Dyad :	A **dyad** is an assembly of **two** PARTS and **three** joints. Each Joint can be a SLIDE-JOINT, a PIN-JOINT, or a BALL-JOINT. - One joint joins the two PARTS together - The other two joints join the two PARTS to two other PARTS that are **kinematically-defined**. The two PARTS in a **dyad** are **kinematically-defined**.
Assur Groups :	A different name for a **dyad**.
Dyad Closures :	The different ways you can assemble the two PARTS of a **dyad**
“**Configuration of the Dyad's Assembly**” is a different way to express “**Dyad Closure**”.	
Types of Dyad :	Planar Dyads: R-R-R, R-R-P, R-P-R*, R-P-P, P-R-P Spatial Dyads: S-S-R, S-S-P
R :	Revolute Joint = <u>Pin-Joint</u> [102]
P :	Prismatic Joint = <u>Slide-Joint</u> [110]
S :	Spherical Joint = <u>Ball-Joint</u> [114]
*	This **dyad** does not correctly change its closure if the PIN-JOINT(R) are offset from the SLIDE-JOINT and along the **y-axis** of each PART in the dyad.
See more: Dyads	

Change Dyad Closure



RRR Dyad
Closure 1

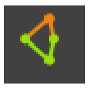


Command-Manager: Change Dyad Closure

STEP 1: Start the Change Dyad Closure command

1. Mechanism menu > Change Dyad Closure

OR



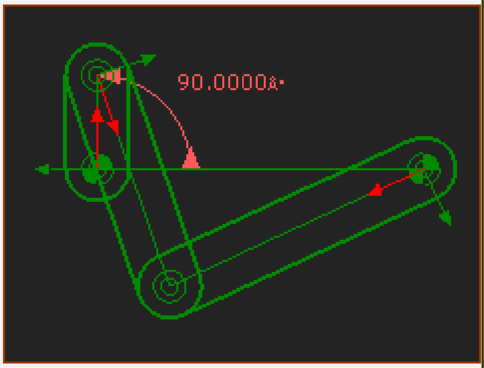
1. Kinematic elements toolbar > Change-Dyad Closure

The COMMAND-MANAGER indicates you must select a PART in the **Dyad**.

STEP 2: Select one Part in the Dyad

2. Click the PART-OUTLINE of a PART in the **Dyad** whose assembly-configuration (Dyad-Closure) you want to change.

STEP 3: Complete the Command



RRR Dyad
Closure 2

3. Click ✅ in the COMMAND-MANAGER

The configuration of the assembly (Dyad Closure) should now be different.

<<< compare the bottom image with the top image.

STEP 4: Do again, if needed

4. If necessary, do **1 to 3** again and again to find the configuration of the assembly you want to apply to your design.

Top-Tip:

When there are many **dyads** in the model, it is sometime difficult to see which **dyad** whose closure you need or want to change.

1. **KINEMATICS-TREE**: Click to expand each **Kinematic-Chain** in the KINEMATICS-TREE
2. **KINEMATICS-TREE**: Click each **dyad**

The color of the five elements in the dyad (**2** PARTS + **3** JOINTS) change to the SELECTED COLOR (usually red) in the graphics-area.

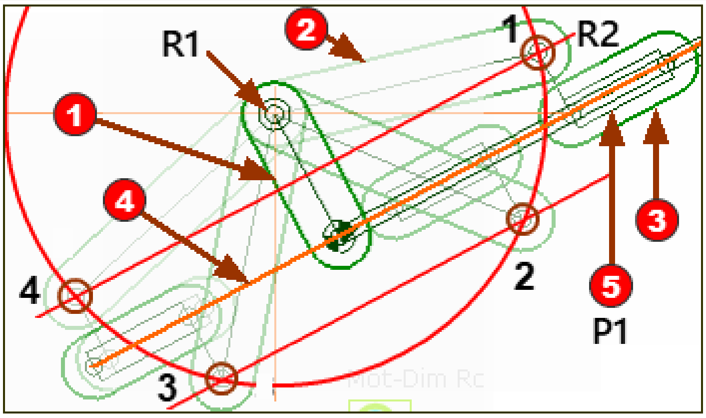
Assembly-Configurations of the R-R-P Dyad

The joints in the **R-R-P** Dyad are: **Revolute – Revolute – Prismatic.**

In **MechDesigner**, the joints are: **Pin-Joint – Pin-Joint – Slide-Joint**.

There are 4 possible assembly configurations (Dyad Closures) for this **dyad**.

The image below shows an Offset-**Slider-Crank** mechanism.



4 x Assembly Configurations of an Offset-Crank-Slider

PART❶ is the **Crank** - to illustrate the 4 dyad closures. The **Crank** is not in the Dyad.

Dyad: The PARTS in the **R-R-P dyad** are PARTS ❷ and ❸.

To imagine the four assembly-configurations, we imagine we have not yet added the **PIN-JOINT** (R2) between **PART❷** and **PART❸**.

PART❷ : can rotate around the **PIN-JOINT**, **R1**, at the end of the **Crank**.

Therefore, **PIN-JOINT** **R2** can **ONLY** be on the **red circle** at the end of **PART ❷**.

PART❸ : can only slide along the **SLIDE-JOINT**, **P1**, along **LINE❹**.

IMPORTANT: The **POINT** in **PART❸** for **PIN-JOINT** (**R2**) is **offset** from the **SLIDE-JOINT** and **not on** the **SLIDE-JOINT**.

Therefore, **PIN-JOINT** **R2** can **ONLY** be on one of the **red lines** that are offset from the **SLIDE-JOINT**.

The **red circle** intersects the **red lines** at 4 places.

Therefore, the **PIN-JOINT** **R2** can be at 4 places.

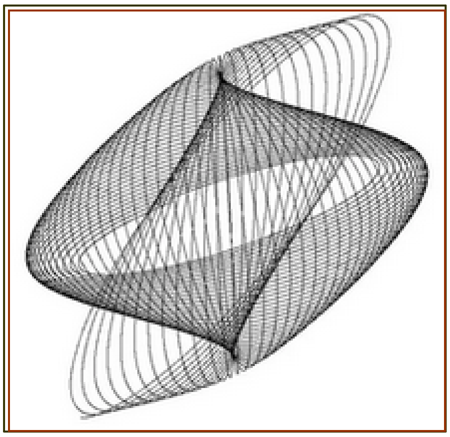
Therefore, the **Offset Slider-Crank** and the **R-R-P** dyad has 4 possible assembly configurations (Dyad Closures).

1.5.5.1.2.7 Add Trace-Point

Trace-Point

Terminology:

TRACE-POINT :	the locus, or path, of a moving **POINT*** relative to the **MECHANISM-PLANE** for one machine-cycle.
* POINT, **START-POINT**, **END-POINT**, **CENTER-POINT**, **MOTION-POINT**	



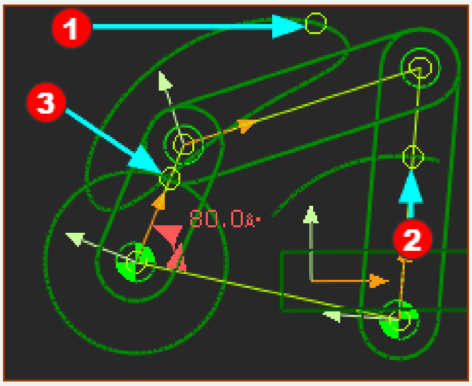
Add Trace-Point

Add Trace-Point does NOT add a **POINT** to your model.

You must select a **POINT** * that is already in your model.

---

* POINT, **START-POINT**, **END-POINT**, **CENTER-POINT**, **MOTION-POINT**.



Three example Trace-Points

STEP 1: Start the Add Trace-Point command

1. Mechanism menu > Trace-Point

OR

1. Kinematic elements toolbar > Add Trace-Point

STEP 2: Click a Point

2. Click a **POINT*** in the graphics-area.

For example, in the image, POINTS ❶❷❸

* **START-POINT**, **END-POINT**, **CENTER-POINT**, POINT, or **MOTION-POINT**

See below: How to drag a Point with a Trace-Point. 123

If the SELECT-ELEMENT DIALOG 616 opens, you have clicked more than one POINT.

1.a. **CTRL + click** a **POINT** in the **SELECT-ELEMENTS DIALOG**

1.b. Click ✅ to close the **SELECT-ELEMENTS DIALOG**

STEP 3: Complete the command

3. Click ✅ **in the Command-Manager**

The **TRACE-POINT** is now in the graphics-area.

Video:

Double-click to watch Video

How to **drag** a Trace-Point

Normally, when the **MECHANISM-EDITOR** is active, you cannot drag a sketch-element.

However, as a special-case, you can move a **POINT**** with a **TRACE-POINT**, if the Point does not have any constraints.

In this special case, it is easier to search for a "good" **TRACE-POINT**.

** NOT a **START-POINT**, **END-POINT**, **CENTER-POINT** or **MOTION-POINT**

To drag a **POINT** in the **MECHANISM-EDITOR**:

In the **PART-EDITOR**:

1. Do **Add Point**

   Do **not** add a dimension or a constraint to the **POINT**

2. Exit the **PART-EDITOR**

In the **MECHANISM-EDITOR**:

3. Do **Add Trace-Point** and select the **POINT**
4. Drag the **POINT**!

Note:

To make it easier to drag the **POINT**:

- Reduce the **NUMBER-OF-STEPS** to ~60 - see Machine Setting dialog 56

and / or

- Drag the **POINT** but do not lift your mouse-pointer until the **TRACE-POINT** also moves

To add a Trace-Point of a Point relative to a Part that is NOT the Base-Part

A **TRACE-POINT** is the locus of a **POINT** in a moving **PART** relative to the **BASE-PART**. To see the locus of a **POINT** in a moving **PART** relative to a different moving **PART**, you can add a **2D-CAM**, and show only the path of the **PITCH-CENTER**.

1. Edit the **PART** with the **POINT** whose locus you want to see relative to a moving **PART**.

2. Add a CIRCLE, and add a **Coincident** constraint between the CENTER-POINT of the CIRCLE and the POINT.
3. Exit the PART-EDITOR
4. Add a PROFILE to the CIRCLE

Add 2D-Cam - you must select two elements:

5. **Cam-Part**: Select the PART in which you want to show the locus of the POINT
6. **Follower Profile**: Select the PROFILE of the CIRCLE

To show the locus of the POINT

7. Edit the 2D-CAM.
8. In 2D-CAM DIALOG > **Display tab** > CAM-VISIBILITIES > **Enable** PITCH-CENTER.

The locus of the PITCH-CENTER is the locus and TRACE-POINT of the POINT relative to the **Cam-Part.**

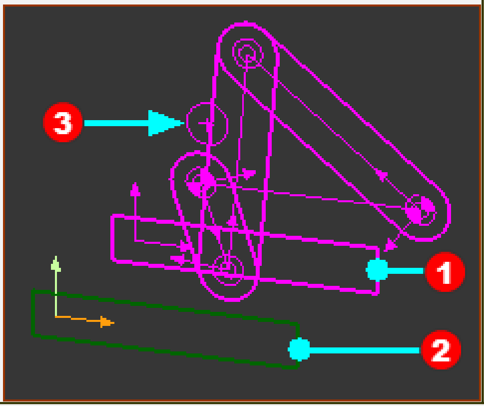
1.5.5.1.2.8 Add Reference Geometry

Reference Geometry

Terminology:

Reference Geometry :	General term for a sketch-element that we copy from a different MECHANISM-EDITOR to the active MECHANISM-EDITOR.
Source Sketch-Element :	A sketch-element, in a moving or stationary PART, in a **different MECHANISM-EDITOR**.
Reference Sketch-Element :	A copy of the **Source sketch-element, and its motion,** to a PART in the **active** MECHANISM-EDITOR.

Preparation



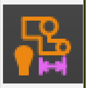
Preparation example:

Two(2) MECHANISM-EDITORS:

- Source ❶
- Reference ❷ - the active editor

In the image, there is a CIRCLE❸ in the "source MECHANISM-EDITOR".

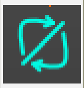
To see the sketch-elements and PARTS in the "source MECHANISM-EDITOR" when the "reference MECHANISM-EDITOR" is active:



- **Visibility toolbar** (or **menu**) > Show other Kinematic and Sketch elements[63]

AND

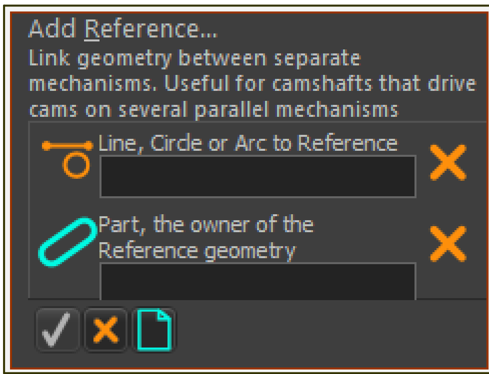
- Right-click MECHANISM NAME-TAB of the "Source MECHANISM-EDITOR" and select Show with 'other Kinematic and Sketch elements'[63] .



AND

- **View toolbar** > **Spin** or use your arrow keys on your keyboard to spin the model to see the two editors.

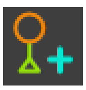
Add Reference Geometry

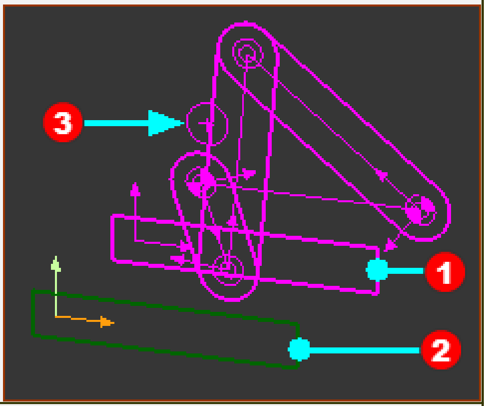


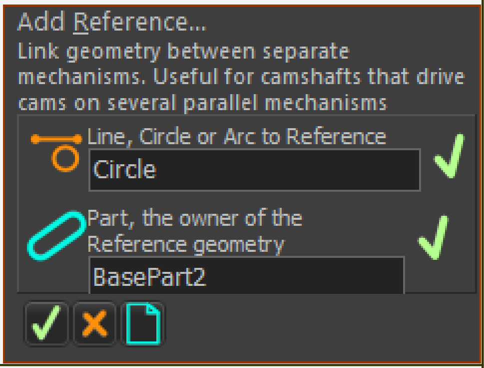
STEP 1: **Start the Add Reference-Geometry command**

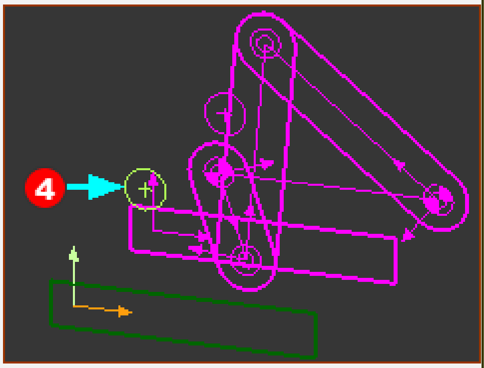
1. **Mechanism menu > Add Reference Geometry**

OR









1. Kinematic elements toolbar > Add Reference Geometry

The **COMMAND-MANAGER** indicates you must select two(2) elements

STEP 2: Select the two elements in the graphics-area

1. Click a sketch-element in the Source **REFERENCE-EDITOR**.

e.g. Click the **CIRCLE**❸ in the Source **MECHANISM-EDITOR**❶.

2. Click a **PART** in the Reference **MECHANISM-EDITOR**

In this case there is only one **PART** - the **BASE-PART** - in the Reference **MECHANISM-EDITOR**.

STEP 3: Complete the Command

4. **Click ✓ in the COMMAND-MANAGER.**

RESULT :

The **REFERENCE GEOMETRY**❹ is now in the reference **MECHANISM-EDITOR**.

We also transfer the motion of the sketch-element from the source **MECHANISM-EDITOR**❸ to the reference **MECHANISM-EDITOR**.

Video:

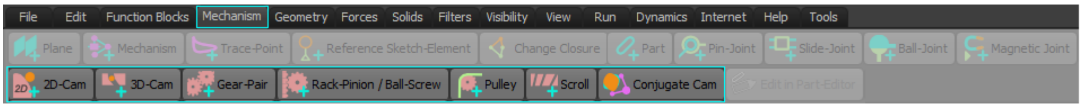
Double-click to watch Video Clip

1.5.5.1.3 Machine elements

Machine elements

Machine elements are the hardware components that you install on industrial machines.

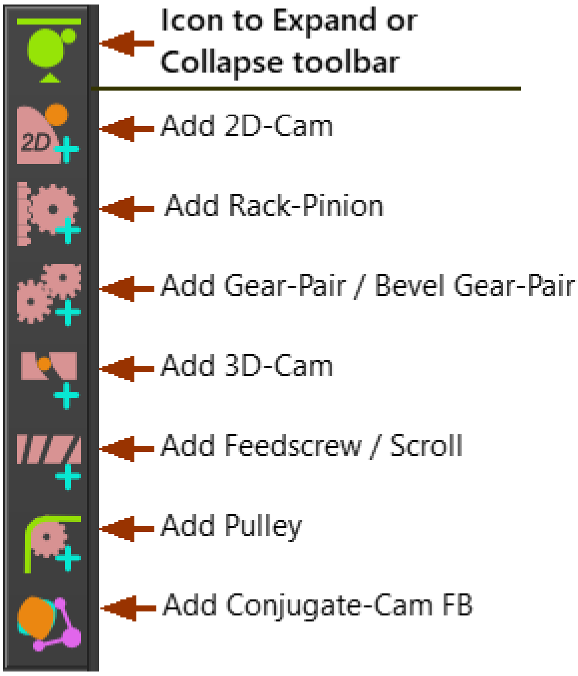
Mechanism menu > Machine elements



Mechanism menu > Machine elements (MD17)

Machine elements toolbar

The **Machine elements toolbar** is to the **left** of the graphics-area.



Machine elements toolbar

1.5.5.1.3.1 Add 2D Cam

2D-Cam

See also: 2D-Cam dialog 401

Add 2D-Cam does NOT remove a degree-of-freedom from the model.

We calculate for you the shape of a **2D-CAM** from the relative motions of a **Cam-Part** and a **Follower-Part**, together with the shape of the **Follower-Profile**.

Add the **Cam-Part**, **Follower-Part**, and **Follower-Profile** to the model before you do Add 2D-Cam.

Cam-Terminology / 2D-Cam Work-flow

Cam Terminology

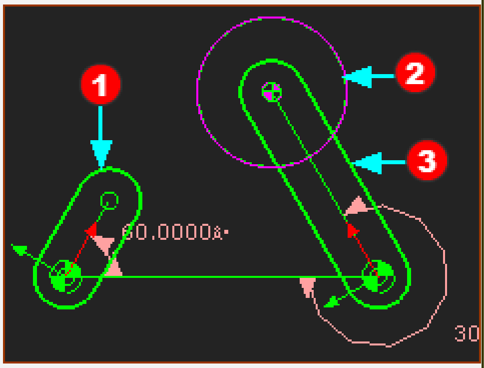
Terms :	Definitions
Cam (or **Cam-Part**) :	The PART to which you add the (2D-CAM) to generate the shape of the **Cam-Profile.**
Cam-Shaft :	The most common **Cam-Part**. It is a **rotating-Part** (a shaft), to which you add the 2D-CAM (or 3D-CAM) as a **Cam-Profile**. A **Cam-Shaft** usually rotates with a constant angular-velocity.
Cam-Profile :	The Cam-Flank and surface that is an extrusion of a 2D-CAM (or 3D-CAM) which is in continuous contact with the **Follower-Profile**.
Track-Cam or **Groove-Cam :**	A groove that is cut into a **Cam-Blank** with an Outer and an Inner **Cam-Profile**. A **Follower-Roller** fits in the groove.
Follower (or **Follower-Part**) :	The PART that supports the **Follower-Profile**.
Follower Kinematic-Chain (or **Kinematic Mechanism**) :	The **Follower-Part** and the other PARTS that you join to the **Follower-Part**, to move the **Tooling** or **Tool-Part**.
Follower-Profile :	The surface of a machine component that is rigidly connected to the **Follower-Part**. The surface is in continuous contact with the **Cam-Profile**.
Follower-Roller :	A **Follower-Profile** that is cylindrical or barrel-shaped that is rigidly connected to the **Follower-Part**.
Flat-faced Follower :	A **Follower-Profile** that is a flat surface that is rigidly connected to the **Follower-Part**.
Translating Follower :	A **Follower-Part** that that moves along a straight axis.
Reciprocating Motion :	A **Translating Follower** with a non-progressive motion.
Rotating Follower :	A **Follower-Part** that rotates about a fixed axis.
Oscillating Motion :	A **rotating-Part** with a non-progressive motion.

Terms :	Definitions
Progressive Motion :	A motion, usually followed by a Dwell, that moves the **Follower-Part** progressively in one direction.
Non-Progressive Motion :	A motion that returns the **Follower-Part** to its original position after each machine cycle.
Indexing :	A **progressive motion**, usually rotating.
Indexer :	A device whose input is a constant-speed (usually) **Cam-Shaft** and output is a rotating-Part with a **progressive motion**. The input rotates one time to index the output one time. The index-angle is such that 360°/(Index-Angle) is an integer.
Cam-Blank :	The material from which you cut the shape of the **Cam-Profile**.

Cam Work-flow

Action	Help Topic
1. Add a **2D-Cam**	see Add 2D-Cam 128
If the new **2D-CAM** is one of a pair of **Conjugate-Cams**, or it is one flank of a **Groove-Cam**:	
1.a. Add a **CONJUGATE-CAM FB**	see Add Conjugate Cam FB 165
1.b. Edit the **CONJUGATE-CAM FB** to select the two **2D-CAMS**.	see Conjugate-Cam dialog 436
2. Select a **2D-CAM** or a **CONJUGATE-CAM FB** as the Power Source for the kinematic-chain that includes the Follower	see Configure-Power Source 589
3. Review the **2D-CAM** : **Display, Properties, Roller-Life, Cam-Life, ...**	see 2D-Cam dialog 401
4. Add a **Cam-Data FB**	see Add Cam-Data FB 199
5. Edit the **CAM-DATA FB** to link it to a **2D-CAM** - close the dialog	see Cam-Data dialog 440
6. Connect wires from the output-connectors of the **CAM-DATA FB** to a **GRAPH FB**	
7. Analyze the **2D-CAM**	see Cam-Data dialog : Cam Analysis 440
8. Edit the **CAM-DATA FB** again to calculate the Cam's Coordinates	see Cam-Data dialog : Cam-Coordinates 446

Prepare to add 2D-Cam (typical):



Preparation for Add 2D-Cam

The elements you need in the model before you can do Add 2D-Cam:

Cam-Part ❶ - any PART that is **kinematically-defined**

Follower-Part ❸ - any other PART that is **kinematically-defined**

Follower-Profile ❷ - a PROFILE in the **Follower-Part**❸

The **Cam-Part** usually moves, but it may be stationary.

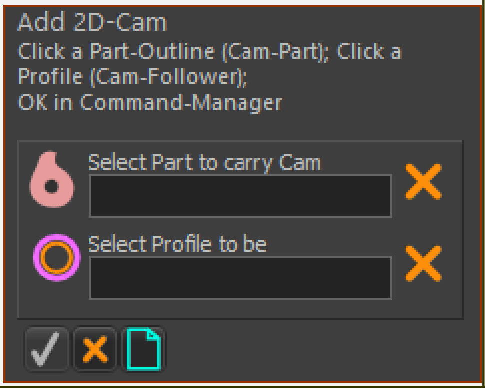
The **Follower-Part** usually moves, but it may be stationary.

The **Cam-Part** and the **Follower-Part** must move relative to each other.

The **Cam-Part** and **Follower-Part** are usually in different **kinematic-chains**, but they may be in the same kinematic-chain.

See also Follower-Profile Shapes.

Do Add 2D-Cam:



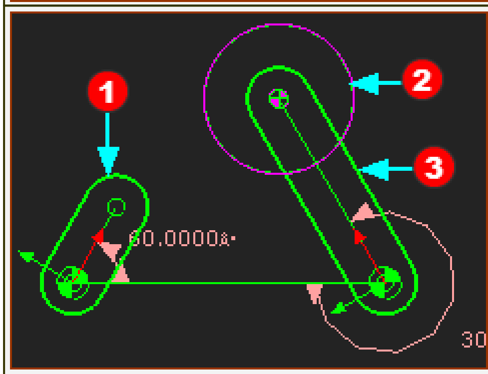
STEP 1: Click Add 2D-Cam

1. Mechanism menu > Add 2D-Ca

OR

1. Machine-elements toolbar > Add 2D-Cam

The COMMAND-MANAGER indicates you need to select two elements.



STEP 2: Select the two elements

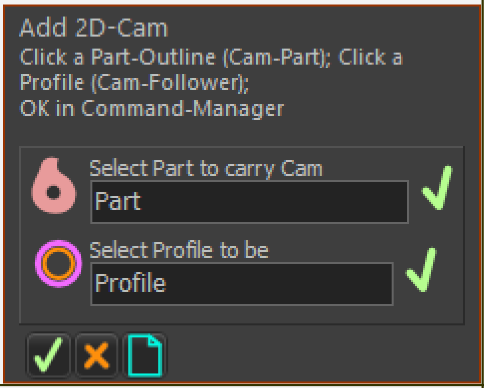
Element 1 is the PART to which you want to add the 2D-CAM - the **Cam-Part**.

1. Click the PART-OUTLINE ❶ in the graphics-area, or the PART element in the ASSEMBLY-TREE

Element 2 is the **Follower-Profile** in the **Follower-Part**.

2. Click the PROFILE❷ in the graphics-area or the PROFILE element in the **ASSEMBLY-TREE**

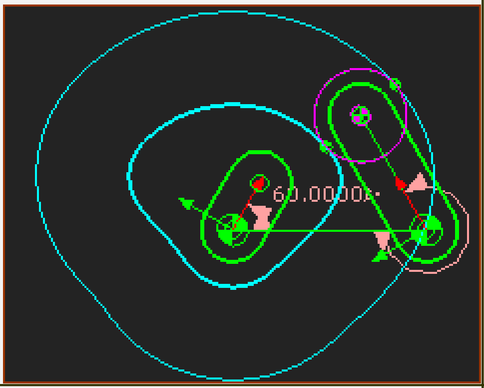
Typically, the **Follower-Profile** is a **Follower-Roller** or a **Flat-Faced Follower**.



STEP 3: Complete the Command

3. **Click ✔ in the COMMAND-MANAGER.**

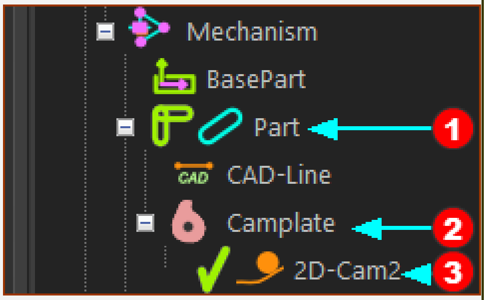
It may be necessary to do Rebuild Now - see **Quick Access menu**



RESULT :

Graphics-area

The **INNER** and **OUTER 2D-CAMS** show in the graphics-area.



RESULT :

Assembly-Tree

A **Cam-Plate**❷ as a child to PART ❶ (**Cam-Part**).

The 2D-CAM❸ is a child to the **Cam-Plate**❷.

The icon for the 2D-CAM element in the **ASSEMBLY-TREE** may warn you that it is a "**Bad Cam**".

We warn you that a 2D-CAM is a "**Bad Cam**" when its minimum **Radius-of-Curvature** is less that than a preset percentage of the radius of the **Follower-Roller**. There is a default percentage and a percentage we can set for a each 2D-CAM.

Default Percentage - **see** **Application-Settings** [341]

Each 2D-CAM - **see** **2D-Cam dialog > Cam Range and Radius** [403]

YOU must make sure the cam is suitable for your needs, even if it is a "Good Cam".

"Good Cam"

"Bad Cam"

Next Steps: see 2D-Cam Work-Flow[128] .

Video (EN):

Double-click to watch Add a 2D-Cam

1.5.5.1.3.2 Add 3D Cam

3D-Cam

See also: 3D-Cam dialog 384

Add 3D-Cam does NOT remove a degree-of-freedom from the model.

We calculate for you the shape of a 3D-CAM from the relative motions of a **Cam-Part** and **Follower-Part**, together with the shape of the **Follower-Profile**.

You must also add the shape of the **Cam-Blank** and its **rotating-axis**. The elements are in different 3 or 4 MECHANISM-EDITORS.

We recommend you do Tutorial 6C: Barrel and Globoidal Cams before you use this command the first time.

Terminology

3D-CAM :	A 3D-CAM has complex and twisting Cam-Surfaces (Cam-Flanks) that interact with **Follower-Rollers**. The rotating-axis of the **Cam-Part** is not parallel with the rotating-axis of the **Follower-Part**.

There many variants of a 3D-CAM.

Barrel, **Cylindrical**, and **Globoidal Cams** are different types of 3D-CAMS.

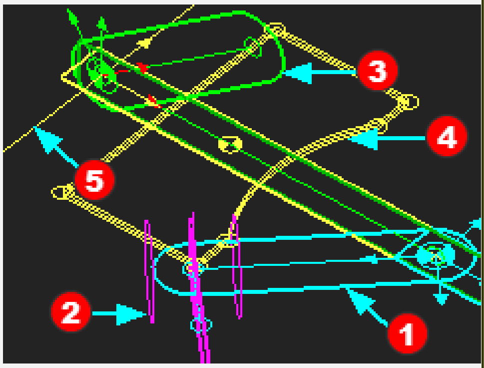
Globoidal Cams are also known as **Roller-Gear-Drives** and **Ferguson Cams**.

There are also **Face**, **Groove**, and **Rib** types. The CAM-PART, or the FOLLOWER-PART, can be stationary. or rotate with a constant, or a non-constant angular-velocity.

Prepare for Add 3D-Cam (typical)

ALL PARTS are kinematically-defined before you do Add 3D-Cam.

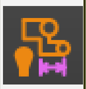
You must select 5 elements, from 3 or 4 MECHANISM-EDITORS.



The five elements are:

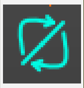
1. PART : **Follower**
2. PROFILE : **Follower-Roller**
3. PART : **Cam** (in the active MECHANISM-EDITOR)
4. PROFILE : **Cam-Blank**
5. LINE : **Cam-Blank Rotational-Axis**

To see the five elements in the graphics-area:

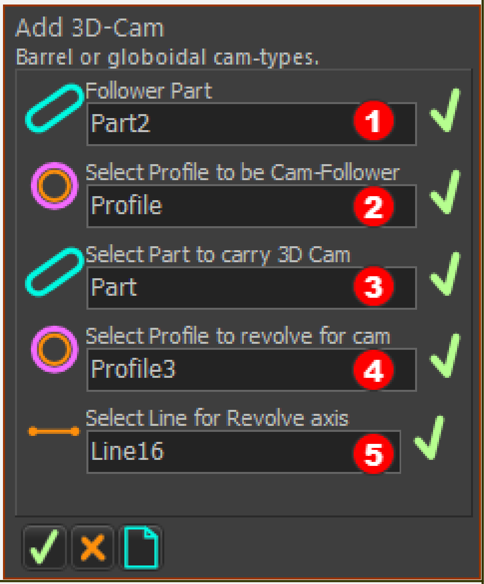


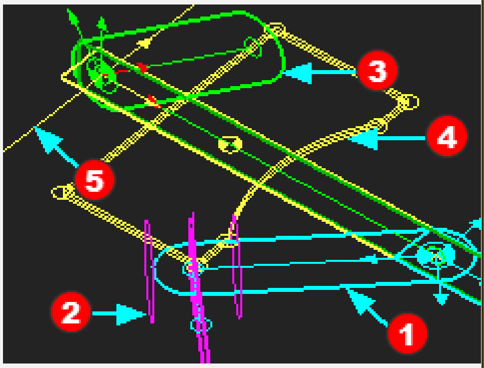
- **Visibility toolbar** (or **menu**) > Show other Kinematic and Sketch elements 63

AND

	• Right-click the **Mechanism name-tab** of each MECHANISM-EDITOR and click Show with 'other Kinematic and Sketch elements' 63 .
	AND • **View toolbar > Spin**, or use your arrow keys on your keyboard, to spin the model to see the 5 elements in the 3 or 4 MECHANISM-EDITORS.
	It is also easier if you hide SOLIDS: Deselect : Visibility toolbar (or menu) > Show Solids in Mechanisms 66

Add 3D Cam





Elements to add a 3D-Cam:

STEP 1: Click Add 3D-Cam

1. **Mechanism menu > Add 3D-Cam**

OR

1. **Machine-elements toolbar > Add 3D-Cam**

There are five elements to select in the COMMAND-MANAGER.

STEP 2: Click the five elements in the graphics-area or Assembly-Tree.

❶ PART: **Follower**: the Cyan PART-OUTLINE

❷ PROFILE: **Follower-Roller**: the Pink PROFILE

❸ PART: **Cam**: the Green PART-OUTLINE in the **active Mechanism-Editor**

❹ PROFILE: **Cam-Blank Profile**: the Yellow Profile (contour)

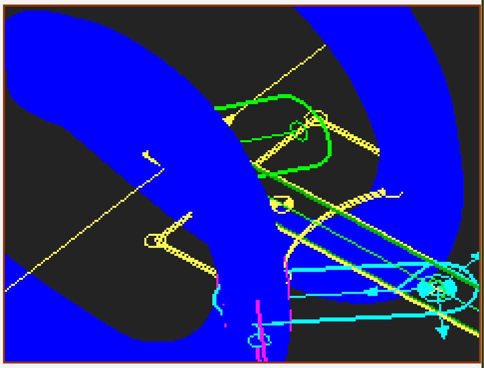
❺ LINE: **Cam-Blank Rotational Axis**: the Yellow Line

STEP 3: Complete the command

1. Click ✓ in the COMMAND-MANAGER.

STEP 4: Edit and save the 3D-Cam

1. Open the 3D-Cam dialog 384

	Edit the 3D-CAM parameters, export the XYZ surface data-points, or save the 3D-Cam as a STEP file.
	RESULT You can see the **3D-CAM** in the graphics-area. **See 3D-Cam dialog** 384 The **3D-CAM** has **four surfaces**, which enclose the solid volume that you cut from a **Cam-Blank.** The four surfaces are: • **Cam Flank × 2** - one flank for each working side of the **Follower-Roller** • **Floor Surface -** a surface to connect the **bottom** edges of the **Cam-Flanks** • **Top Surface** - a surface to connect the **top** edges of the **Cam-Flanks**. This surface should be outside of the **Cam-Blank**.

Video:

Double-click to watch Video

1.5.5.1.3.3 Add Rack-Pinion - Ball-Screw

Rack-Pinion / Ball-Screw

See also: Rack-Pinion dialog 577

Add Rack-Pinion removes ONE degree-of-freedom from the model.

Before you do Add Rack/Pinion, the PINION OR the RACK is **kinematically-defined**.

After you do Add Rack/Pinion, the PINION AND the RACK are **kinematic-ally-defined**.

We calculate for you:

- the motion of a RACK from the motion of a PINION

OR

- the motion of a PINION from the motion of a RACK

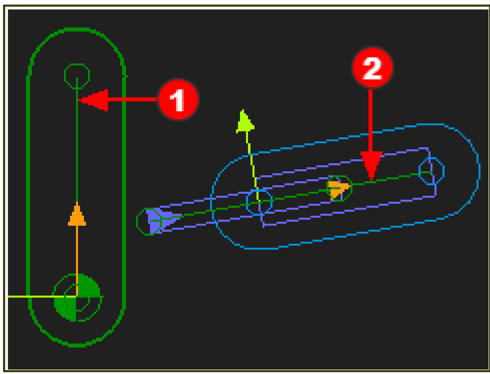
Terminology

RACK -PINION :	A RACK-PINION is the term for a sliding, straight, linear-gear (RACK) that is in mesh with a rotating, circular, gear-wheel (PIN-ION). The motions of the two PARTS are kinematically related by the **module** and **number-of-teeth** on the PINION.
BALL-SCREW :	A BALL-SCREW is a device in which a **Screw** rotates to move a **Nut**, or vice-versa. The Linear-Motion of the **Nut** and the rotation of the **Screw** are related by the **lead** of the screw-thread.
sliding-Part :	A PART that is joined to another PART with a SLIDE-JOINT.
rotating-Part :	A PART that is joined to another PART with a PIN-JOINT.

How to prepare for Add Rack-Pinion (typical)

There are two model types.

A: The motion of the Rack is from the motion of a Pinion:



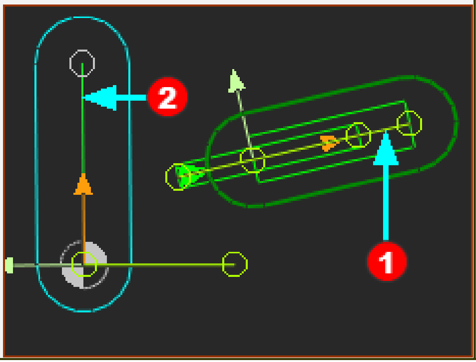
Elements before you do Add Rack-Pin-ion

LINE❶ - in a **rotating-Part** that is **kin-ematically-defined**

LINE❷ - in a **Sliding-Part** that is not **kinematically-defined**

LINE **or** CAD-LINE

B: The motion of the Pinion is from the motion of a Rack



Elements before you do **Add Rack-Pinion**

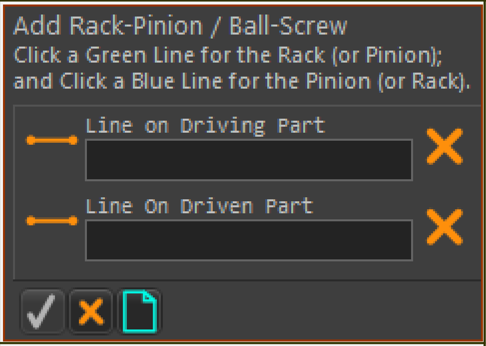
LINE❶ - in a **sliding-Part** that is **kinematically-defined**

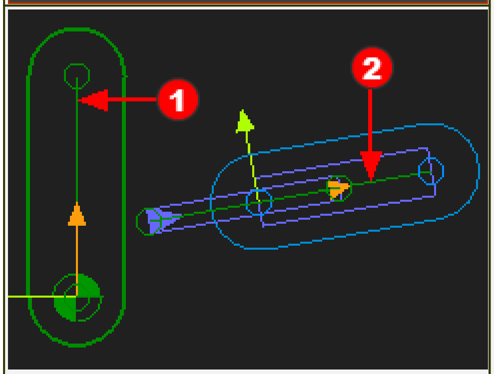
LINE❷ - in a **rotating-Part** that is **not kinematically-defined**

LINE or CAD-LINE

Add Rack-Pinion

A: If the motion of the Rack is from the motion of a Pinion

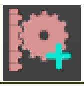




STEP 1: Click Add Rack-Pinion

1. Mechanism menu > Rack-Pinion

OR



1. Machine-elements toolbar > Add Rack-Pinion

In the COMMAND-MANAGER, there are two elements to select.

STEP 2: Select the two elements in the graphics-area

1. Click LINE❶ in the PART that is **kinematically-defined.**
2. Click LINE❷ in the PART that is NOT **kinematically-defined**.

STEP 3: Complete the Command

1. **Click** ✅ to complete Add Rack-Pinion.

RESULT :

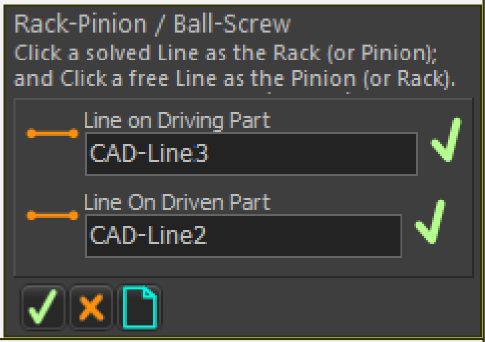
The PINION is on the **Rotating-Part**.

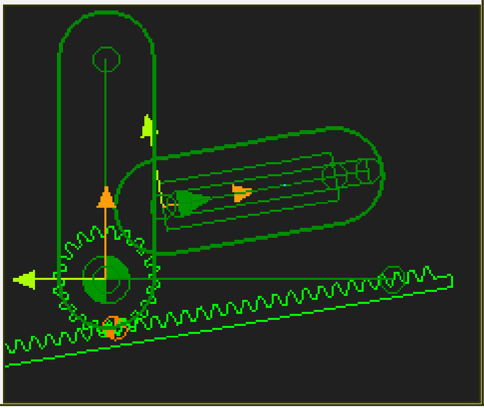
The rotating-axis of the PINION is coincident with the PIN-JOINT.

The RACK is on the **Sliding-Part**.

The RACK is parallel with the SLIDE-JOINT.

The **Pitch-Line** of the RACK is offset from the center of the PINION

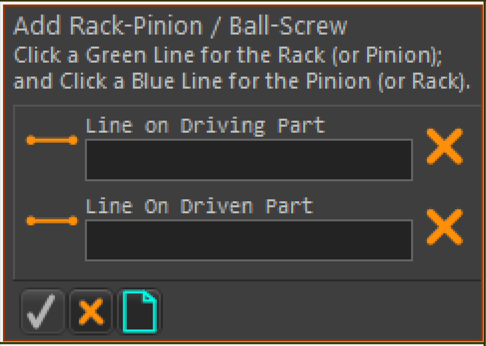


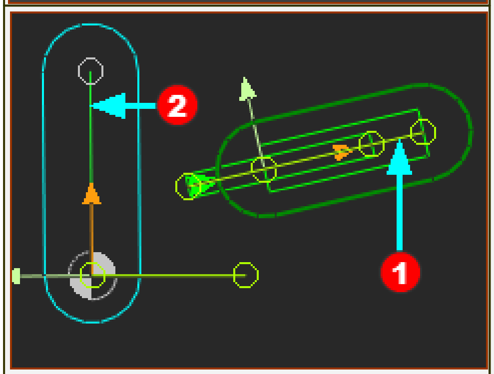


by the **Pitch-Circle Radius** of the PINION.

The **sliding-Part** is now a PART that is **kinematically-defined**.

B: If the motion of the Pinion is from the motion of a Rack

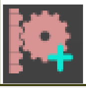




STEP 1: Add Rack-Pinion

1. Mechanism menu > Add Rack-Pinion

OR



1. Machine-elements tool-bar > Add Rack-Pinion

In the COMMAND-MANAGER, there are two elements to select.

STEP 2: Select the two elements in the graphics-area

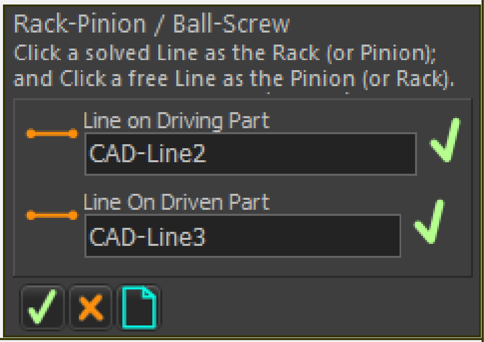
1. Click LINE❶ - it is in the PART that is **kinematically-defined**.
2. Click LINE❷ - it is in the PART that is NOT **kinematically-defined**.

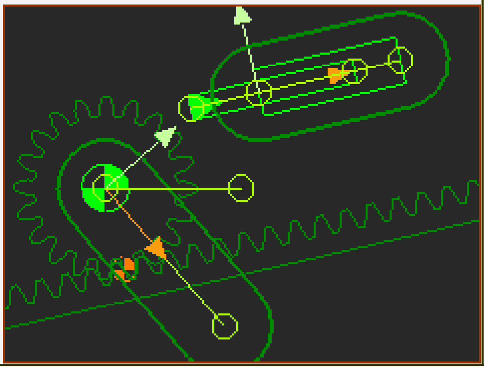
STEP 3: Complete the Command

4. Click ✓ in the COMMAND-MANAGER.

The RACK-PINION is now in the ASSEMBLY-TREE and graphics-area.

RESULT :





The **PINION** is on the **Rotating-Part**.

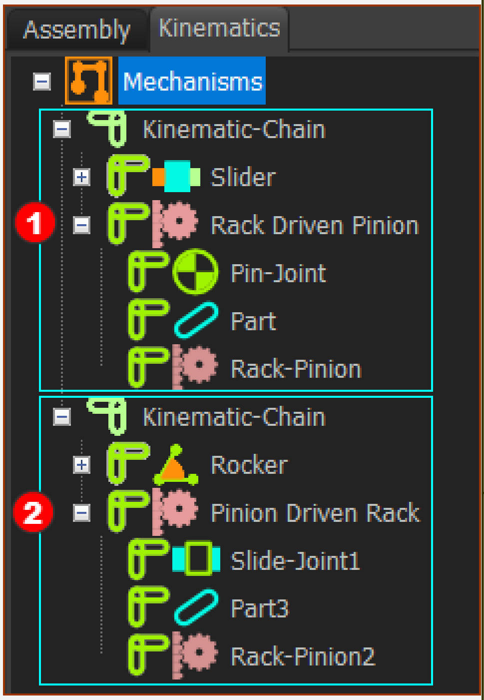
The rotating-axis of the **PINION** is coincident with the **PIN-JOINT**.

The **RACK** is on the **Sliding-Part**.

The **Pitch-Line** of the **RACK** is parallel to the **SLIDE-JOINT** and **sliding-Part**.

The **rotating-Part** is now a **PART** that is **kinematically-defined**.

Kinematics-Tree of Rack-Pinion



1 If the motion of the Pinion is from the motion of the Rack

Before you do **Add Rack-Pinion**, there is a **sliding-Part** that is kinematically-defined and a **rotating-Part** that has **one** degree-of-freedom.

After you do **Add Rack-Pinion**, the **sliding-Part(Rack)** and the **rotating-Part (Pinion)** are **kinematically-defined.**

2 If the motion of the Rack is from the motion of the Pinion

Before you do **Add Rack-Pinion**, there is a **rotating-Part** that is **kinematically-defined** and a **sliding-Part** that has **one** degree-of-freedom.

After you do **Add Rack-Pinion**, the **rotating-Part** (Pinion) and the **sliding-Part (Rack)** are **kinematically-defined**, and in one kinematic-chain.

Video of Add Rack-Pinion

Double-click to watch Video

1.5.5.1.3.4 Add Gear-Pair

Gear-Pair

See also: Gear-Pair dialog 566 , Add Bevel Gear-Pair 146

Add Gear-Pair removes ONE degree-of-freedom from the model.

Before you do Add Gear-Pair,

- the **Driving-Part**, which will be the input PINION, is **kinematically-defined**.
- the **Driven-Part**, which will be the output WHEEL, is NOT **kinematically-defined**.

After you do Add Rack/Pinion,

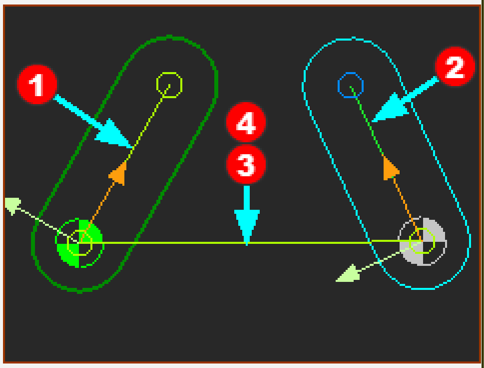
- the **Driving-Part** AND the **Driven-Part** are **kinematically-defined**.
- we add a Gear to the **Driving-Part**
- we add a Gear to the **Driven-Part**

Gear Terminology

Gear-Wheel (or Gear) :	A **rotating-Part** with **gear-teeth** at a fixed diameter. You control its diameter with the number-of-teeth and **module**.
GEAR-PAIR :	Two inter-locking **gear-wheels**. Their teeth have **External** or **Internal mesh**. The angular velocity of each **gear-wheel** is related by the number-of-teeth on each **gear-wheel**, and the type of **mesh**.
Driving Part :	The **rotating-Part** that is **kinematically-defined**, and whose motion you control (even if it is stationary) before you do Add Gear-Pair.
Driven Part :	The **rotating-Part** whose motion you control by the motion of the **Driven-Part**, the NUMBER-OF-TEETH on each **gear-wheel** in the GEAR-PAIR, and the MESH.
Gear-Mesh (or Mesh) :	Inter-locking **gear-teeth** of a GEAR-PAIR that transmit torque and motion from the **Driving Part** to the **Driven Part**.
External Mesh :	The gear-teeth of the two **gear-wheels** point outwards from their centers-of-rotation.
Internal Mesh :	The gear-teeth of one **gear-wheel** point inwards towards its center-of-rotation.
Simple Gear-Pair :	Two **gear-wheels** that rotate about two fixed centers.
Epicyclic Gear-Pair :	One **gear-wheel** orbits around the center of the other **gear-wheel**.

Prepare to Add Gear-Pair

A : Simple Gear-Pair



3 × PARTS ; 3 × LINES ; 2 × PIN-JOINTS

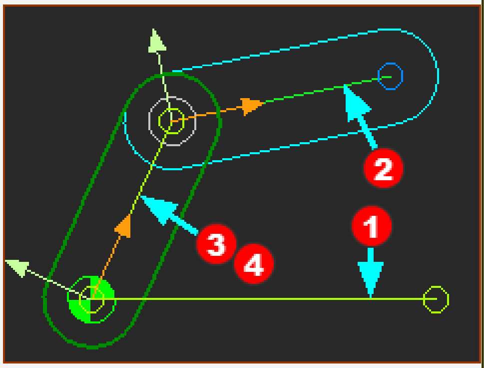
LINE❶ and LINE❸ and PARTS are **kinematically-defined**

LINE❷ and PART is not **kinematic-ally-defined**

LINES❶❷ are joined with PIN-JOINTS to each end of LINE❸

LINE❸ has a DIMENSION❹ (in the PART-EDITOR)

B : Epicyclic Gear-Pair



3 × PARTS ; 3 × LINES ; 2 × PIN-JOINTS

LINE❶ and LINE❸ and PARTS are **kinematically-defined**

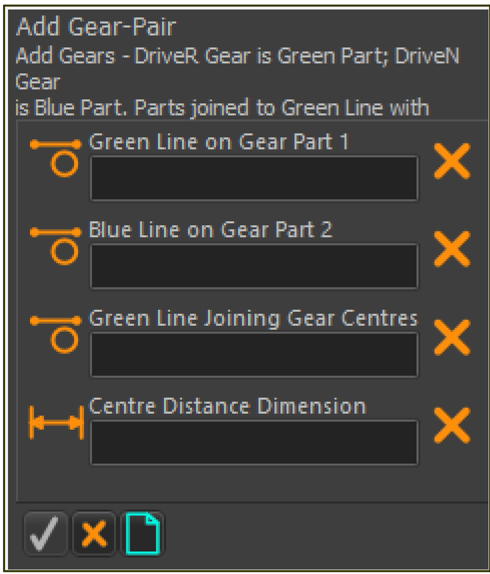
LINE❷ and PART is not **kinematic-ally-defined**.

LINES❶❷ are joined with PIN-JOINTS to each end of LINE❸

LINE❸ has a DIMENSION❹ (in the PART-EDITOR)

Add Gear-Pair

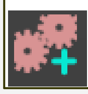
A : Simple Gear-Pair



STEP 1: Click Add Gear-Pair (Simple)

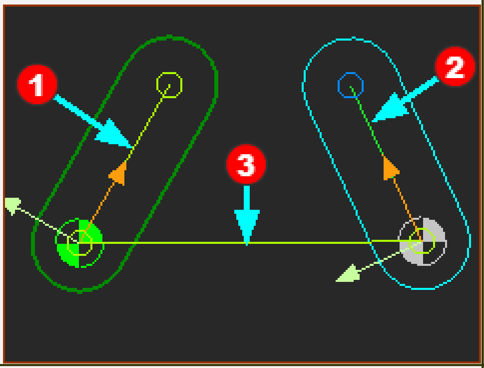
1. Mechanism menu > Gear-Pair

OR



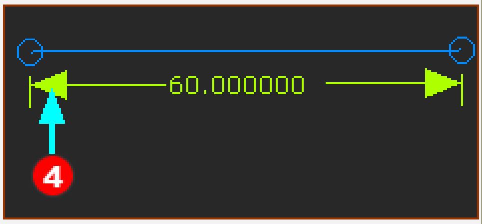
1. Machine-elements tool-bar > Add Gear-Pair

There are four elements to select in the COMMAND-MANAGER



STEP 2: Select the four elements

1. **MECHANISM-EDITOR** > Click **LINE** ❶
2. **MECHANISM-EDITOR** > Click **LINE** ❷
3. **MECHANISM-EDITORS** : Click **LINE** ❸

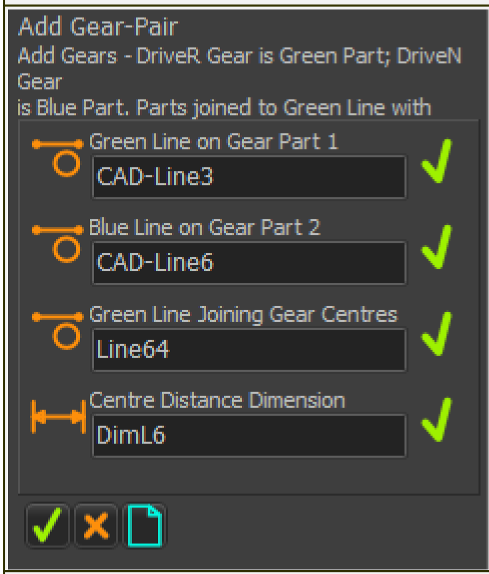


STEP 2: continued...

The **PART-EDITOR** opens automatically.

4. **PART-EDITOR**: Click the **DIMENSION**❹

The **PART-EDITOR** closes automatically.



STEP 3: Complete the Command

5. **Click** in the **COMMAND-MANAGER.**

RESULT:

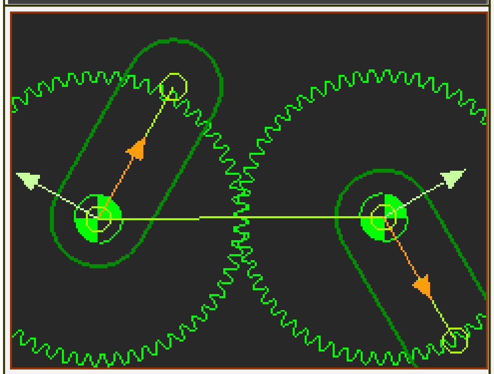
The **GEAR-PAIR** is in the graphics-area.

The default **GEAR-PAIR** has an External Mesh and the gears have an equal number-of-teeth.

The length of the **LINE** between the centers of the gears - called the **Line-of-centers** - is now a **Driven-Dimension**.

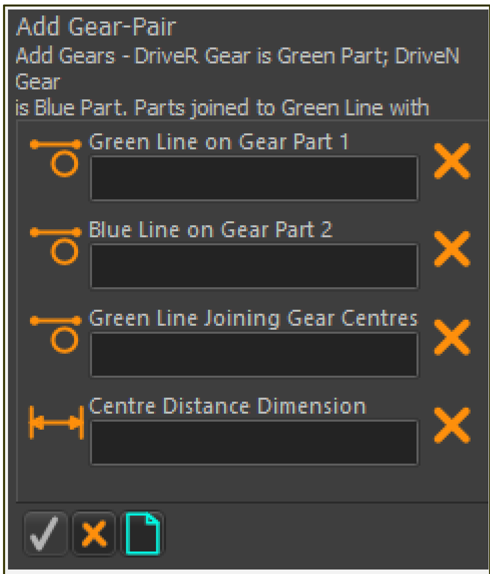
The length of the **Line-of-Centers** = **(# Gear-Teeth 1 + # Gear-Teeth 2) × Module**

The output **PART** is a Geared-Rocker in the **KINEMATICS-TREE**[318].



To edit the **GEAR-PAIR** parameters: **see** **Gear-Pair dialog**[566]

B : Epicyclic Gear-Pair



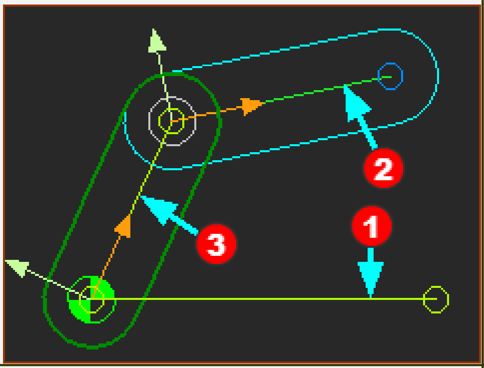
STEP 1: Click Add Gear-Pair (Epicyclic)

1. Mechanism menu > Gear-Pair

OR

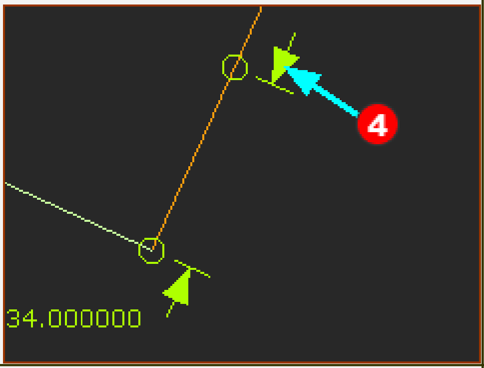
1. Machine-elements toolbar > Add Gear-Pair

There are four elements to select in the COMMAND-MANAGER



STEP 2: Select the four elements

2. MECHANISM-EDITOR > Click LINE ❶
3. MECHANISM-EDITOR > Click LINE ❷
4. MECHANISM-EDITOR > Click LINE ❸

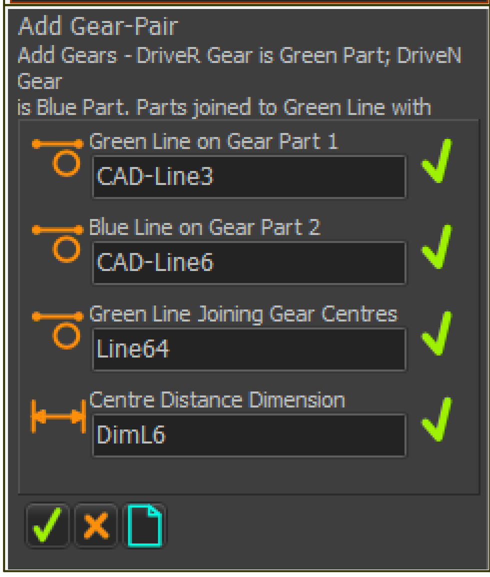


STEP 2: continued...

The PART-EDITOR opens automatically.

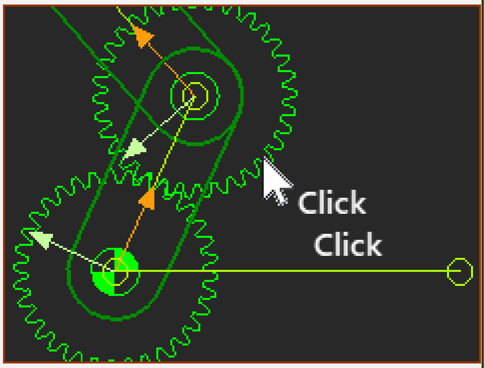
4. PART-EDITOR: Click the DIMENSION❹

The PART-EDITOR closes automatically.



STEP 3: Complete the Command

5. Click ✓ in the COMMAND-MANAGER.



RESULT:

The GEAR-PAIR is in the graphics-area.

The default GEAR-PAIR has an External Mesh and the gears have same number-of-teeth.

The length of the LINE between the Gear centers - called the **Line-of-centers** - is a **Driven-Dimension.**

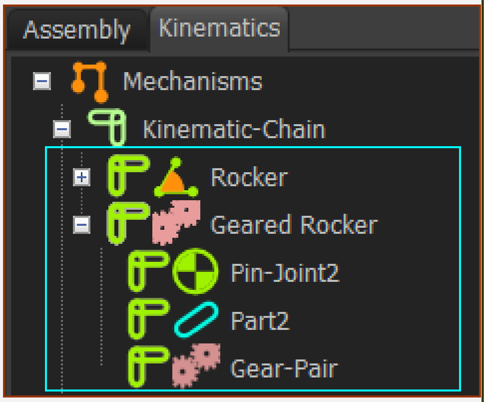
The length of the Line-of-Centers = **(# Gear-Teeth 1 + # Gear-Teeth 2) × Module)**

The output PART is a Geared-Rocker in the KINEMATICS-TREE[318].

To edit the GEAR-PAIR parameters, **see** **Gear-Pair dialog**[566]

Kinematics-Tree of Gear-Pair

Add Gear-Pair removes one degrees-of-freedom.



Kinematics-Tree

Before you do Add Gear-Pair:

- a **rotating-Part(1)** that is **kinematically-defined**
- a **rotating-Part(2)** that is NOT **kinematically-defined** - it has one degree-of-freedom.

After you do Add Gear-Pair:

- the two **rotating-Parts(1 &2)** are **kinematically-defined**
- the **rotating-Part(2)** is now a **Geared-Rocker**

Videos of Add Gear-Pair

Simple Gear-Pairs: Double-click to watch 'Add Gear-Pair - Simple'

Epicyclic Gear-Pairs: Double-click to watch ' Add-Gear-Pair - Epicyclic'

1.5.5.1.3.5 Add Bevel Gear-Pair

Add Bevel Gear-Pair

See also: Gear-Pair dialog 566

Add Bevel Gear-Pair and Degrees of Freedom

Add Bevel Gear-Pair removes one(1) degrees-of-freedom.

What is a Bevel Gear-Pair?

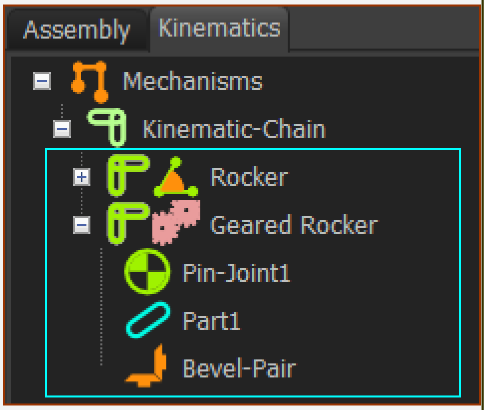
When you do Add Bevel Gear-Pair, you add two gears that are in mesh, with intersecting, **PERPENDICULAR**, rotating-axes.

When you do Add Gear-Pair, you add two gears that are in mesh, with intersecting, **PARALLEL**, rotating-axes.

We find for you the motion of the **Driven-Gear** from the motion of the **Driving-Gear**, the number-of-teeth, and the **mesh** (internal or external).

Kinematics-Tree of Bevel Gear-Pair

Add Bevel Gear-Pair removes one degrees-of-freedom.



Bevel Gear-Pair

Before you do Add Bevel Gear-Pair, there is a

- rotating-Part that is **kinematically-defined**, and a
- **rotating-Part** that has one degree-of-freedom in a different Mechanism-Editor

After you do Add Bevel Gear-Pair, the **rotating-Parts** are **kinematically-defined**.

A **Bevel-Pair** is a child to the **Geared-Rocker.**

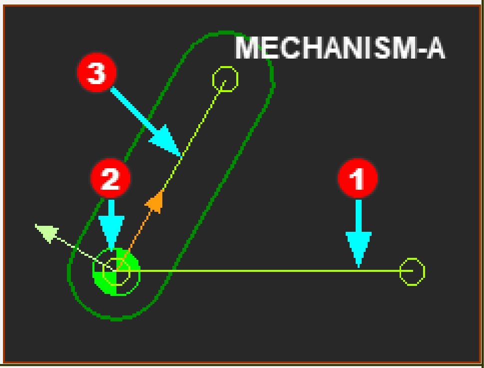
Prepare Bevel Gear-Pair

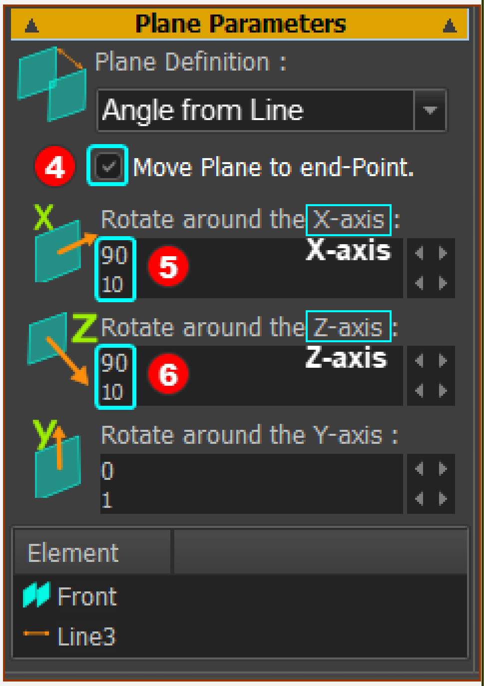
To add a **Bevel Gear-Pair** is more complex than to add a **Gear-Pair**.

The PARTS you add for the two **Bevel-Gears** are on two different MECHANISM-EDITORS.

The Mechanism-Planes of the two(2) MECHANISM-EDITORS must intersect. They are frequently perpendicular to each other.

Below, for convenience, the names of the two MECHANISM-EDITORS are **MECHANISM-A** and **MECHANISM-B.**





PREPARATION A1: MECHANISM A

LINE❶ and LINE❸ are in PARTS that are **kinematically-defined**

LINES❶❷ are joined with a PIN-JOINT

LINE❷ has a DIMENSION (in the PART-EDITOR)

See Tutorial 1: Add a Rotating-Part.

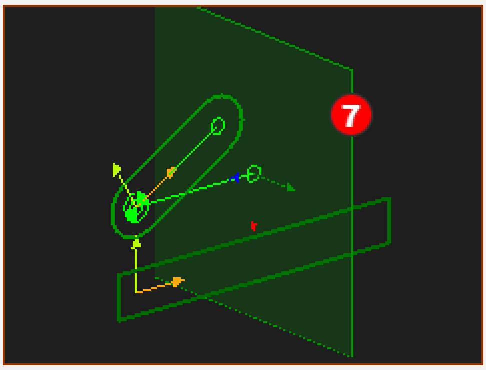
Preparation A2: Add a Plane to the Line in the Base-Part

1. Click **Mechanism menu or Model elements toolbar > Add Plane**
2. Click the LINE❶ in the BASE-PART

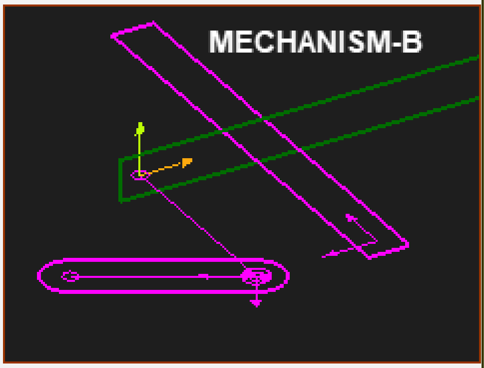
In the ADD PLANE DIALOG:

1. Enable MOVE PLANE TO END-POINT❹
2. Enter **90º** in the ROTATE AROUND THE Z-axis❺
3. Enter **90º** (default value) is in ROTATE AROUND THE x-axis❻.

See Tutorial 1: Add a Rotating-Part.



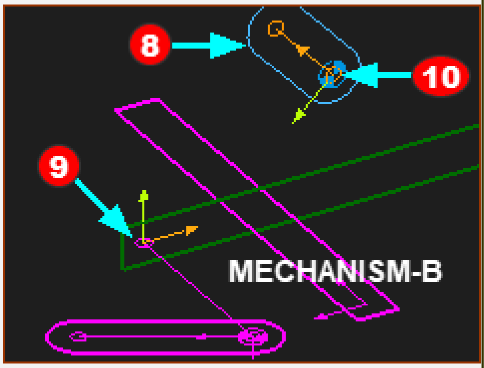
New Plane for Mechanism-B



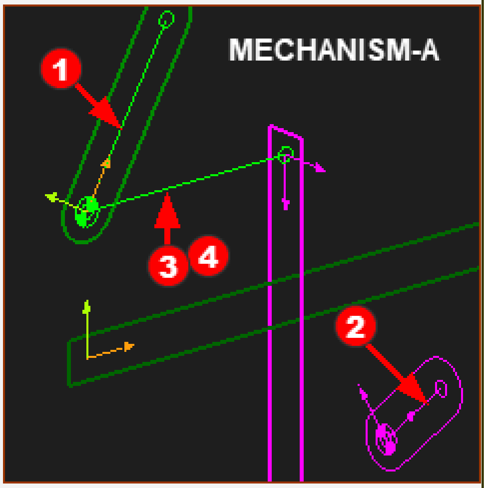
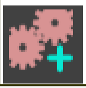
Preparation A3: Add Mechanism-B to the new Plane

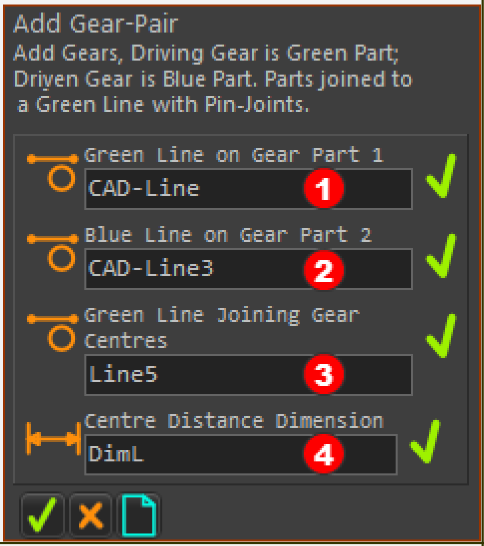
1. Click **Mechanism menu or Model elements toolbar > Add Mechanism-Editor**
2. Click the new PLANE❼

You jump to the new MECHANISM-EDITOR - MECHANISM-B

	A) Enable Visibility toolbar > Show other Kinematic and Sketch elements 63 AND B) Right-click the **Mechanism name-tabs Light-Bulb** > Enable Show with other Kinematic and Sketch-Elements 63 C) Spin the model to show the other kinematic and sketch-elements **Preparation B1: Add a new Part and Pin-Joint** 1. Click **Kinematic elements toolbar > Add Part** | Drag to add the PART 8 2. Click **Kinematic elements toolbar > Add Pin-Joint** a. Click the START-POINT of the new PART 10 b. Click the END-POINT 9 of the LINE in MECHANISM-A
The PIN-JOINT does not move the POINTS together. The PART 8 moves to a new place!!! **See also: Geared-Rocker, Dyads and** Kinematics-Tree 318	

Add Bevel Gear-Pair

	**NOTE: Click MECHANISM-A** to make it the active MECHANISM-EDITOR. **STEP 1: Click Add Gear-Pair** 1. **Mechanism menu > Add Gear-Pair** OR  1. **Machine-elements toolbar > Add Gear-Pair** There are four elements to select in the COMMAND-MANAGER. **STEP 2: Select the four elements**

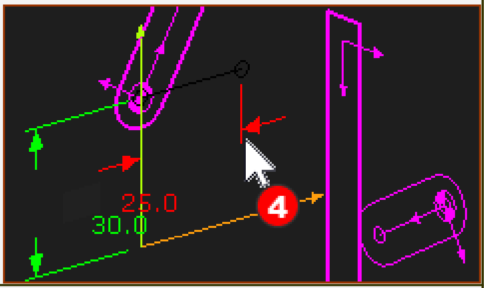


❶ The LINE along the center of the **rotating-Part** in **MECHANISM-A**

❷ The LINE along the center of the **rotating-Part** in **MECHANISM-B**

❸ The LINE in BASE-PART

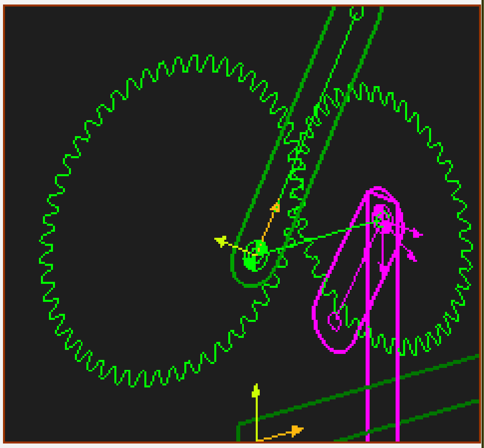
...



The PART-EDITOR opens to show LINE❸ and its dimension❹.

...

❹ Click the arrowhead, or the dimension line.



STEP 4: Complete the Command

Click ✅ in the COMMAND-MANAGER.

RESULT:

The BEVEL GEAR-PAIR is in the graphics-area.

The default BEVEL GEAR-PAIR has an External Mesh and the gears have an equal number-of-teeth.

All PARTS are **kinematically-defined**.

BEVEL GEAR PART is in the KINEMATICS-TREE as a Geared-Rocker.

To edit the BEVEL-GEAR-PAIR parameters: **see** Gear-Pair dialog 566

1.5.5.1.3.6 Add Scroll

What is a scroll?

A SCROLL feeds products, typically bottles or cans, into a Rotating Machine. The products are in a buffer as they move into the start of the Scroll. At the end of the scroll, the products move into a star-wheel. The star-wheel feeds the products into a rotating machine.

The pitch of the products in the buffer, at the start of the scroll, is the same as the length of the product. The products are moved apart by the scroll until their pitch is the same as the pockets in the star-wheel, that is at the end of the scroll. The pitch of the products on the star-wheel is the same as the pitch of the products on the Rotary Machine.

Other names for a SCROLL are: Feedscrew, Worm.

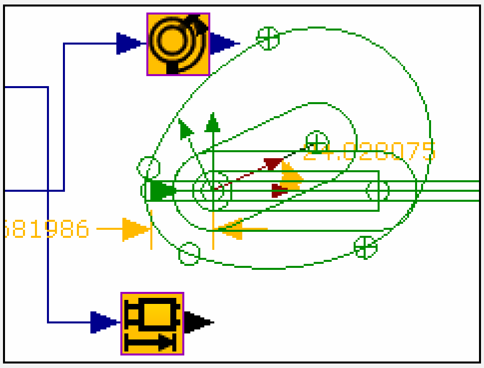
Add Scroll

	Machine Elements toolbar > Add Scroll
Menu :	Add menu > Mechanism sub-menu > Add Scroll
What to do :	You must do the Preparation [150] before you can do Add Scroll. You need five elements: 1. A PART for the moving 'Pack'. A sketch-loop is the cross-section of the 'Pack'. You must also add a MOTION-PATH FB (see 5) and generate a number of MOTION-POINTS to the sketch-loop. 2. A PART that is the rotating SCROLL. 3. A sketch-loop and PROFILE that is the cross-section of the SCROLL. 4. A LINE to be the SCROLL'S axis-of-rotation. 5. A MOTION-PATH FB.
Result :	A SCROLL in the graphics-area.
Preparation :	There is a significant amount of preparation. You must prepare five elements in 2 MECHANISM-EDITORS. **See Preparation** [133] When you click Add Scroll, you see five selection-boxes in the COMMAND-MANAGER.

Preparation for 'Add Scroll'

STEP 1: Pack: Shape; Motion, and Motion-Points

The Pack moves along a line that is parallel to the scroll's rotation-axis. It is also possible to rotate the Pack on its own axis as it moves from the entry to

<table>
<tr><td colspan="2">the exit of the scroll.</td></tr>
<tr><td></td><td>

1. Add a Mechanism to a 'Plane' - the 'Front' Plane - in the Model-Editor.
2. Rename the Mechanism-Editor to 'Pack'.

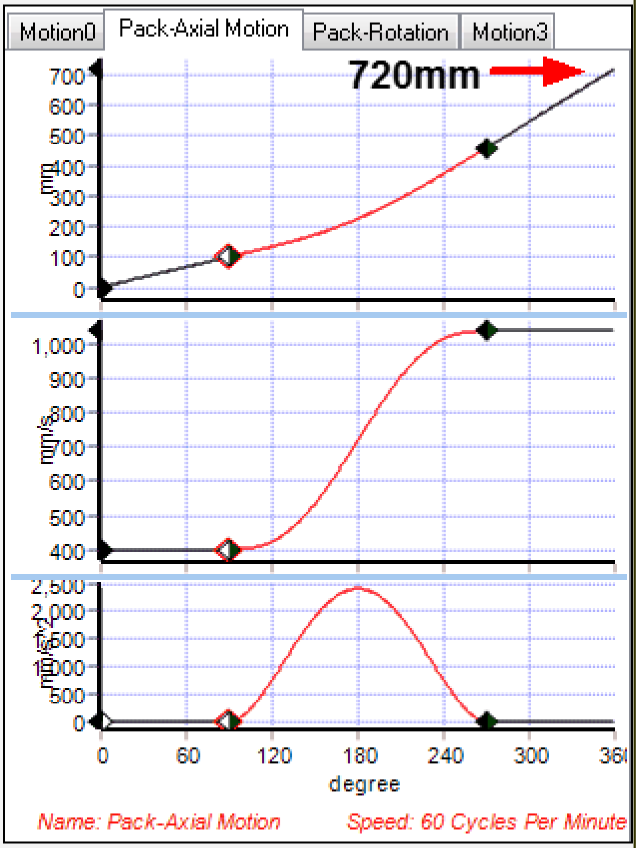
In the new Mechanism-Editor:

3. Add a Slider with a motion to define the axial motion of the Pack

If the Pack rotates as it moves along the scroll:

4. Add a Rocker to the Slider Part, and a motion to define the rotation of the Rocker / Pack
5. Then add the shape of the Pack to the Slider or Rocker.

The shape of the Pack must be a sketch-loop. If the Pack is not prismatic, then the shape should represent the its cross-section at the height of the scroll's rotational-axis.
</td></tr>
<tr><td colspan="2">The Motion for the Axial and Rotation of the Pack</td></tr>
</table>



Click to Expand and Collapse

Pack Axial Motion

The motion usually has a '*Constant Velocity Segment*' as its first and last segment.

Thus, there are two(2) Velocities you must consider.

Start Velocity, (SV)

Packs are usually adjacent '(bunched up', 'back-to-back')

SV = Product-Length ÷ Time for scroll to rotate one time

Final Velocity, (FV)

Packs should be at the same pitch as the star-wheel or circular pitch of the Rotary Machine

FV = Rotary Pitch ÷ Time for scroll to rotate one time

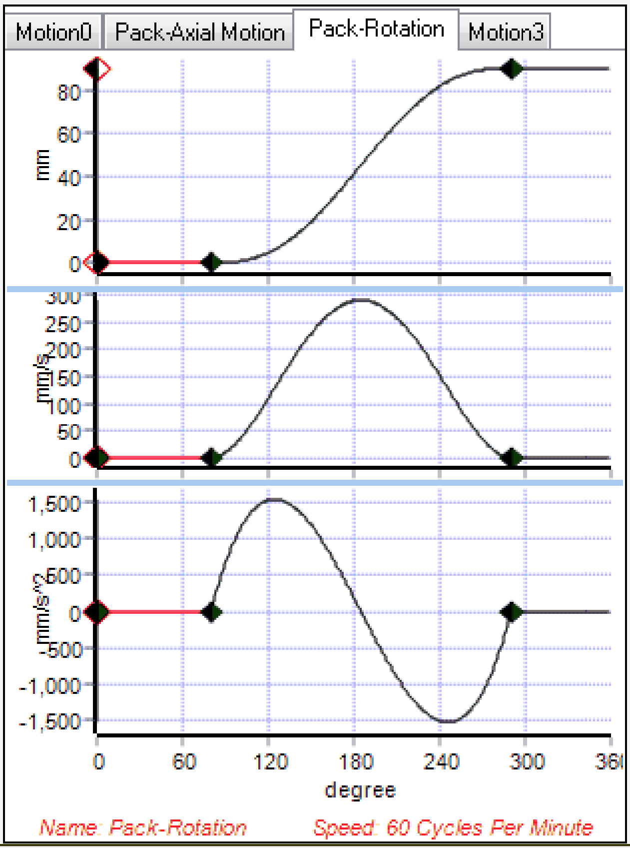
'Time', or 'Number of Machine Degree', for Scroll to rotate one time.

This is a function of the number-of-times the scroll rotates. Thus, of the length of the Scroll

The first constant velocity is the speed of the bottle at its entry.

The last constant velocity is the speed of the bottle at its exit.

You need to edit the motion later.

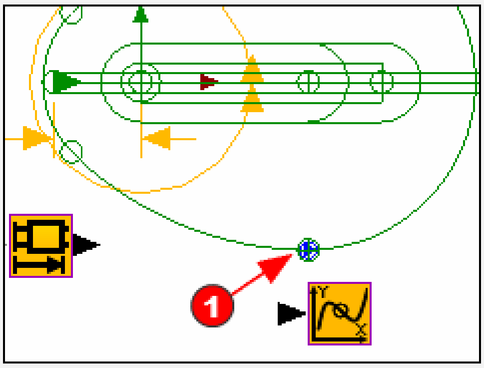


Pack Rotation

The Pack rotates by 90º as it moves from the entry to the exit.

The duration of the segment that rotates the pack is the same duration as the segment that accelerates the pack.

Motion-Path, Motion-Points.

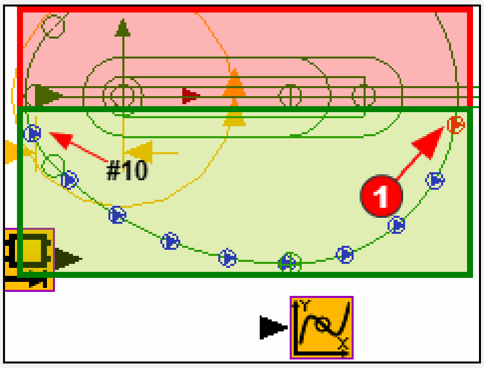


In order to calculate the shape of the scroll, you must define the contact between the Pack and the Scroll.

Rather than a Profile, you add Motion-Points to the shape of the Pack. Each Motion-Point define a 'Rim' along the scroll - as you see.

1. *Click* Add Motion-Path
2. *Click* one of the sketch-elements that give the shape to the Pack

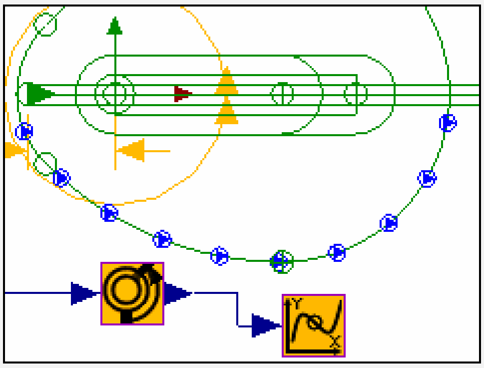
One Motion-Point ❶ shows at the start-Point of the sketch-element that you click.



1. *Double-click* the Motion-Path FB to open the Motion-Path dialog
2. Edit the '# Motion-Points' to 10 - we can edit this number later, if necessary.
3. *Click* the 'Re-generate Motion-Points'.
4. Edit the 'Range' of the Motion-Points to 160º (use the Range option in degrees).
5. Edit the **'BASE-VALUE'** of the **MOTION-POINTS** until they are <u>only</u> in the half of the sketch-loop for the Pack that 'faces' the rotation-axis.

The Motion-Points must be in the **'Green Area'** The **MOTION-POINTS** cannot be in the **'Red Area'**.

A Motion for the Motion-Points

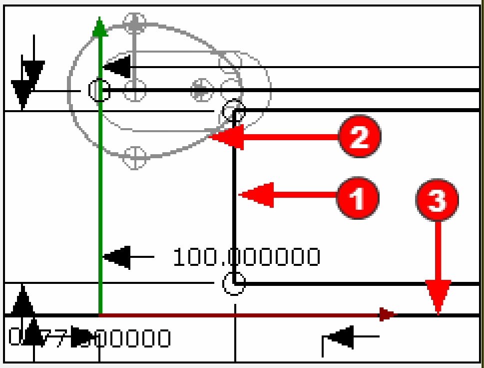


As the Pack rotates, we must also rotate the Motion-Points in the opposite direction so that they remain in the half of the Pack that faces the rotation-axis.

1. Connect a wire from the output-connector of the **MOTION-DIMENSION** that rotates the Pack to the input-connector of the Motion-Path.

You may need to add a **GEARING FB**, with a ratio of -1, to move the Points in the opposite direction.

STEP 2: Add the Scroll rotation-section and its rotation-axis.



(Note: I have rotated the Pack by 180º on the rotating Part. This helps later)

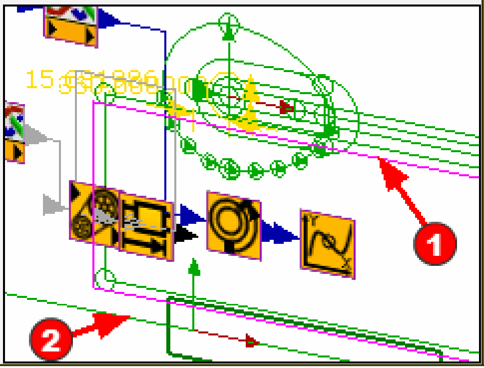
We must add a sketch-loop that represents the rotation-section of the scroll.

1. Edit the **BASE-PART**
2. Click **Visibility toolbar > Show/Hide other Kinematic and Sketch elements** - this shows the shape of the Pack ❷.
3. Add a rectangle❶, that represents the section-of-rotation of the Scroll-Blank.

The rotation-section needs a rotation-axis.

4. Add a **LINE**❸ that represents the rotation-axis of the scroll.

This should be along the X-axis of the **BASE-PART**.



We must also add a **PROFILE** to the rotation-section❶.

1. Close the **PART-EDITOR**
2. Add a **PROFILE**❶ to the rectangle

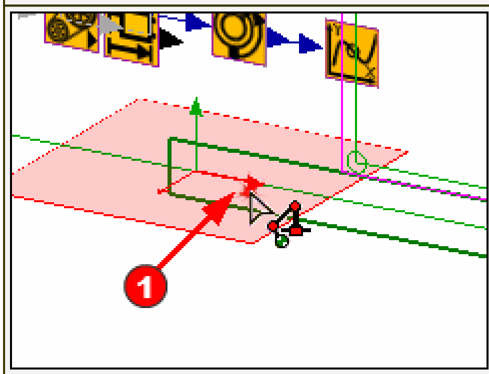
When we send the rotation-section and rotation-axis to SolidWorks, SolidWorks makes a 'revolved-section'.

STEP 3: Add a Plane, Mechanism, add the Scroll Part

We add the scroll in a different Mechanism-Editor. We must add a new Plane for the new Mechanism-Editor.

The Plane to which we add the new Mechanism-Editor must be orientated in a particular direction. If the Plane is not in the correct orientation, we cannot add the scroll.

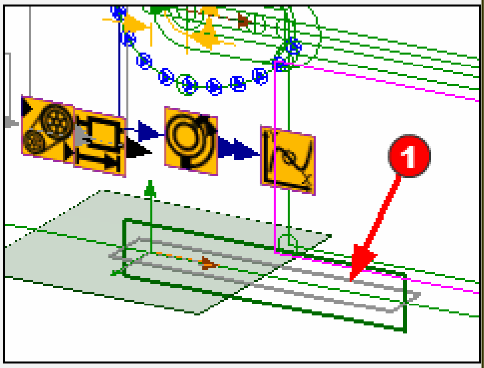
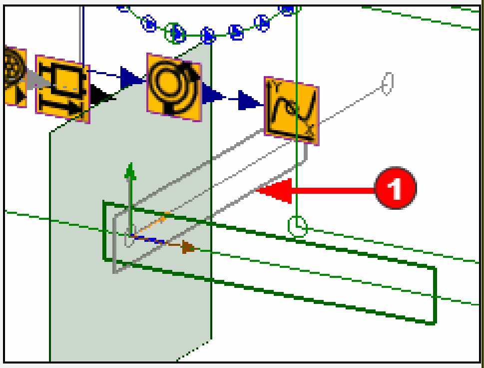
Add the new Plane



1. Spin the model with your keyboard arrow keys
2. Click Add Plane
3. Click the arrowhead of the X-axis at the Origin of the Base-Part❶

(you can also click the Y-axis)

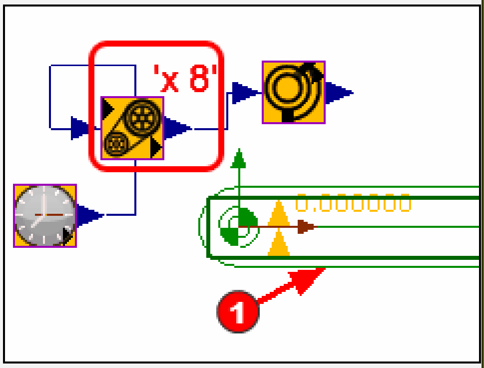
The image shows the **default position** of the new Plane.

	We must use the Add Plane dialog to re-orientate the Plane. It is possible to use the Add Plane dialog to edit the orientation of the new Plane now. However, I find it easier to 'Add a new Mechanism' to the Plane now, and then edit the Plane for the new Mechanism later.
	4. Close the Add Plane **dialog** 5. Click Add Mechanism 6. Click the new Plane 7. Click OK in the **COMMAND-MANAGER** You 'jump' to the new Mechanism-Editor. Rename the new Mechanism-Editor to 'Scroll' 8. Click the 'Pack' Mechanism name-tab to return to the Pack Mechanism-Editor. 9. Click **Tools menu (or toolbar) > 'Show Sketches in Mechanism'** You can now see the new Plane and the Base-Part❶ (in **Grey**) to give the orientation of the new Mechanism-Plane. The XY-axes of the Base-Part are coplanar with Mechanism-Plane.
	10. Edit the new Plane - double-click it to open the Plane dialog ***MechDesigner Rules - relative orientation of the new Plane with respect to the orientation of the Pack's Mechanism Plane.*** • The Z-axis of the Scroll Mechanism's Base-Part must be co-axial with the X-axis of the Pack Mechanism's Base-Part • The Y-axis of the Scroll Mechanism's Base-Part must be co-axial with the Y-axis of the Pack Mechanism's Base-Part

If you clicked the X-axis to add the new Plane, then the X, Y and Z-axis rotations are 90,90,90 respectively.

If you clicked the Y-axis to add the new Plane, then the X, Y and Z-axis rotations are 0,90,90 respectively.

The image shows the new orientation of the Base-Part and Mechanism-Plane of the 'Scroll' Mechanism.



11. Click the Scroll Mechanism name-tab

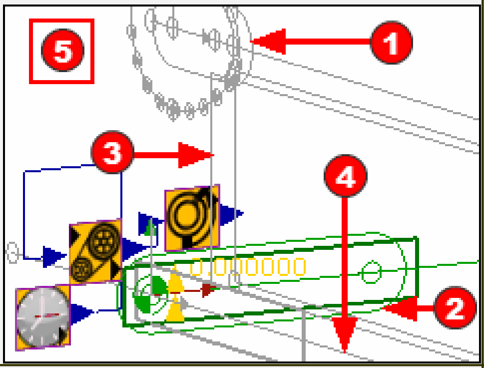
We now add the Part that represents the 'scroll'.

12. Add a rotating Part❶.

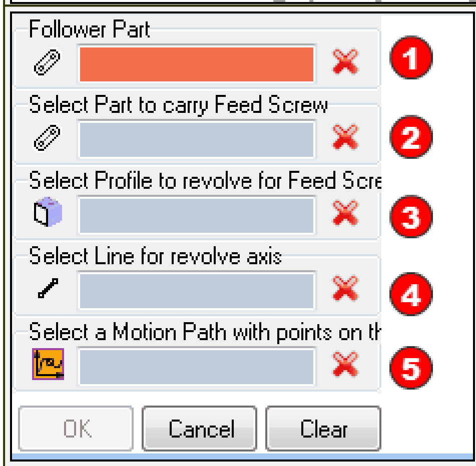
Make sure the Origin of the Part is at the Origin of the Base-Part.

Add a Gearing FB, and edit its Gearing Ratio parameter so that the Scroll Part rotates many times in a machine-cycle.

I suggest a Gearing Ratio of 'x8' as the first estimate.



13. Click **ALT+H** keyboard shortcut to Home the model, in which the MMA is at 0
14. Rotate the view so you can see the elements in the two(2) Mechanism-Editors.
15. Click Add Scroll.



Select the five elements in order.

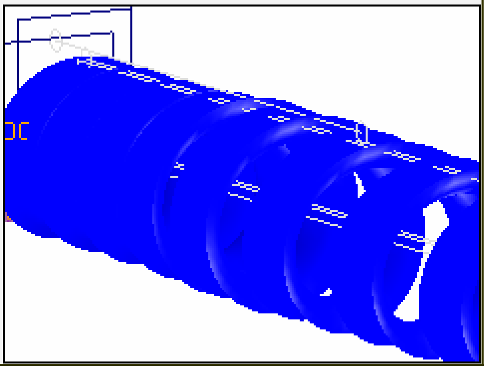
❶ The Follower is the 'Pack' Part

❷ The Part to carry the Feed-Screw is the 'Scroll', in the active Mechanism-Editor

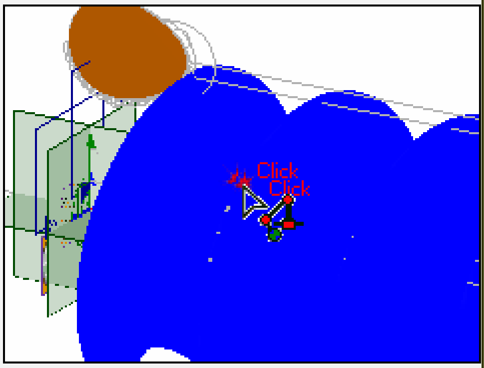
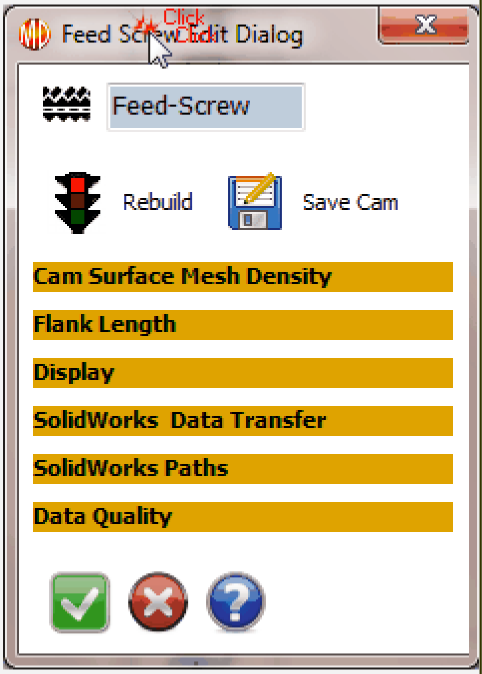
❸ The Profile is the 'rotation-section' - the Profile element

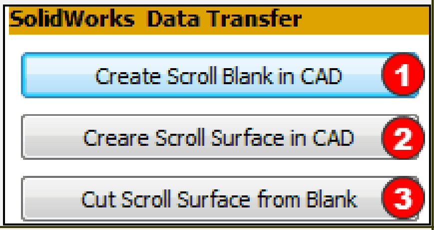
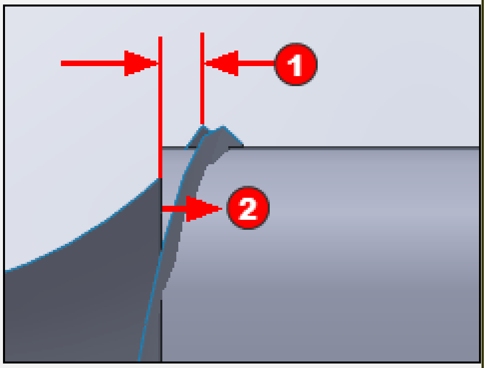
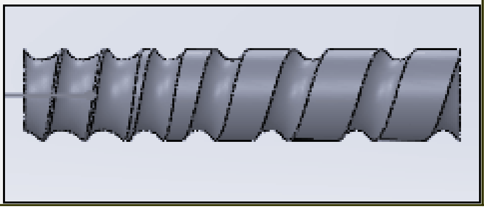
❹ The Line for the 'revolve axis' is the 'rotation-axis'

❺ The MOTION-PATH FB in the graphics-area

	Click OK
	You may need to click the Model-Editor to force a full model rebuild. **MechDesigner** creates a surface for the part of the scroll that becomes in contact with the Pack, as the Pack advances.

STEP 4: Transfer the Scroll to SOLIDWORKS

	To transfer the Scroll to SOLIDWORKS, we need to edit the Scroll element. 1. Double-click the Scroll in the graphics-area or 1. Double-click the Scroll element in the Assembly-Tree
	**The Scroll** Element dialog (Also called the Feed Screw - dialog). The important separators are: **Cam** (that is: Scroll) **Surface Mesh Density** • Edit the number of Points along each Rim. • Typically 500 to 1500. **Flank-Length** The Flank Length is with respect to the MMA. • Typically, set to 0 to 360 **Display** • color • Transparency - applies to view in the Model only • Show as Solid (Surface) and Rims check-boxes.

	**SOLIDWORKS Data Transfer** 1. Start SOLIDWORKS, add a new Part, and Save it. 2. You can click each button in turn
	If the Scroll Surface is not cut from the Scroll Blank, there may be a couple of things you should look at. 1. The end of the Scroll Surface is outside the ends of the Scroll Blank.❶ In the image, you can see that the Scroll-Blank extends past the start of the Scroll Surface. Edit the Scroll-Blank in SOLIDWORKS or ***MechDesigner***. 1. Move the left end of the sketch to the right by a small amount.❷
	When the Scroll Surface is cut from the Blank, then hide the Scroll Surface.

1.5.5.1.3.7 Add Pulley

Add Pulley

See also : Pulley dialog 581

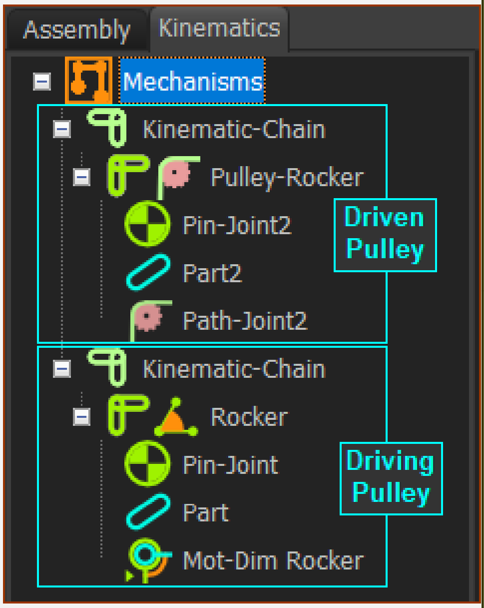
Pulley / Belt Terminology

Term :	Definition
PULLEY :	When you do **Add Pulley**, we add for you the outline of a PULLEY, with **teeth**, to a rotating-Part - see also **Types of Pulley** The rotating-Part of a PULLEY must rotate about the **CENTER-POINT** of an ARC that is on the sketch-path of a **Belt**.
Belt :	A **sketch-path** to represent the path of the **Belt**. The motion of a **MOTION-POINT** along the **sketch-path** represents the motion of the **Belt**.
We relate the angular motion of each PULLEY to the linear motion of the Motion-Point on a **Belt** by the radius of each PULLEY. To control the radius of each PULLEY, you can control its NUMBER-OF-TEETH and the TOOTH-PITCH of the **Belt.**	

Types of Pulley

You can do **Add Pulley** to a rotating-Part that is kinematically-defined (**Type 1**) or is not kinematically-defined (**Type 2**).	
Type 1: A Driving-Pulley :	Before you do **Add Pulley,** the rotating-Part is kinematically-defined. After you do **Add Pulley**, we control the linear motion of a **Belt** from the angular motion of the rotating-Part (**Driving-Pulley**). Add a maximum of one **Driving-Pulley** to a **Belt**.
Type 2: A Driven-Pulley :	Before you do **Add Pulley**, the rotating-Part is not kinematically-defined. After you do **Add Pulley**, we control the angular motion of a rotating-Part (**Driven-Pulley**) from the linear motion of the **Belt**.

Kinematics-Tree of Pulley



Driven-Pulley

It is a PULLEY-ROCKER in the **Kinematics-Tree** after you do **Add Pulley**.

A PATH-JOINT is a child to the PULLEY-ROCKER.

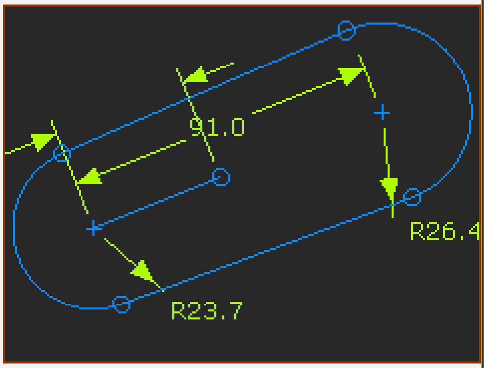
Driving-Pulley

It is a PART that is **kinematically-defined** in the **Kinematics-Tree** before you do **Add Pulley**.

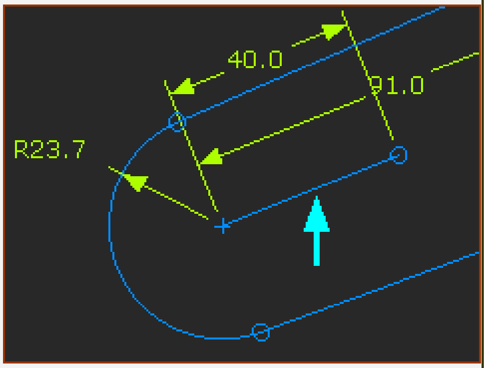
For example, a **Driving-Pulley** in the KINEMATICS-TREE is a **Rocker**.

Prepare to Add Pulley (TYPICAL)

STEP 1: Add the sketch-path for the Belt.



Sketch-loop as the path of the Belt.



A Line for a Motion-Dimension FB

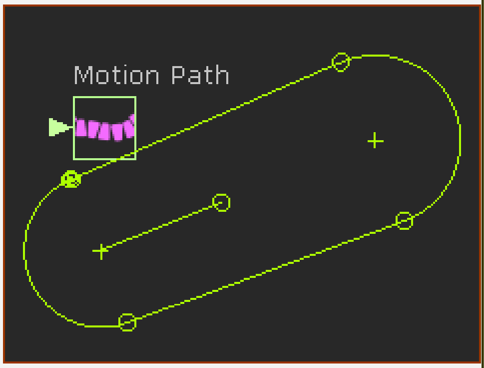
STEP 1: Add a sketch-path to represent the path of the Belt.

The **sketch-path** should include only LINES and ARCS. Usually, add TANGENT constraints between each LINE and ARC. Do not add EQUAL constraints to the ARCS. The **sketch-path** is usually a closed **sketch-loop**. It is usually helpful to fully define the geometry of the sketch-path.

1. MECHANISM-EDITOR: Edit the BASE-PART (usually) or PART
2. PART-EDITOR: Add a **sketch-path** with LINES and ARCS to represent the path of the **Belt**. You need one ARC for each PULLEY.
3. PART-EDITOR: Add TANGENT constraints between each LINE and ARC
4. PART-EDITOR: Add a dimension to the radius of each ARC. (Do not add EQUAL constraints between ARCS)

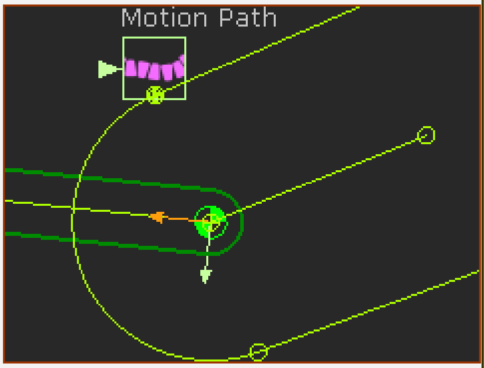
	IF the **rotating-Part** is a **Rocker** for a **Driving-Pulley - see STEP 3A**: 5. **PART-EDITOR**: Add a **LINE** from the **CENTER-POINT** of the **ARC** that is the rotating-axis of the **Rocker** / **PULLEY** Why? You need the **LINE** to add a **MOTION-DIMENSION FB** to the **rotating-Part**.

STEP 2: Add the Motion-Path FB to the sketch-path

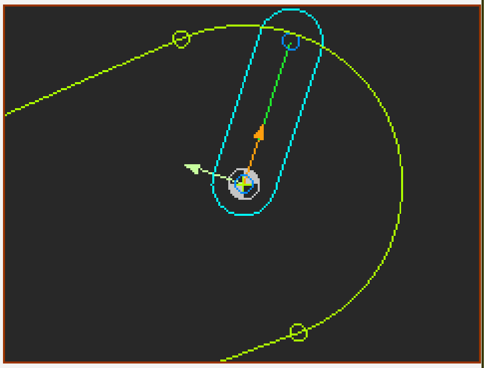
 	**STEP 2**: Add a **MOTION-PATH FB** Add **ONE MOTION-PATH FB** to the **sketch-path**. 1. Click **Function-Blocks menu > Add Motion-Path FB.** 2. Click a sketch-element in the **sketch-path** The **MOTION-PATH FB** is in the graphics-area. And, a **MOTION-POINT** is at the **START-POINT** of the sketch-element you click.

STEP 3: Add a Rotating-Part for a Pulley

A **PULLEY** is a **Driving-Pulley** or **Driven-Pulley**. It is a **rotating-part**.

 **rotating-Part for a Driving-Pulley**	**STEP 3A: Type 1 - Driving-Pulley** A **Driving-Pulley** is a **rotating-Part** that **is kinematically-defined** before you do **Add Pulley**. Add a maximum of **ONE Driving-Pulley** to a Belt. 1. Add a **Rocker** with its **PIN-JOINT** at the **CENTER-POINT** of the **ARC** with a **LINE** (see **PREPARATION 1: 5**, above) OR 1. Add **PARTS** to the model, in which there is a **rotating-Part** with its **PIN-JOINT** at the **CENTER-POINT** of the **ARC** in the

sketch-path of the **Belt** - and it is **kinematically-defined.**



rotating-Part for a Driven-Pulley

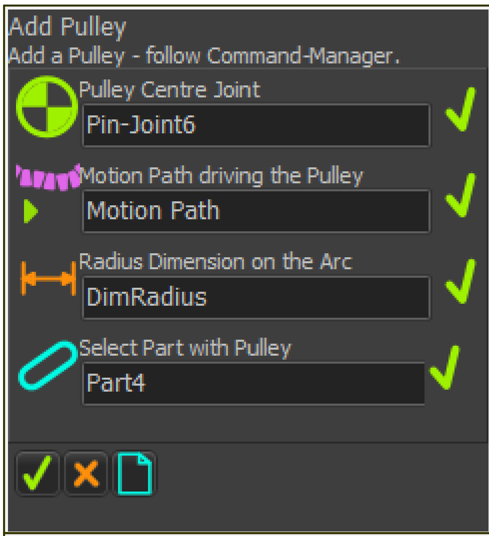
STEP 3B: Type 1 - Driven-Pulley

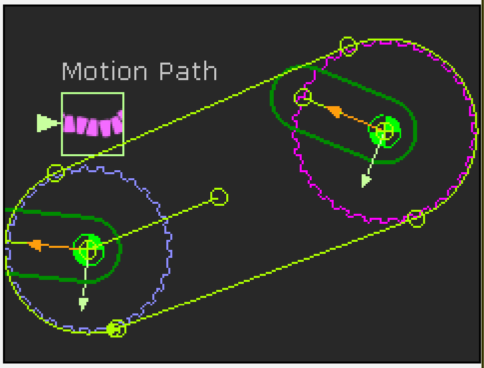
A Driven-Pulley is a **rotating-Part** that is not **kinematically-defined** before you do **Add Pulley**.

The motion of the BELT and the **Pulley's Pitch-Circle Diameter** of the control the motion of a **Driven-Pulley.**

1. Add a **rotating-Part** with its PIN-JOINT at the CENTER-POINT of each ARC with a **Driven-Pulley**.

Add Pulley





1 x Driving-Pulley (Purple)
1 x Driven-Pulley (Magenta)

Do Add Pulley to add 1 x PULLEY.

The image shows two PULLEYS after you do **Add Pulley** two times.

STEP 1: Click Add Pulley

1. **Mechanism menu > Add Pulley**

- or -

1. **Machine-elements toolbar > Add Pulley**

There are four elements to select in the COMMAND-MANAGER

STEP 2: Click the four elements

1. Click a PIN-JOINT at the center of a **rotating-Part***.
2. Click the MOTION-PATH FB.

The PART-EDITOR opens

3. Click the dimension that controls the radius of the ARC.

The PART-EDITOR closes

4. Click the **rotating-Part*** that has a PIN-JOINT (**see 1**) at the CENTER-POINT of the ARC (**see** 3)

* If the **rotating-Part** is :

- is **kinematically-defined** - the motion of the PULLEY moves the BELT (**Driving-Pulley**).

	• **is not kinematically-defined** - the motion of the **BELT** moves the **PULLEY** (**Driven-Pulley**). STEP 3: Complete the Command 5. COMMAND-MANAGER: Click ✅ in the COMMAND-MANAGER. RESULT: The schematic of the **PULLEY** shows in the graphics-area. • Use the MOTION-PATH DIALOG 469 to edit the **TOOTH-PITCH** and **LENGTH** of the **Belt**. The **PULLEY** has an integer number-of-teeth. • Use the PULLEY DIALOG 581 to edit the **NUMBER-OF-TEETH** on each **PULLEY**.

Video: Add Pulley:

Double-click to watch Video

1.5.5.1.3.8 Add Conjugate Cam FB

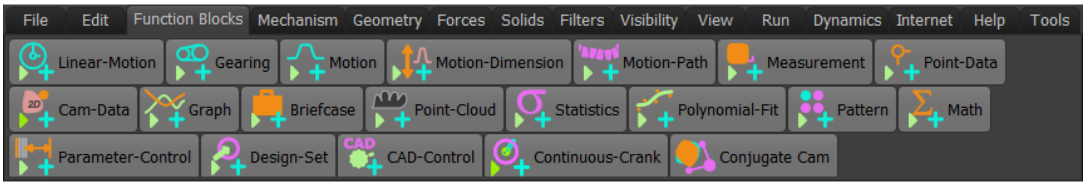
Add Conjugate Cam FB

See Function-Blocks menu > Conjugate-Cam FB[222]
See Conjugate-Cam dialog[436]

1.5.5.2 Function-Blocks

Function-Blocks menu

The **Function-Blocks menu** is active ONLY in **MECHANISM-EDITORS**.



Function-Blocks menu

Function-Block toolbars

The **Function-Blocks menu** combines the commands from two toolbars:

- Kinematic FB toolbar[169] - it is to the **right** of the graphics-area.
- Modeling FB toolbar[206] - it is **above** the graphics-area.

See also: Function-Blocks: Connecting, and Data-Types and Channels[166]

1.5.5.2.1 Function-Blocks | Connecting, Data-Types & Channels

What is a Function-Block?

FUNCTION-BLOCKS control, measure, and analyze data.

Kinematic FUNCTION-BLOCKS are elements you add:

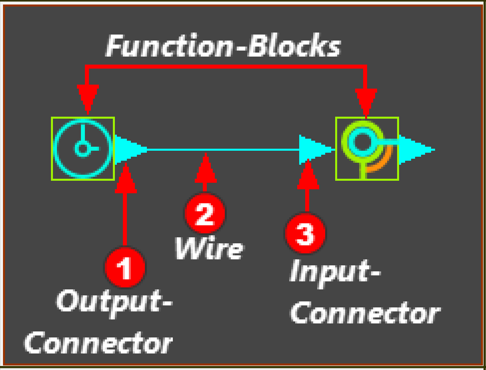
- to control the motion of **Motion-Parts** and **Motion-Points**
- to measure and plot the motion of POINTS and PARTS
- to analyze and export cam-coordinates and cam performance data

---

Modeling FUNCTION-BLOCKS are those elements you add:

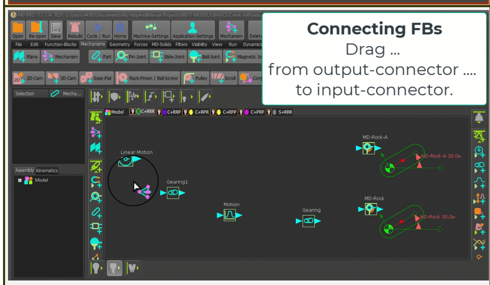
- to provide special functions for more complex modeling
- to analyze data from the output of Kinematic FUNCTION-BLOCKS
- to control the model behavior
- to increase your productivity

Function-Blocks: Wires and Connectors



FUNCTION-BLOCKS (most) have **input-connectors**❸ and/or **output-connectors**❶.

When you cycle the model, data flows instantly along **wires**❷ and through the FUNCTION-BLOCKS that you connect together.



Video - Connecting FBs

To connect FUNCTION-BLOCKS with a wire❷, ...

... hover then drag your mouse-pointer from the **output-connector** of a FUNCTION-BLOCK to

... hover and drop at the **input-connector** of a different FUNCTION-BLOCK.

Video: How to connect Function-Blocks with wires 643

All Data has a data-type.

For example: the data-type that controls the motion of a Slider is the **Linear data-type**.

The color of a wire is a function of its data-type

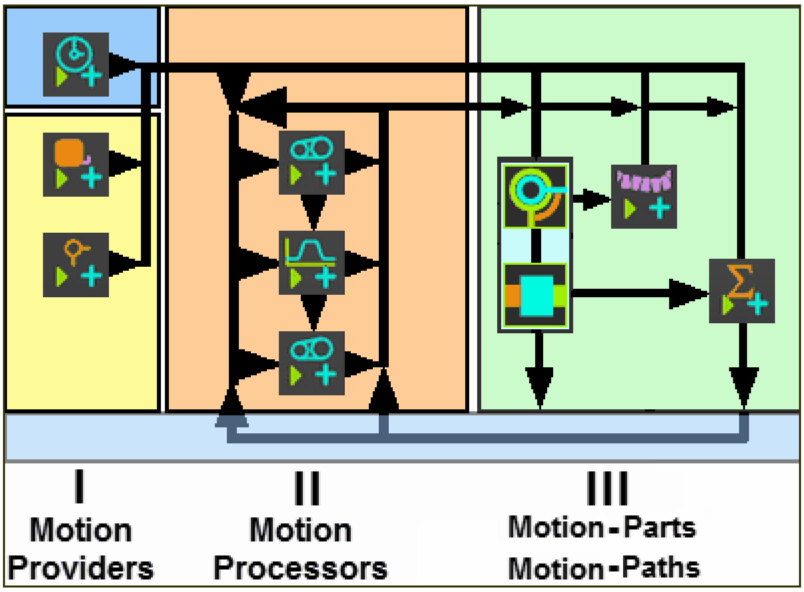
For example: the wire color of the **Linear data-type** is Blue.

Each Data-Type has up to three Data-Channels.

For example: the Data-Channels of the **Linear data-type** are Position, Velocity, and Acceleration.

How to arrange the wires that connect Function-Blocks

This image is a schematic of how you can connect with wires the FUNCTION-BLOCKS from the Kinematic Function Blocks toolbar.



Schematic: Function-Block Wires and Connectors

Kinematic Function-Blocks: Data-Types and Data-Channels

LINEAR-MOTION FB

Output DATA-TYPE = ROTARY :

DATA-CHANNELS: Master Machine Angle, Angular-Velocity, and Angular-Acceleration. The Angular Velocity is proportional to the CYCLES / MIN - **see** Machine-Settings dialog351 .

GEARING FB

Output DATA-TYPE = Input DATA-TYPE

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

MOTION FB

Input DATA-TYPE = ROTARY OR LINEAR

Output DATA-TYPE = ROTARY OR LINEAR

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

MOTION-DIMENSION FB

Input DATA-TYPE = ROTARY OR LINEAR

Output DATA-TYPE = ROTARY if Rocker ; LINEAR if Slider

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

MOTION-PATH FB

Input **DATA-TYPE** = **ROTARY** **OR** **LINEAR**

Output : no connector

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

---

MEASUREMENT FB

Output **DATA-TYPE** = **ROTARY** **OR** **LINEAR**

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

---

POINT-DATA FB

Output **DATA-TYPE** = **LINEAR**

DATA-CHANNELS: Linear or Angular Position, Velocity, and Acceleration

---

MATH FB (in Modeling toolbar[206])

Input **DATA-TYPE** = **LINEAR**, **ROTARY**, **FORCE**, or **TORQUE**

Output **DATA-TYPE** = **ANY**

DATA-CHANNELS: different Data-Types with different data-channels, **See Math FB dialog[510]**

FORCE DATA FB (in Forces toolbar[226])

Output **DATA-TYPE** = **TORQUE** or **FORCE**

DATA-CHANNELS: Force or Torque, X-Force component, Y-Force component

1.5.5.2.2 Kinematic Function-Blocks

Kinematic Function-Blocks (FB)

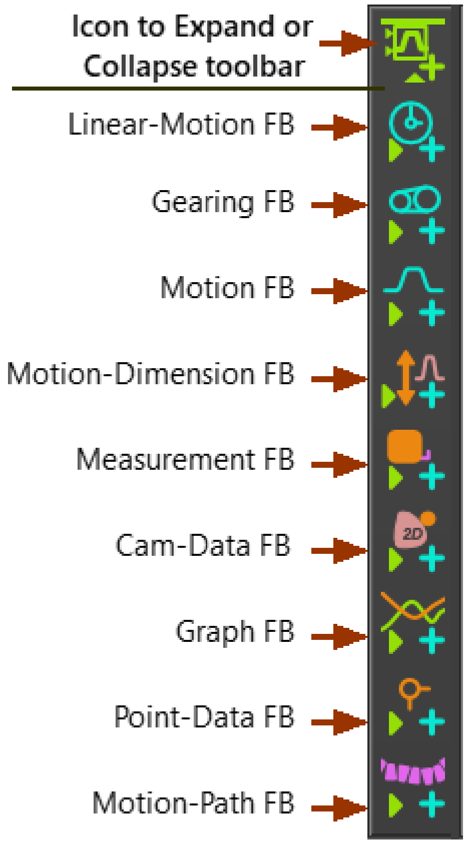
Use **KINEMATIC FBs** to plan and control the motion* of kinematic-chains; to measure and plot linear or angular motion over a machine-cycle; and to calculate and export **Cam-Coordinates**.

* **Motion** - Position, Velocity, and Acceleration, with Linear or Angular motion-units[352] .

See also How to connect FBs[643]

Kinematics FB toolbar

The **Kinematic FB toolbar** is to the **right** of the graphics-area.



Kinematic FB toolbar

1.5.5.2.2.1 Add Linear-Motion FB

Linear-Motion FB

See also: Linear Motion dialog [458]

Terminology

MASTER MACHINE ANGLE (MMA) :	The **MMA** is the Master machine-clock, that, when you run your model, increases at a constant rate from 0 to 360, again and again. One cycle of the MMA (from 0 to 360) and machine is one machine-cycle. The **MMA** is at the bottom and left of the **MechDesigner** application.
LINEAR MOTION FB :	The default output from a **LINEAR-MOTION FB** is equal to the **MMA (0 - 360)**. You can edit the **LINEAR-MOTION FB** to add or subtract a value from the default output. The **LINEAR-MOTION FB** is usually the first of the **FBS** that you connect together with wires.

Linear-Motion FB function

The function of the **LINEAR-MOTION FB** is:

$$[\![MMA + a]\!] = y_{out}$$

Output = **MMA** ± 1

Use the LINEAR-MOTION DIALOG [458] to edit 1

Add Linear-Motion FB

STEP 1: Add a Linear-Motion FB to the graphics-area

1. Click Kinematics FB toolbar [169] > **Linear-Motion FB**

OR

1. Click **Function-Blocks menu** > **Linear-Motion (FB)**

2. Click the graphics-area

The **LINEAR-MOTION FB** is now in the graphics-area (and **ASSEMBLY-TREE**).

For most models, the default output from the **LINEAR-MOTION FB** (equal to the **MMA**) is correct.

If you want to change the output relative the **MMA** by a constant:

STEP 2: Open the Linear-Motion dialog:

1. Double-click the **LINEAR-MOTION FB** in the graphics-area.

OR

1. **See How to Open a dialog** [627]

The **LINEAR-MOTION DIALOG** is now open.

Dialog :	STEP 3: **See Linear-Motion dialog** 458

1.5.5.2.2.2 Add Gearing FB

Gearing FB

See also: Gearing FB dialog[459]

Terminology

GEARING FB :	The **GEARING FB** modifies motion-values with a linear equation / function. The function has 3 parameters that you can edit in the Gearing FB dialog[459]

Gearing FB function

The flow from the input, through the **GEARING FB**, to the output is:

$$x_{in} \Rightarrow [\![a(x_{in} + b) + c]\!] \Rightarrow y_{out}$$

Or, you can say:

$$Output = (a \times (input + b)) + c$$

Use the GEARING FB DIALOG[459] to edit a, b, and c.

Add Gearing FB

What to do:	**STEP 1: Add a Gearing FB to the graphics-area**  1. Click Kinematics FB toolbar[169] > **Gearing FB** OR 1. Click **Function-Blocks menu > Gearing (FB)** 2. Click the graphics-area The **GEARING FB** is now in the graphics-area (and **ASSEMBLY-TREE**). **STEP 2: Open the Gearing FB dialog** 1. Double-click a **GEARING FB** in the graphics-area, or the **ASSEMBLY-TREE** OR 1. See **How to Open a dialog**[627]
Dialog :	**STEP 3: See Gearing FB dialog**[459]

Notes:

- The default parameters do not change the motion-data.
- Connect a **GEARING FB** to the input of a **MOTION FB** to change the frequency of a motion by the Gearing-Ratio
- Connect a **MOTION FB** to the input of a **GEARING FB** to change the amplitude and/or direction of a motion by the Gearing-Ratio.

1.5.5.2.2.3 Add Motion FB

Motion FB

See also: Motion FB dialog 462

Terminology

MOTION FB :	The MOTION FB is a link to one motion-design, in **MotionDesigner**.
Motion name-tab :	In **MotionDesigner**, the tab at the top of each motion that you can click to switch to that motion.

Motion FB function

The **MOTION FB** has a link with one **Motion** in **MotionDesigner**.

You can edit the **MOTION FB** to select which **Motion** - identified by its **Motion name-tab**.

The motion-values at the input-connector to the **MOTION FB** correspond to the X-axis of the **Motion**.

The motion-values at the output-connector from the **MOTION FB** correspond to the Y-axis values of the **Motion**.

$$(x) \Rightarrow [\![Motion(x)]\!] \Rightarrow (y)$$

Add Motion FB

What to do:	STEP 1: Add a Motion FB to the graphics-area.  1. Click Kinematics FB toolbar 169 > Motion FB OR 1. Click Function-Blocks menu > Motion (FB) 2. Click the graphics-area The **MOTION FB** is now in the graphics-area and ASSEMBLY-TREE. STEP 2: Open the Motion FB dialog 1. Double-click the **MOTION FB** in the graphics-area or ASSEMBLY-TREE OR 1. **See How to Open a dialog** 627 The **MOTION FB DIALOG** is now in open.
Dialog :	STEP 3: See Motion FB dialog 462

1.5.5.2.2.4 Add Motion-Dimension FB

Motion-Dimension FB

See also: Motion-Dimension dialog [466]

Terminology

Motion-Part :	A PART whose angular or linear position and motion relative to a different PART you control with a MOTION-DIMENSION FB.
Rocker :	A **Motion-Part** that rotates.
Slider :	A **Motion-Part** that slides.
MOTION-DIMENSION FB :	Add this FUNCTION-BLOCK to a PART that has one degree-of-freedom to change it to a **Motion-Part**: **Rocker** or **Slider**.
BASE-VALUE :	The parameter we use to offset the **Motion-Part**.

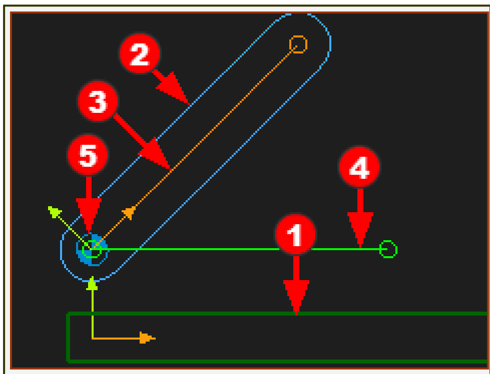
Add Motion-Dimension FB - ROCKER

Prepare the model with these elements.

ROCKER

Element #	Element Type	Rules
#1	PIN-JOINT	Is between POINTS that are in two different PARTS • each POINT is the START-POINT or END-POINT of a LINE (or CAD-LINE)
#2	LINE	• This LINE radiates from the PIN-JOINT (see ELEMENT #1) • AND this LINE is a child to a PART that IS **kinematically-defined**
#3	LINE	• This LINE also radiates from the PIN-JOINT (see ELEMENT #1) • AND this LINE is in a PART that IS NOT **kinematically-defined**

Preparation: Motion-Dimension - Rocker (typical)

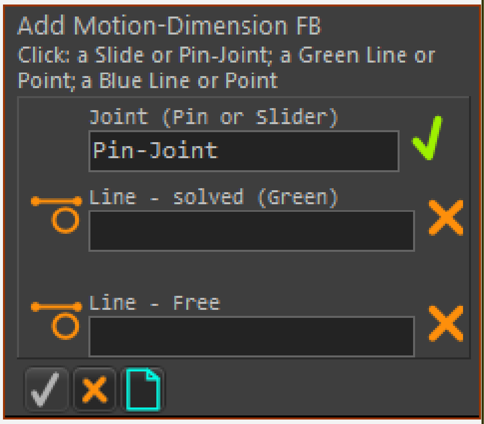
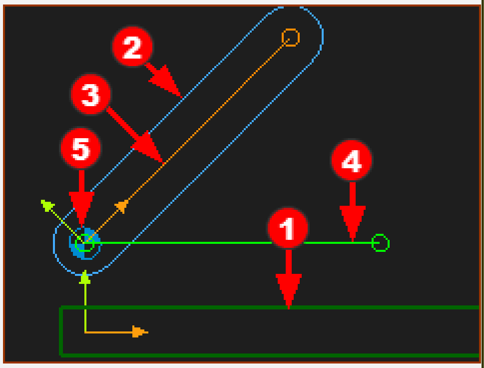


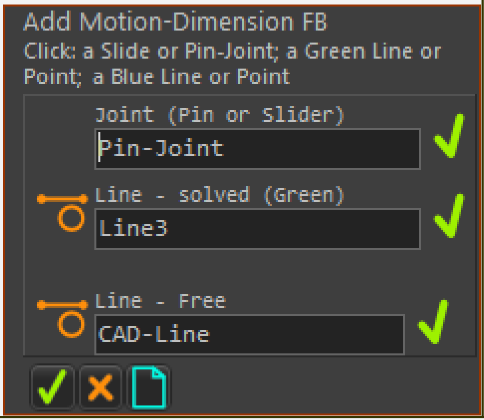
Preparation example:

- Two(2) PARTS. In this case the BASE-PART❶ and a ROTATING-PART❷.
- LINES❸❹ in each PART
- PIN-JOINT❺ joins the START-POINT and/or END-POINTS of each LINE❸❹
- PART❶ is **kinematically-defined**

	• PART❷ is not kinematically-defined See Add Line 277, Add Part 108, Add Pin-Joint 102

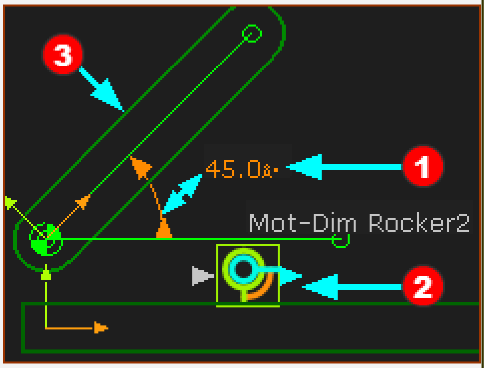
Add Motion-Dimension FB (Rocker)

	STEP 1: Select the Add Motion-Dimension FB command 1. Click Kinematics FB toolbar 169 > Motion-Dimension FB OR 1. Click Function-Blocks menu > Motion-Dimension FB The COMMAND-MANAGER indicates that there are three elements to select:
	STEP 2: Select the three elements in the graphics-area ELEMENT #1: PIN-JOINT 1. Click a PIN-JOINT❺ The PIN-JOINT must be a joint between two(2) PARTS, and: • One PART must be kinematically-defined • The other PART must be free and joined with a PIN-JOINT to the PART that is kinematically-defined ELEMENTS #2 and ELEMENT #3: LINES ❸❹ Each LINE must be a child to a POINT and also a child to the PIN-JOINT. (ELEMENT #1) 2. Click LINE❹ in the PART that is kinematically-defined❺ 3. Click LINE❸ in the free PART❷ STEP 3: Complete the Command 1. Click ✓ in the COMMAND-MANAGER to complete Add Motion-



Dimension FB (Rocker).

RESULT:



The **Mobility** of the kinematic-chain is now Zero(0).

PART❸ is now a PART that is **kinematically-defined**.

The MOTION-DIMENSION❶ and MOTION-DIMENSION FB❷ controls the angle between the LINES

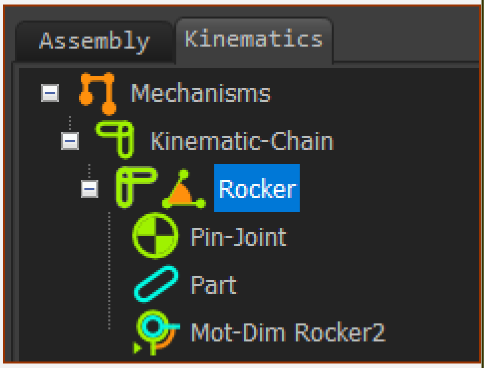
- The MOTION-DIMENSION FB icon ❷ in the graphics-area for a ROCKER.

Note: In the graphics-area:

- To move the MOTION-DIMENSION❶ : CTRL+ DRAG **the FB icon**❷
- To move the MOTION-DIMENSION FB ❷ : DRAG **the FB icon**❷

Dialog : STEP 3: Open the dialog - **See** Motion-Dimension dialog[466]

Kinematics-Tree - Motion-Dimension (Rocker)



When you add a MOTION-DIMENSION FB to a PIN-JOINT, you add a **Rocker** to the KINEMATICS-TREE.

The kinematic elements are:

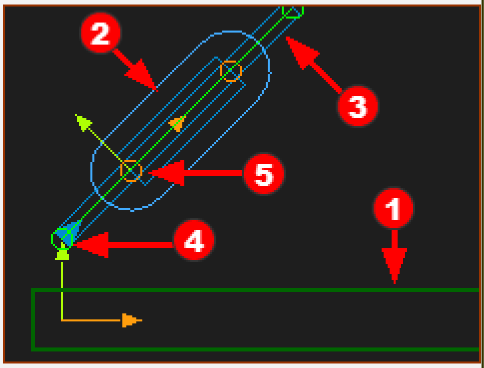
Part + Pin-Joint + Motion-Dimension = ROCKER

Add Motion-Dimension FB and SLIDER

Prepare the model with these elements.

SLIDER		
Element #	Element type	Rules
#1	SLIDE-JOINT	The SLIDE-JOINT between LINES* that are in two different PARTS • Each LINE* is a child to a different PART (* LINE and/or CAD-LINE)
#2	START-POINT or END-POINT	The START-POINT or END-POINT of a LINE in the SLIDE-JOINT (ELEMENT #1), • the LINE is in a PART that IS **kinematically-defined**
#3	START-POINT or END-POINT	The START-POINT or END-POINT of the other LINE in the SLIDE-JOINT (ELEMENT #1) • the LINE is in a PART that is IS NOT **kinematically-defined**

Preparation: Add Motion-Dimension - Slider (typical)



Preparation example:

1. Two(2) PARTS❶❷

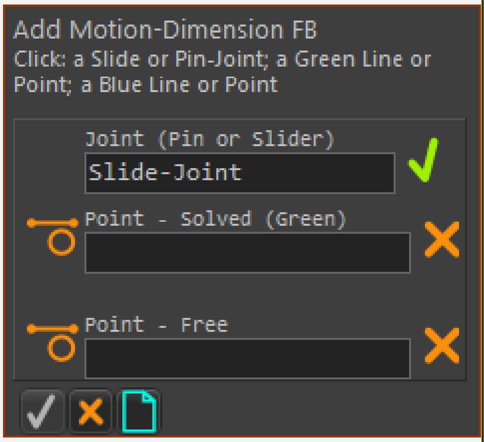
   One PART is **kinematically-defined** ...the BASE-PART❶

   The other PART that is **free** ❷
2. The PARTS are Joined... with a SLIDE-JOINT❸
3. START POINT❹ (or END-POINT) of a LINE in the PART that is **kinematically-defined**
4. START-POINT❺ (or END-POINT) of a LINE in the PART that is **free**

The LINES are those that you select for the SLIDE-JOINT❸.

See Add Line 277 , Add Part 108 , Add Pin-Joint 102

Add Motion-Dimension FB (Slider)

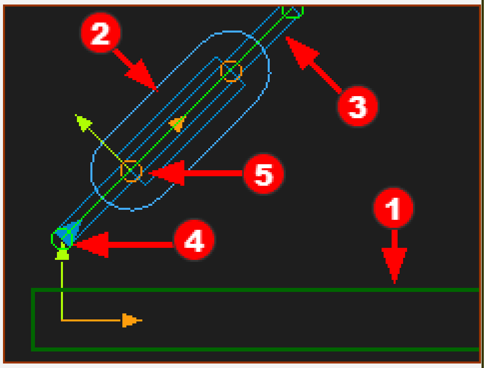


STEP 1: Add the **MOTION-DIMENSION FB**

1. Click Kinematics FB toolbar[169] > **Motion-Dimension FB**

OR

1. Click **Function-Blocks > Add Motion-Dimension FB**



STEP 2: **Select three elements in the graphics-area**

ELEMENT #1: SLIDE-JOINT

1. Click a SLIDE-JOINT 3

The SLIDE-JOINT must be a joint between two(2) PARTS, and:

- One PART is **kinematically-defined** 1
- The other PART is **free** 2

ELEMENTS #2 and ELEMENT #3: POINTS 4 5

Each POINT must be a child to a LINE that is also a child to the SLIDE-JOINT. (ELEMENT #1)

2. Click the POINT 4 in the PART that is **kinematically-defined** 1
3. Click the POINT 5 in the PART that is **free** 2

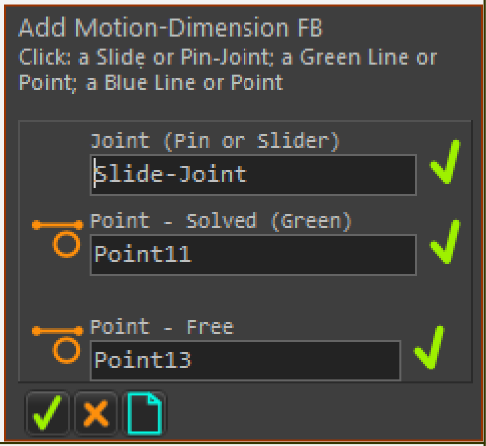
STEP 3: **Complete the Command**

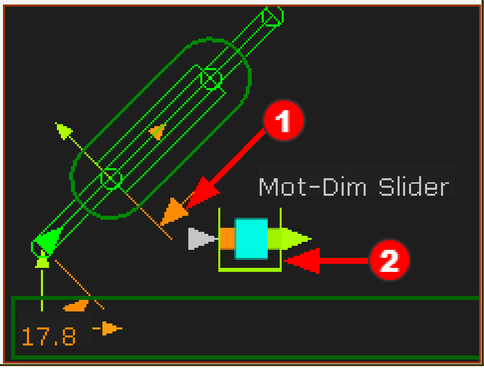
1. **Click** ✓ **in the COMMAND-MANAGER** to complete **Add Motion-Dimension FB (Slider)**.

RESULT :

The free PART is now **kinematically-defined**.

The MOTION-DIMENSION 1 and MOTION-DIMENSION FB 2 controls the distance between the POINTS





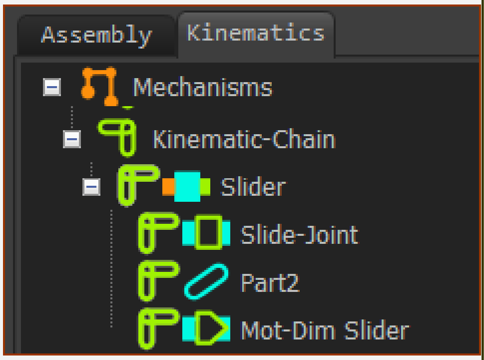
The MOTION-DIMENSION FB icon ❷ in the graphics-area for a SLIDER.

Note: In the graphics-area:

- To move the MOTION-DIMENSION : CTRL + DRAG the FB icon
- To move the MOTION-DIMENSION FB : DRAG the FB icon

STEP 4: Open the dialog - See Motion-Dimension dialog [466]

Kinematics-Tree - Motion-Dimension (Slider)



When you add a MOTION-DIMENSION FB to a SLIDE-JOINT, you add a **Slider** to the KINEMATICS-TREE.

The kinematic elements are:

Part + Slide-Joint + Motion-Dimension = SLIDER

Videos: Add Part, Add Joint, Add Motion-Dimension FB:

Add Motion-Dimension FB to a Pin-Joint Double-click to watch Video (Rocker)

Add Motion-Dimension FB to a Slide-Joint Double-click to watch Video (Slider)

Special Methods

Frequently, in a machine, PIN-JOINTS can be coincident (co-axial) and SLIDE-JOINTS can be collinear.

There are two or more **rotating-Parts** that rotate about one center, or two or more **sliding-Parts** that slide along one axis.

Special Method: Coincident Pin-Joints

If you want to control the motion of each **rotating-part** with a different MOTION-DIMENSION FB, you must carefully plan as to which POINTS you select when you add the PIN-JOINTS.

Then, when you add the MOTION-DIMENSION FBS, the MOTION-DIMENSIONS can reference the correct PARTS.

The POINTS you select when you add the PIN-JOINTS determine between which two PARTS you can add the MOTION-DIMENSION FB.

Special Method: Coincident Slide-Joints

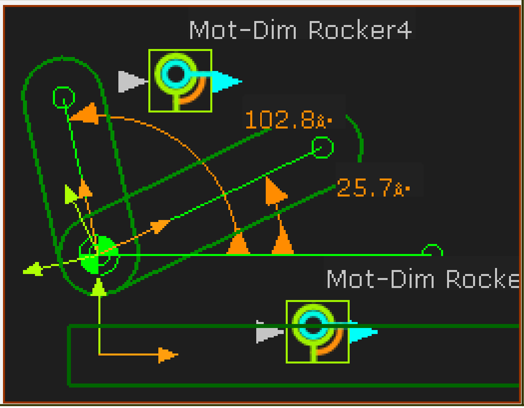
If you want to control the motion of each **sliding-part** with a different MOTION-DIMENSION FB, you must carefully plan as to which LINES you select when you add the SLIDE-JOINTS.

Then, when you add the MOTION-DIMENSION FBS, the MOTION-DIMENSIONS can reference the correct PARTS.

The LINES you select when you add the SLIDE-JOINTS determine between which two PARTS you can add the MOTION-DIMENSION FB.

Special Method 1

The methods and principles described below apply to Rockers and Sliders. However, the descriptions below are given for Rockers only.



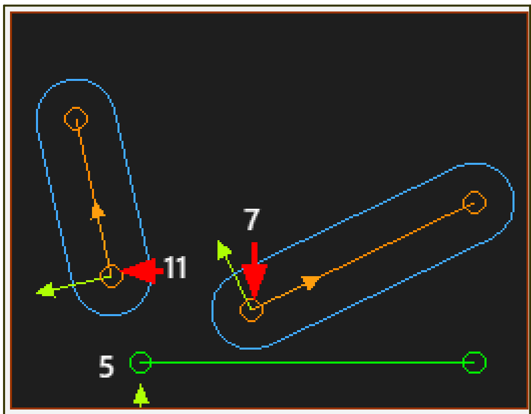
Result of Special Method 1:

The model shows

- Two MOTION-DIMENSION FBS
- They reference the same LINE in the BASE-PART.

You can see the dimension of the two MOTION-DIMENSIONS FBS start at the green horizontal LINE.

STEP 1: Add Pin-Joints two times



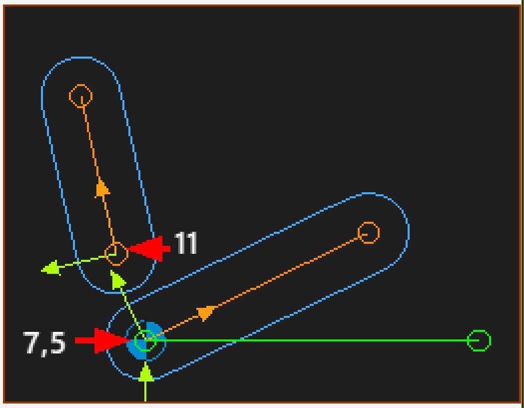
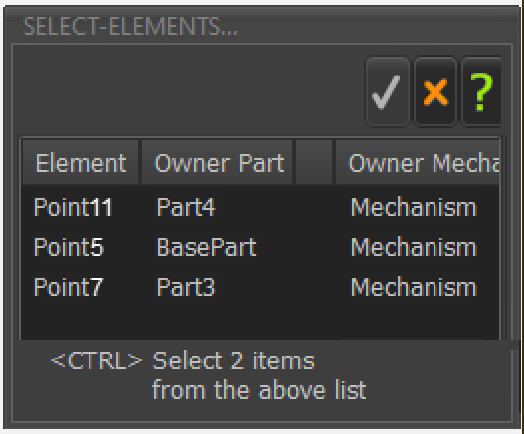
There are two added PARTS

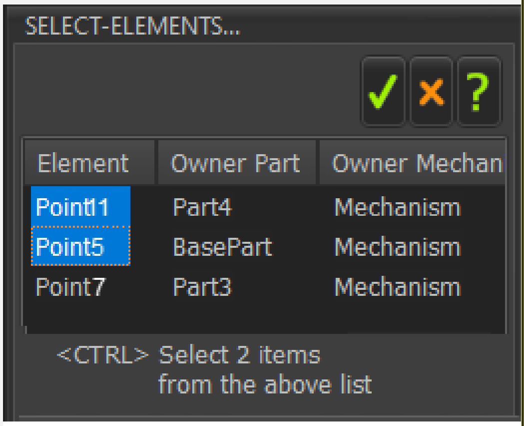
There is an added PART. As always, it has a CAD-LINE, with a START-POINT and an END-POINT.

There is also LINE. This LINE is in the BASE-PART, which you cannot see.

There are **three(3)** LINES in **three(3)** PARTS in total.

The START-POINTS of the LINES are **5**, **7** and **11**.

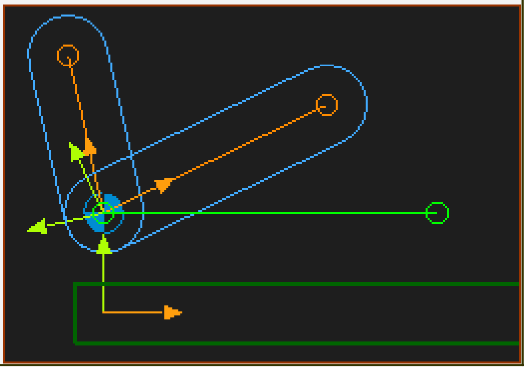
	Note: You can select the **START-POINTS** and/or the **END-POINTS**. However, when possible, use the **START-POINTS**.
	**ADD PIN-JOINT #1** In the image to the left, **PIN-JOINT #1** is between **POINT 7** and **5** Now, add a **PIN-JOINT**. **#2** **ADD PIN-JOINT #2** Add **PIN-JOINT #2** between **POINTS 11** and **5.** Q: Why **POINTS 11** and **5** and not **11** and **7** ? A: You want the **MOTION-DIMENSIONS** to reference the horizontal **LINE** in the **BASE-PART.**
	**Add Pin-Joint** : 1. Click **Point 11** and then ***try*** to click **Point 5.** The **SELECT-ELEMENTS DIALOG** opens! Why? Because there is ambiguity. **POINTS 5** and **7** are at the same position. You have actually clicked three **POINTS** (**11, 7** and **5**). You must select the two **POINTS** for the **PIN-JOINT**. About the **SELECT ELEMENTS DIALOG**: • Is a list of **ALL** of the elements that you have clicked • The element that you selected first is always at the top of the list. • None of the elements are selected.



2. CTRL + CLICK ALL of the elements you need to complete the command.

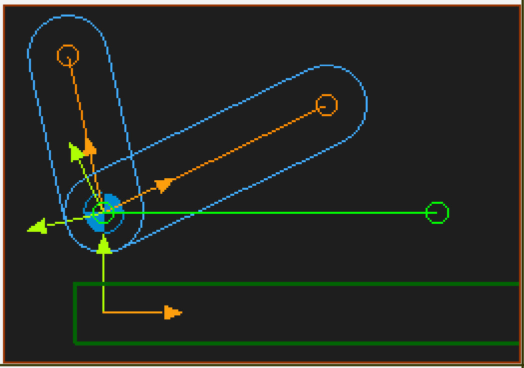
In this image, select POINT 11 and POINT 5

1. **CTRL + CLICK Point11 AND Point5**
2. **Click ✓**



Now, the two PARTS are joined with a PIN-JOINT to one POINT in the BASE-PART.

STEP 2: Add Motion-Dimension FB two times

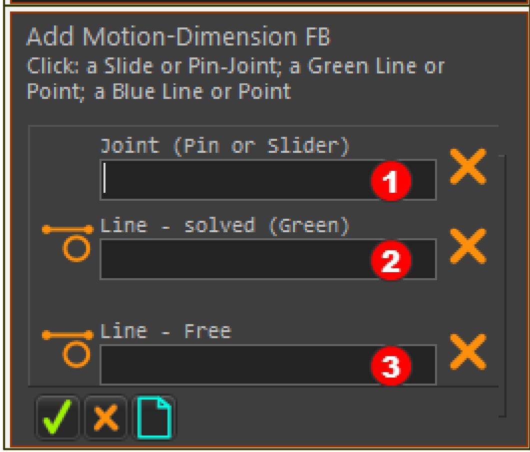


The two PARTS are now joined to the BASE-PART with two PIN-JOINTS

Now, use the MOTION-DIMENSION FB two times

ADD MOTION-DIMENSION 1

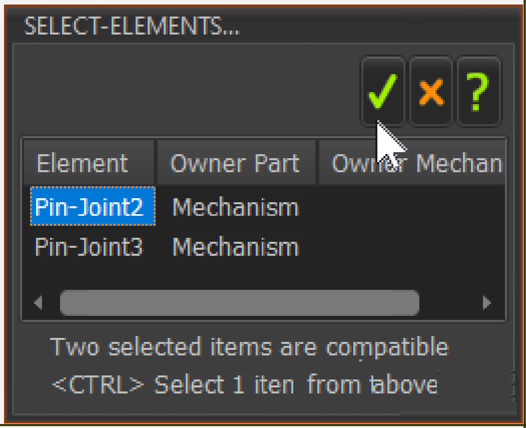
1. Click Function-Block toolbar > Add Motion-Dimension FB.



The **COMMAND-MANAGER** show that you must select three elements ❶, ❷ and ❸.

The first-element must be a PIN-JOINT or SLIDE-JOINT.

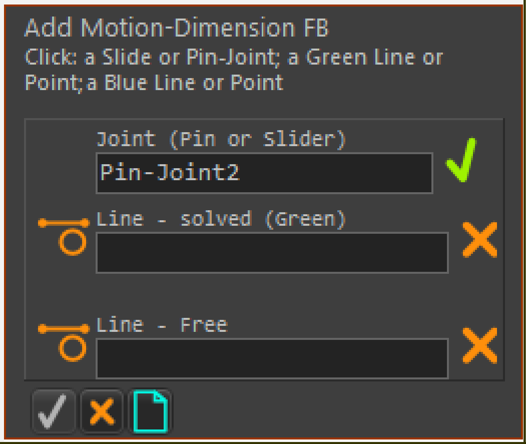
There are two PIN-JOINTS!

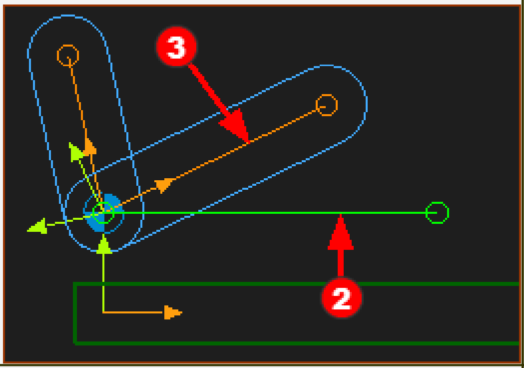


When you click the **PIN-JOINTS** in the graphics-area the **SELECT-ELEMENTS DIALOG** opens as there are two **PIN-JOINTS**.

In the **SELECT-ELEMENTS DIALOG**:

Click the **PIN-JOINT**.

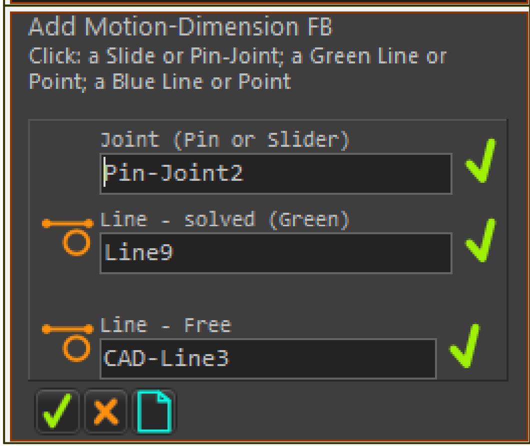




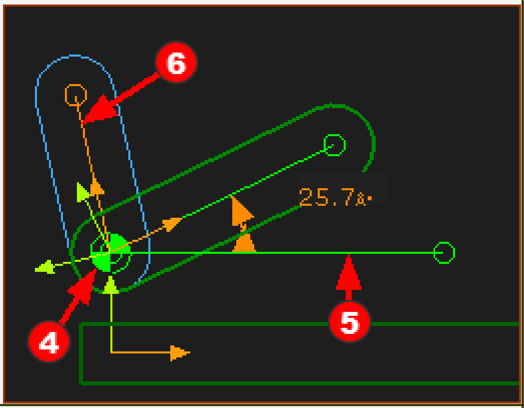
Now, select two **LINES**.

Click the horizontal **LINE** ❷ as the second element.

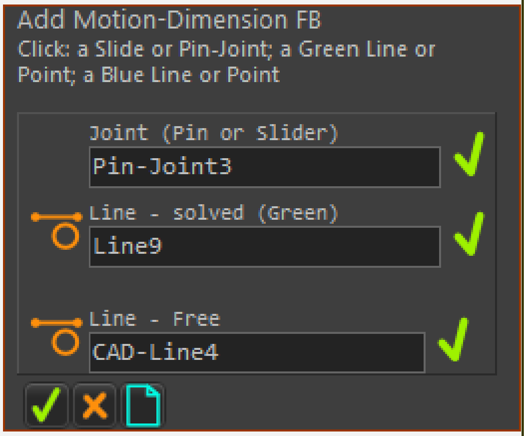
Click the **CAD-LINE** ❸ along one the **PARTS** with which the **PIN-JOINT** is made.



This image shows the three elements in the Command-Manager boxes.

<table>
<tr>
<td>
</td>
<td>The first Rocker MOTION-DIMENSION FB.

ADD MOTION-DIMENSION #2

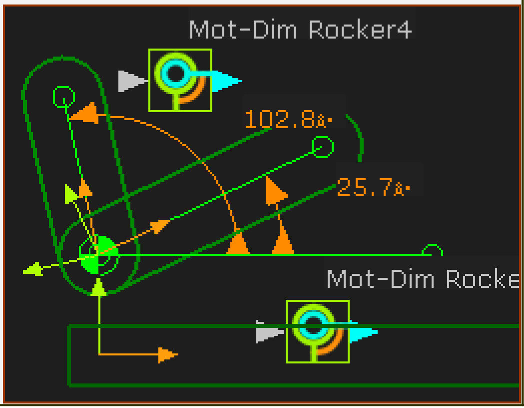
You must now select another three elements,❹❺❻</td>
</tr>
<tr>
<td>
</td>
<td>Function-Block Toolbar > Motion-Dimension FB again.

These are the elements.

❹ JOINT: PIN-JOINT2.

Now, there is no ambiguity. There is only one PIN-JOINT available.

❺ LINE – Solved: select the horizontal LINE.

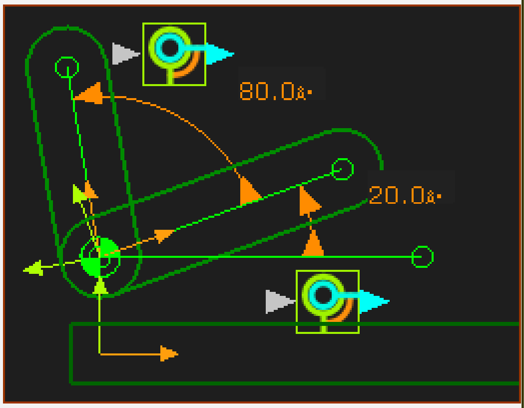
❻ LINE – Free: select the CAD-LINE along the center of the Blue PART.</td>
</tr>
<tr>
<td>
</td>
<td>Here, you can see the result.

Both MOTION-DIMENSIONS FBS use the Horizontal LINE in the BASE-PART as a reference for the motion-dimension.

Note: When you add two MOTION-DIMENSIONS, the FBS may be on top of each other.

Drag each FB so you can see them.</td>
</tr>
</table>

Special Method 2:

<table>
<tr>
<td>
</td>
<td>Result of Special Method 2
MOTION-DIMENSION 1:

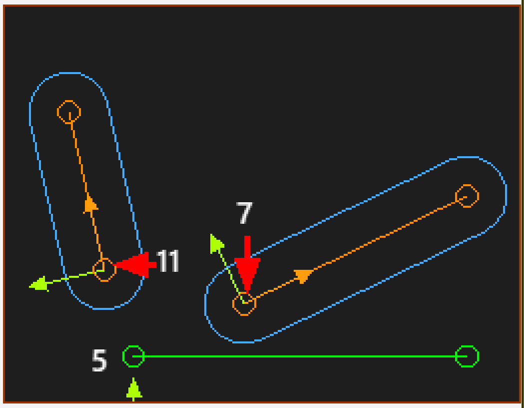
From the LINE in the BASE-PART

To a LINE in 'PART 1'
MOTION-DIMENSION 2:

From the LINE in 'PART 1'

To the LINE in 'PART 2'</td>
</tr>
</table>

STEP 1: Add Pin-Joint two times

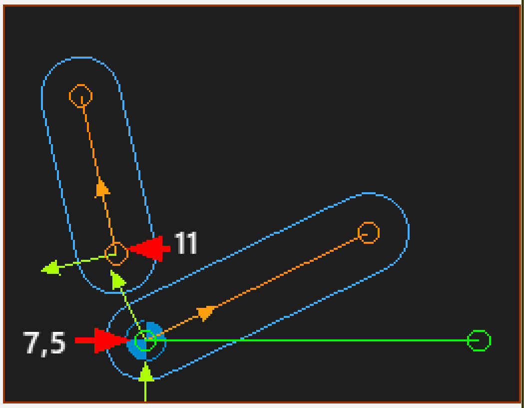


Again, there are two PARTS and a LINE in the BASE-PART.

The POINTS at the ends of the LINES are 5, 7 and 11.

You want to:

- Add a PIN-JOINT between 'POINT7' and 'POINT5', and
- Add a PIN-JOINT between 'POINT11' and 'POINT7'.

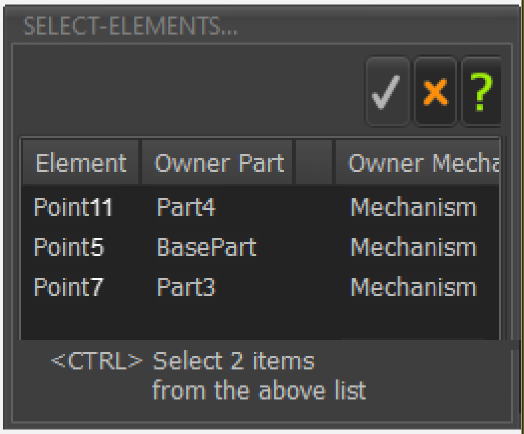


In the image to the left, POINT7 is joined to POINT5

CONDITION 2

Add the second PIN-JOINT between POINT11 to POINT7.

- **Q:** Why POINT7 and **not** POINT5 **?**
- **A:** Because POINT7 is a child to CAD-LINE❶, you want this MOTION-DIMENSION to reference CAD-LINE❶.
- We do <u>not</u> want the MOTION-DIMENSION to reference the LINE in the BASE-PART. That was **Method 1,** above.

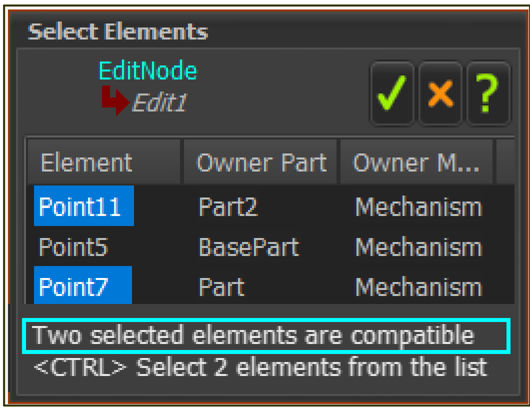


Select POINT11.

Then try to select POINT7

There is ambiguity between POINT5 and POINT7. Hence, the SELECT ELEMENTS DIALOG opens.

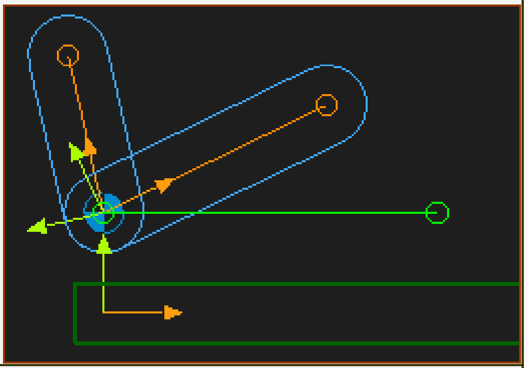
- ALL the elements you need for the command are made available to you
- The first element you select is at the top of the list.



In the image to the left, we have selected for you POINT11 and POINT7.

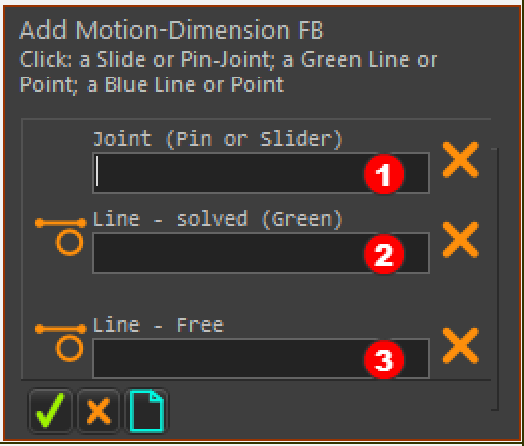
1. CTRL + CLICK Point11 AND Point7
2. Click ✓

STEP 2: Add Motion-Dimension FB two times

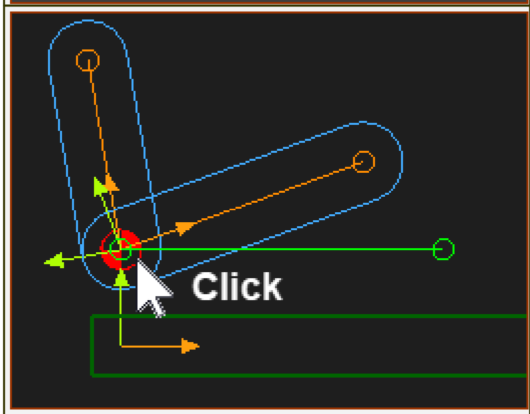


The two PARTS are joined with a PIN-JOINT.

Do Add Motion-Dimension FBs **two times.**



You must select three elements to do Add Motion-Dimension FB

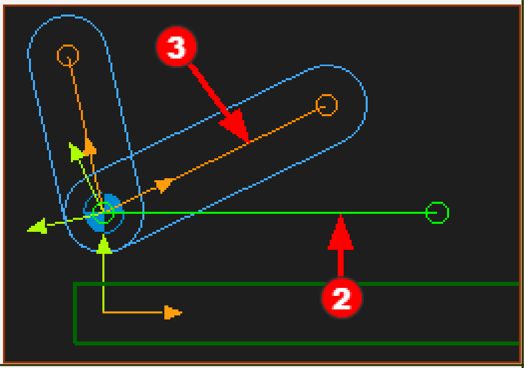
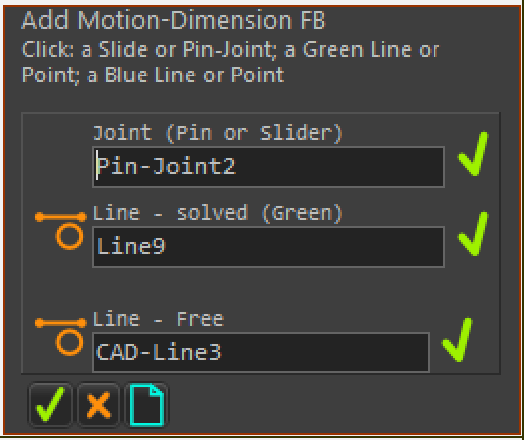
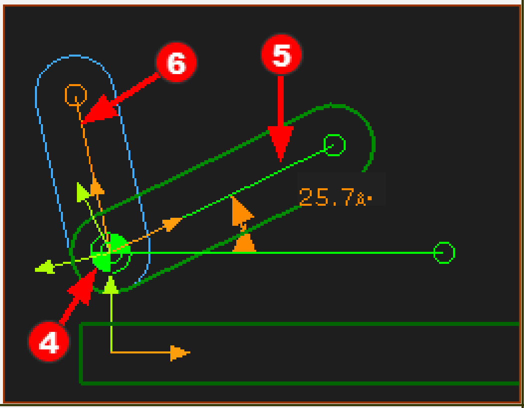
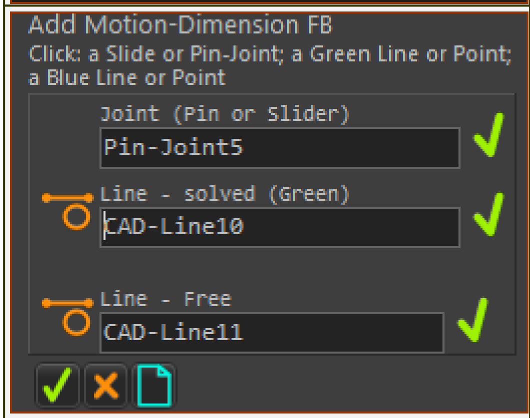


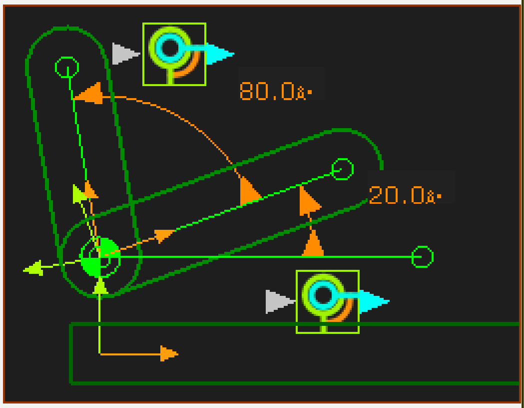
ELEMENT 1: A Joint.

There is NO ambiguity when you select the PIN-JOINT.

There is only ONE PIN-JOINT between a POINT in the PART that is **kinematically-defined** and the other POINT in the PART that is **free**.

The SELECT ELEMENTS DIALOG does NOT open.

	**ELEMENTS 2 and 3:** Two LINES – a **Solved** LINE❷ then a **Free** LINE❸ Select the Horizontal LINE❷ and the CAD-LINE❸
	The three elements in the COMMAND-MANAGER Click ✓ in the COMMAND-MANAGER
	You can see the First MOTION-DIMENSION FB. **Add the second Motion-Dimension.** You must select three elements,❹❺❻
	These are the element-types 1. PIN-JOINT5, there is **no ambiguity** because the existing Motion-Dimension FB uses Pin-Joint2. 2. CAD-LINE10: you must select this CAD-LINE because it is a child to a PART that **IS kinematically-defined** and its START-POINT is referenced by PIN-JOINT6 3. CAD-LINE11: you must select this CAD-LINE because it is a child to a PART that **IS NOT kinematically-defined** and

	its **START-POINT** is referenced by **PIN-JOINT6**
	This image shows the end result. **MOTION-DIMENSION FB #1:** uses the Horizontal **LINE** that is a child to the **BASE-PART** as a **reference Line**. **MOTION-DIMENSION FB #2:** uses the **CAD-LINE** along the center of the ***added*** **PART** as the **reference Line**. The **CAD-LINE** is **kinematically-defined** after you add **MOTION-DIMENSION FB** #1 - see Method 1 Note: When you add two **MOTION-DIMENSIONS**, the FBs may be on top of each other. **DRAG** each FB so you can see each of them.

Positive' Direction of Slide-Joints and Slider

The nursery rhyme : **She swallowed a cat, that swallowed a mouse, that swallowed a spider, that swallowed a fly**... comes to mind!

A Slider

To add a **MOTION-DIMENSION FB** (for a Slider) you must select a **SLIDE-JOINT**, and then one **POINT** from each of the two **LINES** that define the **SLIDE-JOINT**.

- The properties of the **MOTION-DIMENSION FB** are determined by the properties of the **SLIDE-JOINT**.
- The properties of the **SLIDE-JOINT** are determined by the properties of the **LINES** you select to add the **SLIDE-JOINT**.
- The **LINES** are defined by their **START-POINTS** and **END-POINTS**.

Therefore, the **positive-direction** of the **MOTION-DIMENSION** for a **SLIDER** is defined by the **START-POINT** and **END-POINT** of the two **LINES** in the **SLIDE-JOINT**.

If the positive-direction of the **MOTION-DIMENSION** is not as you want, you need to add the **LINES** and **SLIDE-JOINT** again.

Top-Tip - Try to Plan ahead as you add the different elements. Drag **LINES** and **PARTS** from the **START-POINT** to the **END-POINT** in the **same positive direction** of the **MOTION-DIMENSION**.

Always, the **Positive Direction** of a **MOTION-DIMENSION** for a **SLIDER** :

'...is the **Positive Direction** of the LINE, or CAD-LINE, that is a child to the PART that is **kinematically-defined** before you add the MOTION-DIMENSION FB to the SLIDE-JOINT.

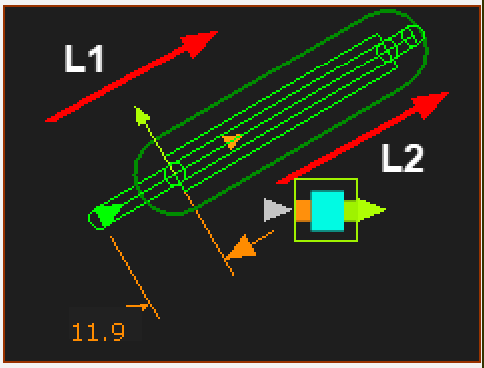
What is the Positive Direction of a Line, CAD-Line, or Part?

The direction in which you drag - from its START-POINT to its END-POINT - when you add the LINE, CAD-LINE, or PART.

EXAMPLES: positive direction of SLIDERS

- LINE 1 is a child to a PART that IS **kinematically-defined** before you add the MOTION-DIMENSION FB
- LINE 2 is a child to a PART that IS **kinematically-defined** after you add the MOTION-DIMENSION FB

I have used the ***red arrows*** to show the direction in which I dragged my mouse-point to add the LINES and PARTS.

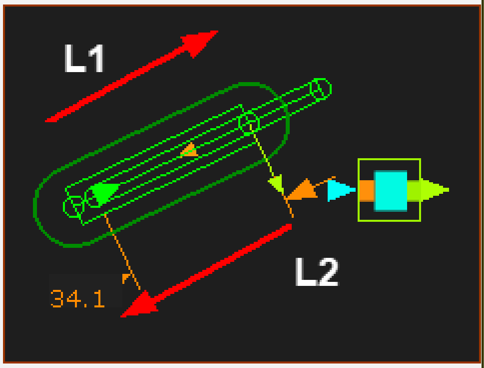


- LINE 1 – **L1** in the BASE-PART- Drag up to the right
- CAD-LINE/PART 2 – **L2** - Drag up to the right

The MOTION-DIMENSION is 11.9mm.

If you Increase the MOTION-DIMENSION value, you move the SLIDER up to the right.

The small **arrowhead** shows the positive direction of the SLIDER.

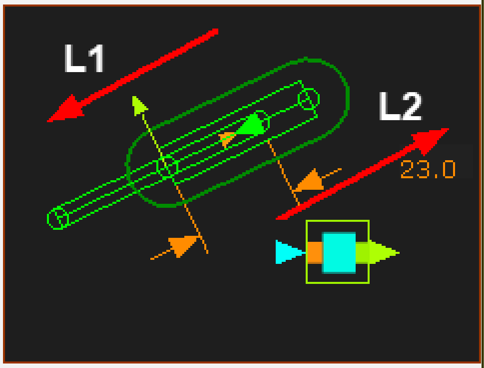


- LINE 1 – **L1** in the BASE-PART - Drag up to the right
- CAD-LINE/PART 2 – **L2** - Drag down from the left

The MOTION-DIMENSION is 34.1mm.

If you increase the MOTION-DIMENSION value, you move the SLIDER up to the right.

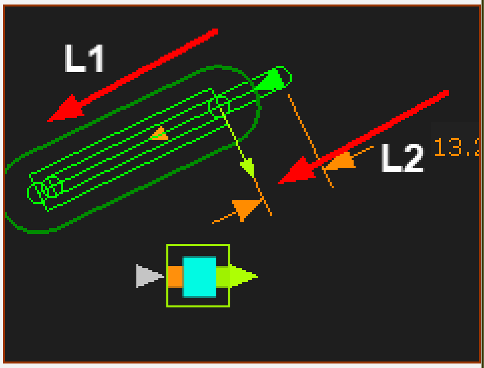
The small **arrowhead** shows the positive direction of the SLIDER.

<table>
<tr>
<td>
</td>
<td>

- **LINE 1** – **L1** in the **BASE-PART** - Drag down from the right
- **CAD-LINE/PART 2** – **L2** - Drag up from the left

The **MOTION-DIMENSION** is 23mm.

If you increase the **MOTION-DIMENSION** value, you move the **SLIDER** down to the left.

The small **arrowhead** shows the positive direction of the **SLIDER**.
</td>
</tr>
<tr>
<td>
</td>
<td>

- **LINE 1** – **L1** in the **BASE-PART** - Drag down Right to Left
- **CAD-LINE/PART 2** – L2 - Drag from Right to Left

The **MOTION-DIMENSION** is 13.2mm.

If you increase the **MOTION-DIMENSION** value, you move the **SLIDER** down to the left.

The small **arrowhead** shows the positive direction of the **SLIDER**.
</td>
</tr>
</table>

1.5.5.2.2.5 Add Motion-Path FB

Motion-Path FB

See also: Motion-Path dialog[469]

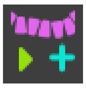
Terminology

MOTION-PATH FB :	A FB that adds a **MOTION-POINT** to a **sketch-path** - see **sketch-loop**
MOTION-POINT :	The motion-values at the input-connector to the MOTION-PATH FB control the motion of the **MOTION-POINT** along the **sketch-path**.

Applications of a Motion-Path FB:

To control the motion of a robot along a sketch-path.
To control the motion of a chain or belt along a sketch-path.
To control the motion of an extending-cylinder to raise a scissor-lift.

Add Motion-Path FB

What to do:	STEP 1: Start the Add Motion-Path FB command  1. Click Kinematics FB toolbar[169] > **Motion-Path FB** OR 1. Click **Function-Blocks menu > Motion-Path (FB)** The **COMMAND-MANAGER** has one selection-box. **2.** Click a sketch-element from a sketch-path **3.** Click ✅ in the **COMMAND-MANAGER** The **MOTION-PATH FB** is now in the graphics-area (and **ASSEMBLY-TREE**). AND A **Motion-Point** is at the **START-POINT** of the sketch-element you click from the sketch-path. STEP 2: Open the Motion-Path dialog 1. Double-click a **MOTION-PATH FB** in the graphics-area OR 1. See How to Open a dialog[627] The **MOTION-PATH DIALOG** is now open.
Dialog :	**Motion-Path dialog**[469]

Compare a Motion-Path FB to a Motion-Dimension FB

FUNCTION-BLOCK	MOTION-PATH FB	MOTION-DIMENSION FB
Motion Element	MOTION-POINT	MOTION-PART
Constraint	SKETCH-PATH	JOINT
Input	MOTION-DATA AT INPUT-CONNECTOR	MOTION-DATA AT INPUT-CONNECTOR
SUMMARY	• A Motion-Point is constrained by sketch-elements along a sketch-path. • Motion-data at the input to the Motion-Path FB controls the position, velocity, and acceleration of the Motion-Point.	• A Motion-Part is constrained by a joint to rotate or slide. • Motion-data controls at the input to the Motion-Dimension FB controls the position, velocity, and acceleration of the Motion-Part.

1.5.5.2.2.6 Add Measurement FB

Measurement FB

Use a **MEASUREMENT FB** to measure between sketch-elements in the same or different **PARTS**.

You can measure the:

- Length of a **LINE, CAD-LINE**
- Radius of a **CIRCLE**, **ARC**
- Distance between two **POINTS**** §
- Distance between a **LINE*** and a **POINT****
- Distance between two parallel **LINES***
- Angle between two **POINTS**** §
- Angle between two **LINES***
- Angle between three **POINTS****

The output from the **MEASUREMENT FB** includes the dimension and its first and second motion derivatives.

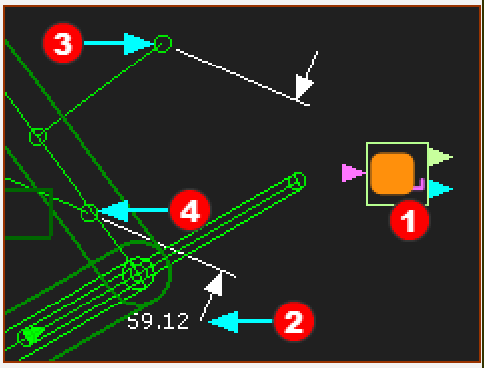
---

§ - There are two(2) output-connectors when you measure between two **POINTS*** - see more details below 194

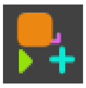
* - **LINE, CAD-LINE, X-AXIS, Y-AXIS**.

** - **POINT, START-POINT, END-POINT, CENTER-POINT**, and/or **MOTION-POINT**.

Add Measurement FB



Measurement FB between two Points



1. Click Kinematics FB tool-bar 169 > **Measurement FB**

OR

1. Click **Function-Blocks menu > Measurement (FB)**

2. Click the sketch-element

OR

2. Click the sketch-elements that you want to measure
3. Click the graphics-area.

The **MEASUREMENT FB**❶ and **DIMENSION**❷ are now in the graphics-area.

In this example, the **MEASUREMENT FB**❶ and **DIMENSION**❷ is between two **POINTS**❸❹

Note:

In the graphics-area, to move the:

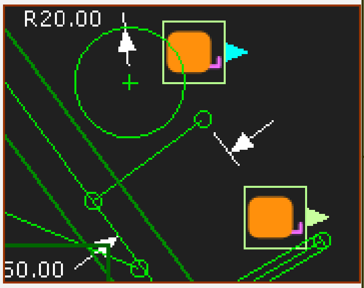
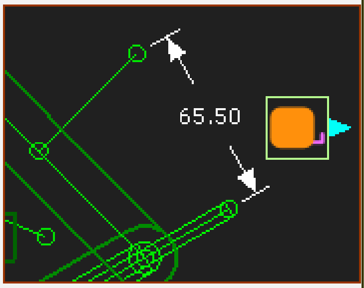
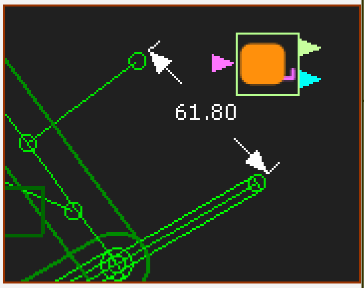
- Measurement FB❶ – Drag the FB❶
- Dimension❷ – CTRL + Drag the FB❶ or the DIMENSION❷.

Measurement FB

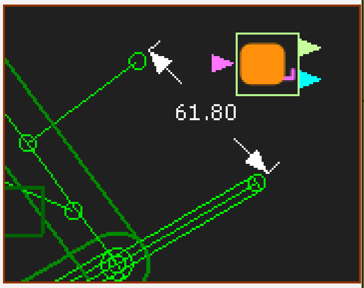
Linear Distance

* LINE, CAD-LINE, X-axis, Y-axis

** POINT, START-POINT, END-POINT, CENTER-POINT, MOTION-POINT.

Image	Sketch-Elements	Measurement Dimension
 Length or Radius	1. Click a LINE or CAD-LINE	Length of the LINE*
	1. Click a CIRCLE or ARC	Radius of the CIRCLE or ARC.
 Distance - Point & Line	1. Click a POINT** 2. Click a LINE*	Perpendicular Distance between the Line and Point.
 Distance - 2 Points	1. Click a POINT** 2. Click a POINT**	Linear Distance AND Angle of two Points.
	A MEASUREMENT FB between two POINTS** has two output-connectors: - **Top output-connector**: distance between two POINTS, and first and second motion-derivatives - **Bottom output-connector**: angle between two POINTS, and first and second motion-derivatives	

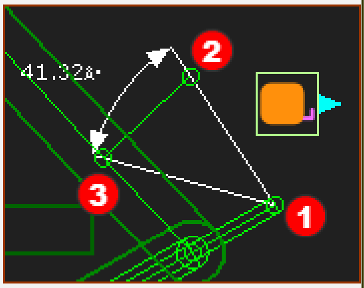
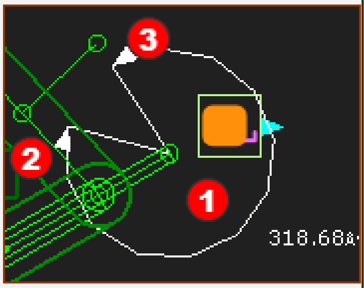
Angle between two(2) Points

 Distance - 2 Points	1. Click a POINT** 2. Click a POINT**	Linear Distance AND Angle of two Points.
	A MEASUREMENT FB between two POINTS** has two output-connectors: - **Top output-connector**: distance between two POINTS, and first and second motion-derivatives - **Bottom output-connector**: angle between two POINTS, and first and second motion-derivatives	

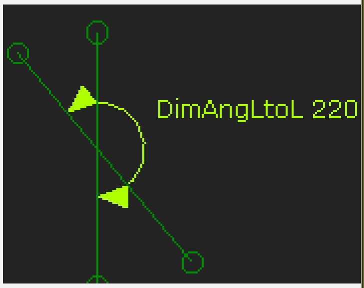
Angle between three(3) Points

Angle between three(3) **POINTS** - Internal Angle** and **External Angle**.

** POINT, **START-POINT, END-POINT, CENTER-POINT**

Image	Sketch-Elements	Measurement Dimension
 **Internal Angle - 3 Points**	Three POINTS 1. Click 'Apex' POINT** ❶ 2. Click POINT** ❷ 3. Click POINT** ❸	**Internal Angle** The angle is from ❷ to ❸ in a **Counter-Clockwise** direction.
 **External Angle - 3 Points**	Three POINTS 1. Click 'Apex' POINT**❶ 2. Click POINT** ❷ 3. Click POINT** ❸	**External Angle** The angle is from ❷ to ❸ in a **Counter-Clockwise** direction.

Angle between Two Lines

Image	Sketch-Elements	Measurement
 **Angle - 2 Lines**	Two LINES 1. Click a LINE*. 2. Click LINE**.	**Angle - from eight(8) possible Angles.**

To display one of **eight** angles:

Before you click in the graphics-area to place the MEASUREMENT DIMENSION and FB ...

... move your mouse-pointer around the APEX of the two LINES:

CASE 1: COUNTER-CLOCKWISE : **4 angles** < **180°** : the **Acute, Obtuse, Supplementary** and **Vertical** angles

CASE 2: CLOCKWISE : **4 angles** > **180°** : the **reflex angles** - or the angles that are external to those angles of **CASE 1**.

Video: Eight Measurement Angles between two Lines:
Double-click to watch Video

How to use the Measurement FB:

You can connect a wire from the output-connector of a MEASUREMENT FB:

... to plot the Position, Velocity and Acceleration of the dimension with a GRAPH FB 202 - **see Note 1 below**

... to the input-connector of a MOTION FB. The motion-data from the MEASUREMENT FB is the independent variable for a Motion in **MotionDesigner**, More usually, the independent variable is the output of a LINEAR-MOTION FB 170 - **see Note 2 below**

... to the input-connector of a MOTION-DIMENSION FB - **see Note 2 below**

Note 1:

To plot the Position, Velocity **and** Acceleration of the Dimension in the same graph.

1. Drag a wire from the **same** output-connector of the MEASUREMENT FB three times to different input-connectors of a Graph FB 202,
2. Use the Y–AXIS DISPLAY OPTIONS in the Graph Interface to display the three different motion-derivatives.

Note 2:

Check the messages in the Feedback-Area 326.

"1 Mechanism dependencies detected". This means, that the motion of a kinematic-chain is a function of (dependent on) the motion (measurement) of a different kinematic-chain. It is usually called **Motion-Dependency**.

1.5.5.2.2.7 Add Point-Data FB

Point-Data FB

See also Point-Data dialog [484]

Use a POINT FB to measure the motion of a POINT* with respect to the MECHANISM PLANE.

It has three output-connectors. From top to bottom, the motion-data at the output-connectors are the:

- ➔ Motion of the POINT* parallel to the X-axis
- ➔ Motion of the POINT* parallel to the Y-axis
- ➔ Magnitude of the motion equal to:
  - ○ $\sqrt{(X^2 + Y^2)}$

Note: Motion includes: **Position**, **Velocity**, and **Acceleration** of the POINT*.

---

* POINT, START-POINT, END-POINT, CENTER-POINT, MOTION-POINT.

The POINT must be a child to a PART that is **kinematically-defined**.

Add Point-Data FB

STEP 1: Add a Point-Data FB to the graphics-area

1. Click Kinematics FB toolbar [169] > Point-Data FB

OR

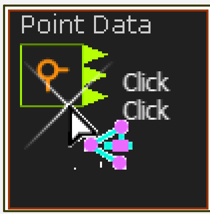
1. Click Function-Blocks menu > Point-Data (FB)

Then:

2. Click the graphics-area

The POINT-DATA FB is now in the graphics-area (and ASSEMBLY-TREE).

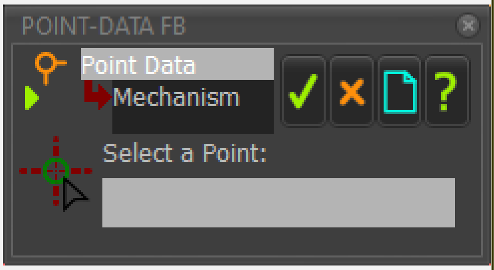
STEP 2: Open the Point-Data dialog:



1. Double-click the POINT-DATA FB in the graphics-area

OR

See How to Open a dialog [627]



Point-DATA FB - with no Point

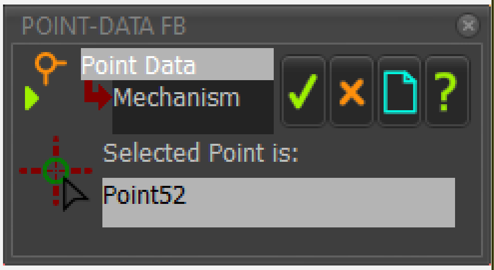
STEP 3: Select a Point

When the box is SELECT A POINT:

1. Click a POINT* in the graphics-area.

* POINT, START-POINT, END-POINT, CENTER-POINT, MOTION-POINT.

The box is now: SELECTED POINT IS:



Point-Data FB- with a Point

STEP 4: Close the Point-Data dialog

1. Click ✅ in the **POINT-DATA DIALOG**

The motion-data of the **POINT** is now at the output-connectors of the **POINT-DATA FB**.

How to use the Point-Data FB:

You can connect a wire from the output-connector of a **POINT-DATA FB**:

... to plot the Position, Velocity and Acceleration of the Point with a GRAPH FB[202] **- see Note 1 below**

... to the input-connector of a **MOTION FB**. The motion-data from the **POINT-DATA FB** is the independent variable for a Motion in **MotionDesigner**, More usually, the independent variable is the output of a LINEAR-MOTION FB[170] **- see Note 2 below**

... to the input-connector of a **MOTION-DIMENSION FB** - **see Note 2 below**

Note 1:

To plot the Position, Velocity **and** Acceleration of the **POINT** in the same graph.

1. Drag a wire from the **same** output-connector of the **POINT-DATA FB** three times to different input-connectors on a Graph FB[202] ,
2. Use the Y–axis display options in the **GRAPH INTERFACE** to display the three different motion-derivatives.

Note 2:

There is a message in the Feedback-Area: '1 Mechanism dependencies detected'.

You should Click Rebuild Now[50] when the number of dependencies is more than 1 if the data is critical, before you use the data for a Cam, for example.

1.5.5.2.2.8 Add Cam-Data FB

Cam-Data FB

See also: Cam-Data FB > Cam Analysis 440 ; Cam-Data FB > Cam Coordinates 446

Why should I use a Cam-Data FB?

When you link a 2D-CAM to a CAM-DATA FB you can use the CAM-DATA FB to:

- Calculate and save coordinates for the 2D-CAM cam-profile - **see** **Cam-Coordinates 446****, Cam-Coordinates File Formats**
- Analyze five design parameters for the 2D-CAM - **see** **Cam Analysis 440**

Cam: Cam Terminology and 2D-Cam Work-flow.

Cam Terminology

Terms :	Definitions
Cam (or **Cam-Part**) :	The PART to which you add the (2D-CAM) to generate the shape of the **Cam-Profile.**
Cam-Shaft :	The most common **Cam-Part**. It is a **rotating-Part** (a shaft), to which you add the 2D-CAM (or 3D-CAM) as a **Cam-Profile**. A **Cam-Shaft** usually rotates with a constant angular-velocity.
Cam-Profile :	The Cam-Flank and surface that is an extrusion of a 2D-CAM (or 3D-CAM) which is in continuous contact with the **Follower-Profile**.
Track-Cam or **Groove-Cam** :	A groove that is cut into a **Cam-Blank** with an Outer and an Inner **Cam-Profile**. A **Follower-Roller** fits in the groove.
Follower (or **Follower-Part**) :	The PART that supports the **Follower-Profile**.
Follower Kinematic-Chain (or **Kinematic Mechanism**) :	The **Follower-Part** and the other PARTS that you join to the **Follower-Part**, to move the **Tooling** or **Tool-Part**.
Follower-Profile :	The surface of a machine component that is rigidly connected to the **Follower-Part**. The surface is in continuous contact with the **Cam-Profile**.
Follower-Roller :	A **Follower-Profile** that is cylindrical or barrel-shaped that is rigidly connected to the **Follower-Part**.
Flat-faced Follower :	A **Follower-Profile** that is a flat surface that is rigidly connected to the **Follower-Part**.
Translating Follower :	A **Follower-Part** that that moves along a straight axis.
Reciprocating Motion :	A **Translating Follower** with a non-progressive motion.
Rotating Follower :	A **Follower-Part** that rotates about a fixed axis.
Oscillating Motion :	A **rotating-Part** with a non-progressive motion.

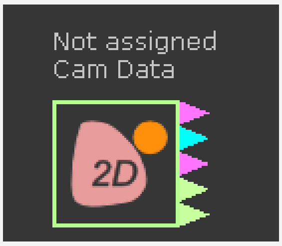
Terms :	Definitions
Progressive Motion :	A motion, usually followed by a Dwell, that moves the **Follower-Part** progressively in one direction.
Non-Progressive Motion :	A motion that returns the **Follower-Part** to its original position after each machine cycle.
Indexing :	A **progressive motion**, usually rotating.
Indexer :	A device whose input is a constant-speed (usually) **Cam-Shaft** and output is a rotating-Part with a **progressive motion**. The input rotates one time to index the output one time. The index-angle is such that 360º/(Index-Angle) is an integer.
Cam-Blank :	The material from which you cut the shape of the **Cam-Profile**.

Cam Work Flow

Cam Work-flow

Action	Help Topic
1. Add a **2D-Cam**	see Add 2D-Cam 128
If the new **2D-CAM** is one of a pair of **Conjugate-Cams**, or it is one flank of a **Groove-Cam**:	
1.a. Add a **CONJUGATE-CAM FB**	see Add Conjugate Cam FB 165
1.b. Edit the **CONJUGATE-CAM FB** to select the two **2D-CAMS**.	see Conjugate-Cam dialog 436
2. Select a **2D-CAM** or a **CONJUGATE-CAM FB** as the Power Source for the kinematic-chain that includes the Follower	see Configure-Power Source 589
3. Review the **2D-CAM** : **Display, Properties, Roller-Life, Cam-Life, ...**	see 2D-Cam dialog 401
4. Add a **Cam-Data FB**	see Add Cam-Data FB 199
5. Edit the **CAM-DATA FB** to link it to a **2D-CAM** - close the dialog	see Cam-Data dialog 440
6. Connect wires from the output-connectors of the **CAM-DATA FB** to a **GRAPH FB**	
7. Analyze the **2D-CAM**	see Cam-Data dialog : Cam Analysis 440
8. Edit the **CAM-DATA FB** again to calculate the Cam's Coordinates	see Cam-Data dialog : Cam-Coordinates 446

Add Cam-Data FB

 Cam-Data FB in Graphic-Area	**STEP 1:** Add a **CAM-DATA FB** to the graphics-area  1. Click Kinematics FB toolbar 169 > **Cam-Data FB** **OR** 1. Click **Function-Blocks menu > Cam-Data (FB)** 2. Click the graphics-area The **CAM-DATA FB** is now in the graphics-area and ASSEMBLY-TREE. The CAM-DATA FB is "**Not Assigned**" - This means you have not yet assigned (or linked) the CAM-DATA FB to a 2D-CAM. You must edit the CAM-DATA FB and select a 2D-CAM in your model. **See more** Cam-Data dialog 440

1.5.5.2.2.9 Add Graph FB

Graph FB

Terminology:

GRAPH FB :	Connect wires to the input-connector of a GRAPH FB to plot, over a complete machine-cycle, any data that is available at the output-connectors of other FUNCTION-BLOCKS.
Data-Channel :	Each wire provides three parallel streams of data. For example, the data is linear or angular position, plus the first and second motion-derivatives. Each stream of data on a wire is a **Data-Channel**.

Add Graph FB

STEP 1: Add a Graph FB to the graphics-area

1. Click Kinematics FB toolbar[169] > Graph FB

OR

1. Click Function-Blocks menu > Graph (FB)

Then :

2. Click the graphics-area

The GRAPH FB is now in the graphics-area.

STEP 2: Connect wires to the input-connectors of the GRAPH GB

The GRAPH FB has five(5) input-connectors.

From the top, the input-connectors are:

- 1 – 4: Y-axis inputs - **See below:** Y-axis Data-Channel Options[204]
- 5: X-axis input - **See below:** X-axis Data-Channel Options[203]

Note: Data-Values at the input-connector for the X-axis (#5 input-connector)

OPTION 1: no data (not connected). The X-axis is equal to the MASTER-MACHINE-ANGLE

OPTION 2: data increases steadily. For example, the output-connector of a LINEAR-MOTION FB, or GEARING FB

OPTION 3: data increases and/or decreases within a range of values. For example, the output-connector of a MOTION FB, MEASUREMENT FB, or POINT-DATA FB

Note: if there is a **fly-back** across the graph, click Rebuild Now[49] - this command may remove the **fly-back**.

If **Rebuild Now** does not remove the fly-back, increase the number-of-steps to 360 - **see** Machine-Settings > Number-of-Steps[351]

STEP 3: Open the GRAPH FB

1. Double-click the GRAPH FB in the graphics-area

OR

See How to open a dialog 627

The GRAPH DIALOG is now open.

STEP 4: See: Graph FB Interface 203.

To review the kinematic, kinetostatic, and/or Cam data that you can plot with a GRAPH FB.

See also: Application Settings | Number Format | DATA FORMAT 343

Graph FB Interface

Graph FB:

1 Y–axis : Scales

- Maximum 4 scales, that correspond to motion-value at input-connectors Y1 to Y4
- The color of the Y–axis and the plot-line are the same.

2 Y–axis : Digital Readout (D.R.O.)

- The X-axis and the Y1 – Y4-axis values at the position of the vertical cursor 6.
- The Number-Format for the X–axis, Y–axis, and data in Clipboard 7 are configured in Application Settings | Number Format tab. 343

3 X-axis and Y-axis Data-Channel Selector

- Each wire that is connected to a Y-axis orthe X-axis input-connector has up to 3 **Data-Channels**

- Select the **Data-Channel** in the drop-down box - ***see* Data-Channel Selectors** 204

4 **The Graph Area:**

- The color-coded graphs for each Y–axis input
- **Vertical-Cursor 6 - see more below**

5 **Toolbar:**

- Save, Print, Graph Settings 480 , Zoom Extents, Pan Left, Pan Right, Copy Graph Data to Clipboard – see 7 below

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6 **Vertical-Cursor**

When you click in the area of the Graph 4, the ***Vertical Cursor*** 6 snaps to your mouse pointer

When you drag your pointer in the graph :

- the Vertical-Cursor follows your pointer
- the Digital Readouts 3 continuously updates to indicate the Y-axis values
- the **MASTER MACHINE ANGLE** updates to the position of the Vertical Cursor
- the kinematic-chains that are **kinematically-defined** move to a position that is defined by the **MASTER MACHINE ANGLE**.

7 **Copy Graph Data to Clipboard**

- When you click the right-most icon in the toolbar 5, the graph data is copied to the Clipboard 7.
- Paste this data to Excel, or
- To **MotionDesigner** in the **DATA TRANSFER TABLE**. You can plot it as an **OVERLAY** or use it as a **MOTION** (use Z Raw-Data).

Notes:

- Configure the Number-Format for the X–axis, Y–axis, and 'Data in Clipboard' in Application Settings | Number Format tab. 343

2 Data-Channel Selectors:

Each wire you connect to the **GRAPH FB** has three **Data-Channels**. The data-channels that are available are a function of the **FB** from which you connector the wire to the **GRAPH FB INPUT-CONNECTOR**.

Use the **Data-Channel Selectors** to select which of the three data-channels to plot.

The data-channels from a:

- Function-Block 169 (**LINEAR-MOTION, GEARING, MOTION, MOTION-DIMENSION**):
  - Linear position, velocity, acceleration.
  - Angular position, velocity, acceleration.

- Measurement FB[193] or Point-Data FB[197] :
  - Linear position, velocity, acceleration of the Measurement dimension or Point's position.
  - Angular position, velocity, acceleration of the Measurement dimension.
- Cam-Data FB[199]
  - Pressure-Angle.
    You can plot three Pressure Angles – See Pressure Angle
  - Cam Radius-of-Curvature.
    You can plot Radii-of-Curvature for Inner Cam and the Outer Cam.
  - Contact Cam-Force
  - Maximum Contact-Shear-Stress.
    You must know the material-properties to obtain this data - See 2D-Cam dialog[401] .
  - Entrainment Velocity
    The Entrainment-Velocity for the Inner Cam and the Outer Cam.
- Force-Data FB[230]

If the **FORCE-DATA FB** references a:

  - **Pin-Joint that is a Power-Source,** you can plot Application-Torque for a Servomotor and Gearbox.
  - **Slide-Joint that is a Power-Source**, you can plot the Application-Load for a Linear Servomotor.
  - **PIN-JOINT** or **SLIDE-JOINT** that is NOT a Power-Source:

    $$F_{total} = \sqrt{F_x^2 + F_y^2}$$

    - F_x - Force in the X-axis direction :
    - F_y - Force in the Y-axis direction:
  - **2D-CAM**: you can plot the Contact Force between the Cam-Profile and the Follower-Profile.
  - **SPRING FB**: you can plot the Total Force, the X Force and the Y Force acting on the **anchor-Point** of the Spring.

TOP-TIP:

To show all three Data-Channels from the same output-connector of a Function-Block,

1. Drag three wires from the same output-connector of the Function-Block to three(3) different **GRAPH FB** input-connectors.
2. Select the different **Data-Channels** with the **Y-axis Data-Channel Selector** drop-down (right-side of graphs)

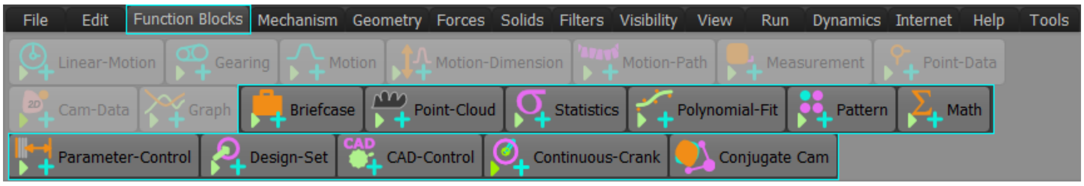
1.5.5.2.3 Modeling Function-Blocks

Modeling Function-Blocks

Use **Modeling Function-Blocks** to improve your model in different ways, such as: to optimize its kinematic performance with a **DESIGN-SET FB**; to improve its visualization with a **PATTERN FB** and or **PARAMETER-CONTROL FB**; to import data for reverse-engineering with a **POINT-CLOUD FB**; to overcome a difficult inverse-kinematics problem with a **CONTINUOUS-CRANK FB**; to design new motions with a **MATH FB**, ...

See also How to Connect FBs 643

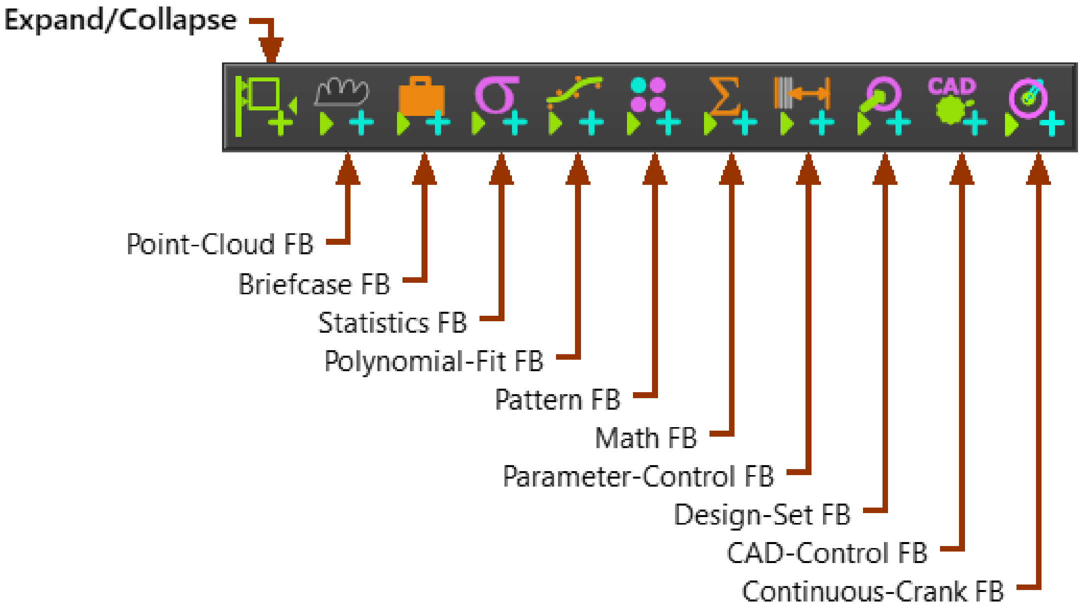
Function-Blocks menu > Modeling FBs



Function-Blocks menu > Modeling FBs - MD17

Modeling FB toolbar

The **Modeling FB toolbar** is above the graphics-area.



Modeling FB toolbar

1.5.5.2.3.1 Add Point-Cloud FB

Why should I use a Point-Cloud FB?

You can use a **POINT-CLOUD FB** to, for example, reverse-engineer the shape of a Cam and then find the motion of a Follower.

Terminology and Definitions

Point-Cloud :	Data-points that represent the planar shape of a body. The data-points can be cartesian (x, y) or polar (r, θ) coordinates.
Curve :	A smooth, continuous function that we fit to the **Point-Cloud** to replace the data-points. From the continuous function, we can evaluate the coordinates of the planar shape at any machine-angle.
POINT CLOUD FB :	A **FUNCTION-BLOCK** that you add to a **PART**. Use the **POINT-CLOUD DIALOG** to: • to import coordinates of a planar shape, and • to fit a **Curve** to replace the coordinates

See also : Point-Cloud dialog[521]

Add Point-Cloud FB

STEP 1 **Add a Point-Cloud FB to a Part**

1. Click **Function-Blocks menu > Point-Cloud**

OR

1. Click Modeling FB toolbar[206] > **Add Point-Cloud FB**

The **COMMAND-MANAGER** has one selection box. You must select a **PART**.

2. Click a **PART** in the graphics-area or **ASSEMBLY-TREE**
3. Click ✓ in the **COMMAND-MANAGER**

The **POINT-CLOUD FB** is now in the graphics-area.

STEP 2 **Open the Point-Cloud dialog:**

1. Double-click a **POINT-CLOUD FB** in the graphics-area or **ASSEMBLY-TREE**

OR

See How to Open a dialog[627] **.**

The **POINT-CLOUD DIALOG** is now open.

STEP 3 **See** Point-Cloud dialog[521] **.**

Video : See YouTube: http://youtu.be/IME9Eb4mpQE

1.5.5.2.3.2 Add Briefcase FB

Why should I use a Briefcase FB?

When a model is complex, and there are many kinematic-chains in each **MECHANISM-EDITOR**, it is more difficult to identify which **FUNCTION-BLOCKS** control which Kinematic-Chain.

Example uses of a **BRIEFCASE FB**:

- Use a **BRIEFCASE FB**s to hide all of the **FUNCTION-BLOCKS** from the graphics-area.
- Use a **BRIEFCASE FB** to hide different groups of **FUNCTION-BLOCKS**. - E.g. Function-Blocks that control one kinematic-chain.

You can:

- Name each **BRIEFCASE FB** to help remind you which **FBs** are in which **BRIEFCASE FB**.
- Edit each **FUNCTION-BLOCK** directly from the **BRIEFCASE FB** interface.
- Add a **BRIEFCASE FB** to hide a different **BRIEFCASE FB**.

See also : Briefcase FB dialog [518]

Add Briefcase FB

STEP 1: Add a Briefcase FB to the graphics-area:

1. Click **Function-Blocks menu > Briefcase**

OR

1. Modeling FB toolbar [206] **> Add Briefcase FB**

Then:

2. Click the graphics-area

The **BRIEFCASE FB** is now in the graphics-area.

STEP 2: Open the Briefcase FB dialog

1. Double-click the **BRIEFCASE FB** in the graphics-area or **ASSEMBLY-TREE**

OR

See How to Open a dialog [627]

The **BRIEFCASE FB DIALOG** is now open.

STEP 3: See Briefcase FB dialog [518]

1.5.5.2.3.3 Add Statistics FB

Why should I use a Statistics FB?

Statistical data may include: RMS, Maximum, Minimum, ... values of a variable (wire data-channel).

Use a STATISTICS FB to list the **Statistical data** for the data that is available at the output of a FUNCTION-BLOCK.

See also : Statistics dialog [488]

Add Statistics FB

STEP 1: Add a Statistics FB to the graphics-area

1. Click **Function-Blocks menu > Statistics**

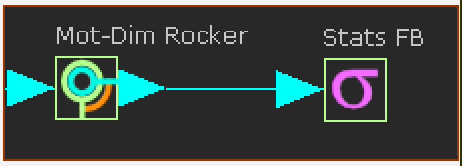
OR

1. Click Modeling FB toolbar [206] > **Add Statistics FB**

Then:

2. Click the graphics-area

The STATISTICS FB is now in the graphics-area



STEP 2: Connect a wire to its input-connector

1. Drag a wire from a different FB to the input-connector of the STATISTICS FB

A wire is now connected to the input-connector of the STATISTICS FB.

STEP 3. Open the Statistics dialog

1. Double-click a STATISTICS FB in the graphics-area

OR

1. **See** **How to Open a dialog [627]**

The STATISTICS DIALOG is now open.

STEP 4: See Statistics dialog [488]

Notes:

Wires that connect FUNCTION-BLOCKS have **3 Data-Channels** (in most cases).

The **3 Data-Channels** are usually:

- Position, Velocity, Acceleration (Angular or Linear),

OR

- Total Force, Force X, Force Y (relative to the MECHANISM-PLANE)

See Data-Channels 167 for more information.

Compare a **GRAPH FB** with a **STATS FB**:

- **GRAPH FB** : to plot data over one machine-cycle.
- **STATS FB** : to summarize a machine-cycle of data with different statistical parameters.

1.5.5.2.3.4 Add Polynomial-Fit FB

Why should I use a Polynomial-Fit FB?

Typically, you design a motion (with **MotionDesigner**) for a Tool/End-Effector. Then, typically, you add more parts, which you join to the Tool-Part, to create a more complex kinematic-chain. Finally, you use a servomotor to drive a part in the kinematic-chain, that has a different motion to the Tool-Part.

To plot the motion for the servomotor you can use a Measurement FB[193], add a Graph FB[202], and then export a list of positional data-points for the servo-controller.

While this is frequently satisfactory, it is preferable to export to the servo-controller a series of polynomials rather than a list of data-points.

The output from the **POLYNOMIAL FIT FB** is the best-fit motion to the data at its input-connector, but defined as a series of 5^{th} order Polynomials.

You can export the Polynomials directly to **MotionDesigner**. In **MotionDesigner**, you can further manipulate the Polynomials, as required.

See also : **Polynomial-Fit dialog**[491]

Add Polynomial-Fit FB

STEP 1: Add a Polynomial-Fit FB to the graphics-area

1. Click **Function-Blocks menu > Polynomial-Fit**

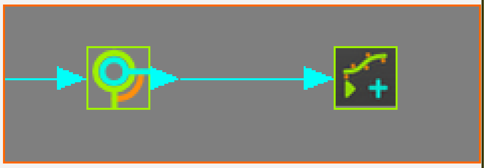
OR

1. Click Modeling FB toolbar[206] **> Add Polynomial-Fit FB**

Then:

2. Click the graphics-area

The **POLYNOMIAL-FIT FB** is now in the graphics-area



STEP 2: Connect a wire to its input-connector.

1. Drag a wire from a different **FB** to the input-connector of the **POLYNOMIAL-FIT FB**

A wire is now connected to the input-connector of the **POLYNOMIAL-FIT FB**.

STEP 3. Open the Polynomial-Fit dialog:

1. Double-click a **POLYNOMIAL-FIT FB** in the graphics-area

OR

1. **See How to Open a dialog**[627]

The **POLYNOMIAL-FIT DIALOG** is now open.

STEP 4: **See** **Polynomial Fit dialog** 491

Notes:

Wires that connect **FUNCTION-BLOCKS** have **3 Data-Channels** (in most cases).

The three(3) **Data-Channels** are usually:

- Position, Velocity, and Acceleration, or
- Total Force, Force X, and Force Y

See Data-Channels 167 for more information.

1.5.5.2.3.5 Add Pattern FB

Why should I use a Pattern FB?

When there are SOLIDS in your model, you can use a PATTERN FB to make an array of one or more of the SOLIDS.

The PATTERN FB is more capable than the Add Array tool as found in your CAD.

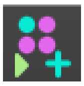
The PATTERN FB can anticipate the motion of each SOLID at each instant of the machine-cycle,

When you use the PATTERN FB to make an array of a SOLID, and hide a Copy at different phases in the machine-cycle, you also remove its MASS-PROPERTIES.

See also: Pattern dialog 500

Add Pattern FB

STEP 1 Add a Pattern FB to the graphic-data



1. Click Function-Blocks menu > Pattern

OR

1. Click Modeling FB toolbar 206 > Add Pattern FB

Then:

2. Click the graphics-area

The PATTERN FB is in the graphics-area.

STEP 2 Open the Pattern dialog

1. Double-click a PATTERN FB in the graphics-area (or ASSEMBLY-TREE)

OR

See How to Open a dialog 627.

The PATTERN DIALOG is now open.

STEP 3 **See** Pattern-FB dialog 500.

Note: Pattern FB and a Driving Pulley:

A **Driving Pulley** is one in which you apply the motion to the PULLEY and not to the MOTION-PATH FB.

If the PULLEY makes one rotation in a machine-cycle, the **Motion-Point** (that represents the motion of the Belt) will not move along the complete length of the **sketch-path** in one machine-cycle.

If you want to use a PATTERN FB to model an array of SOLIDS along the complete length of a **Belt**, you must make changes to the rotation of the PULLEY.

1. Add a **GEARING FB** to the input-connector of the **MOTION-DIMENSION FB** that controls the motion of the **PULLEY**
2. Open the **GEARING FB DIALOG**
3. Edit the **GEARING RATIO** = **Belt-Length / Pulley-Circumference**

The **PATTERN** of the **SOLID** elements should now be at equal spaces along the complete **Belt-Length**.

1.5.5.2.3.6 Add Math FB

Why should I use a Math FB?

A **MATH FB** allows you to develop new functions that may not be available with other FBs.

Examples:

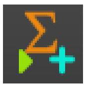
- **Mechanism-Synthesis**, when combined with Measurement FBs[193] and Parameter-Control FBs[216].
- Add two or more Motions to create a new Motion - for example, add a Modified-Sinusoid motion-law to a Constant-Velocity motion-law to give a Starting-Velocity and Ending-Velocity that are not zero.
- Define Parametric equations for Piggyback Sliders.

See also : Math FB dialog[509]

Add Math FB

STEP 1 Add a Math FB to the graphic-data

1. Click **Function-Blocks menu > Math**



OR

1. Click Modeling FB toolbar[206] **> Add Math FB**

Then:

2. Click the graphics-area

The **MATH FB** is in the graphics-area.

STEP 2. Open the Math dialog

1. Double-click the **MATH FB** in the graphics-area

OR

See How to Open a dialog[627].

The **MATH DIALOG** is now open.

STEP 3. See Math FB dialog[509]

1.5.5.2.3.7 Add Parameter-Control FB

Why should I use a Parameter-Control FB?

Use a **PARAMETER-CONTROL FB** to:

- control the **DIMENSION** (length or radius) of a sketch-element
- control the **EXTRUSION DEPTH** of an **MD-SOLID***
- control the **EXTRUSION-OFFSET** of an **MD-SOLID***

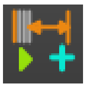
Apply a **PARAMETER-CONTROL FB** for Mechanism-Synthesis, or animations with more realistic effects.

* When a **PARAMETER-CONTROL FB** controls the **EXTRUSION-DEPTH** or **EXTRUSION-OFFSET** of an **EXTRUSION** that has many facets, the model is slower to cycle.

See also : Parameter-Control dialog[497]

Add Parameter-Control FB

STEP 1 **Add a Parameter-Control FB to the graphic-data**



1. Click **Function-Blocks menu > Parameter-Control**

OR

1. Click Modeling FB toolbar[206] > **Add Parameter-Control FB**

Then:

2. Click the graphics-area

The **PARAMETER-CONTROL FB** is in the graphics-area.

STEP 2: **Open the Parameter-Control dialog**

1. Double-click the **PARAMETER-CONTROL FB** in the graphics-area or **ASSEMBLY-TREE**

OR

1. **See How to Open a dialog[627].**

The **PARAMETER-CONTROL DIALOG** is now open.

STEP 3: **See Parameter-Control dialog[497]**

1.5.5.2.3.8 Add Design-Set FB

Why should I use a Design-Set?

Use DESIGN-SETS to edit a number of dimensions and parameters in one place - the DESIGN-SET.

Add to a DESIGN-SET those dimensions and parameters that you believe to be important to the outcome of a design-objective. When dimensions are in a DESIGN-SET, you cannot edit them in the model. You can add more than one DESIGN-SET to the model.

Different DESIGN SETS can be used for different purposes. A Design-Set to help make changes to a machine for a packaging size change.

A Design-Set should also remind you, or instruct other design engineers, which dimensions and parameters to edit.

You can even add to a DESIGN-SET those dimensions that you do **not** want to edit. Give it the Label - **Do Not Edit!** In this way, you cannot accidentally edit the dimensions that you want to protect.

See Design-Set dialog [528]

Add Design FB

STEP 1 Add a Design-Set FB to the graphic-data

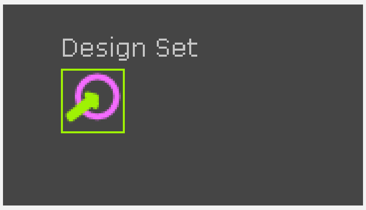
1. Click **Function-Blocks menu > Design-Set**

OR

1. Click Modeling FB toolbar [206] **> Add Design-Set FB**

Then:

2. Click the graphics-area



Design-Set in graphic-area

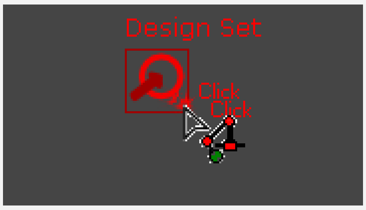
The DESIGN-SET FB is in the graphics-area.

STEP 2: Open the Design-Set dialog

1. Double-click the DESIGN-SET FB in the graphics-area or **ASSEMBLY-TREE.**

OR

See How to open a dialog [627]



Double-click the Design-Set

The **DESIGN-SET DIALOG** is now open.

STEP 3: **See Design-Set dialog** 528

Notes : When you add a dimension to a **DESIGN-SET**, you can edit the dimension **only** in the **DESIGN-SET**. The dimension-lines and extension lines of a Dimension that you add to the **DESIGN-SET** are **gray** in the **PART-EDITOR**.	
	A **MOTION-DIMENSION FB** is **gray** if you add the **BASE-VALUE** parameter of the **MOTION-DIMENSION** to a **DESIGN-SET**. Also, it includes a small icon at its bottom,right corner, to remind you its value has been added to the **DESIGN-SET**.
See also:	Online Video : Tutorial 7: Design-Sets

1.5.5.2.3.9 Add CAD-Control FB

Why should I use a CAD Control FB?

Use a **CAD CONTROL FB** to synchronize the motion of one or more parts that are in a **SOLIDWORKS**® Assembly with the motion of same **PARTS** in a ***MechDesigner*** model/assembly.

Question: Why do this when **MechDesigner** is perfect to synchronize the motions of all of the **PARTS** in a model?

Answer: Because SOLIDWORKS® has useful tools. For example, **Collision Verification, Interference Detection, ...**

The **Clearance Detection** tool in SOLIDWORKS® evaluates the exact gap between parts. You can use this tool to check that a **3D-CAM** you export to SOLIDWORKS has the same Clearance as the Radial Clearance that you enter in the **3D-CAM DIALOG**.

After you configure the **CAD CONTROL DIALOG**, motion-data that controls **PARTS** in **MechDesigner** model/assembly are piped to the SOLIDWORKS Distance or Angle mates that define the position of a Part in the assembly in SOLIDWORKS®.

See also: CAD Control dialog [486]

Add CAD Control FB

STEP 1 **Add a CAD-Control FB to the graphic-data**

1. Click **Function-Blocks menu > CAD-Control**

OR

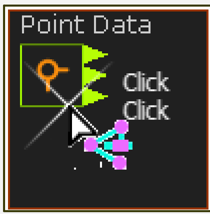
1. Click Modeling FB toolbar [206] **> Add CAD-Control FB**

Then:

2. Click the graphics-area

The **CAD-CONTROL FB** is in the graphics-area.

STEP 2: **Open the CAD-Control dialog:**



1. Double-click a **CAD-CONTROL FB** in the graphics-area

OR

2. **See** How to Open a dialog [627] **.**

The **CAD-CONTROL DIALOG** is now open.

STEP 3: **See** CAD Control dialog [486]

Note:

Angle mates in SOLIDWORKS® cannot be negative, but they can be in **MechDesigner**. Thus, you may need to use **GEARING FBS** to add a constant to the output values so that they have the same minimum and maximum values as those in SOLIDWORKS®.

1.5.5.2.3.10 Add Continuous Crank FB

Why use a Continuous-Crank FB?

In a Cam mechanism, you can design the oscillating or reciprocating motion for a **Tool-Part** and let **MechDesigner** do the inverse-kinematics to calculate the oscillating motion of a swinging **Follower-Part**. Typically, the **Follower-Part** must rotate by an angle that is less than 60º, usually less than 45º, and ideally less than 30º.

In a Servo mechanism, you can design the motion for a **Tool-Part** and let **MechDesigner** do the inverse-kinematics to calculate the motion of a rotating servo-axis. However, the rotation of a servo-axis is not limited. It can even oscillate by 180º, or even continually rotate with a modulated motion, to give the motion you have designed for the **Tool-Part**.

This is one application of the CONTINUOUS-CRANK FB - it automatically calculates the correct length and motion of a servo-axis to give the motion you have designed for a **Tool-Part**.

See also: Continuous-Crank FB dialog [535]

Add Continuous Crank FB

STEP 1: Add a Continuous-Crank FB to the graphics-area

1. Click Function-Blocks menu > Continuous-Crank

OR

1. Click Modeling FB toolbar [206] > Continuous-Crank FB

Then:

2. Click the graphics-area

The CONTINUOUS-CRANK FB is now in the graphics-area and ASSEMBLY-TREE.

STEP 2: Open the Continuous-Crank dialog:

1. Double-click a CONTINUOUS-CRANK FB in the graphics-area

OR

See How to Open a dialog [627] .

The CONTINUOUS-CRANK DIALOG is now open.

STEP 3: See Continuous-Crank FB dialog [535]

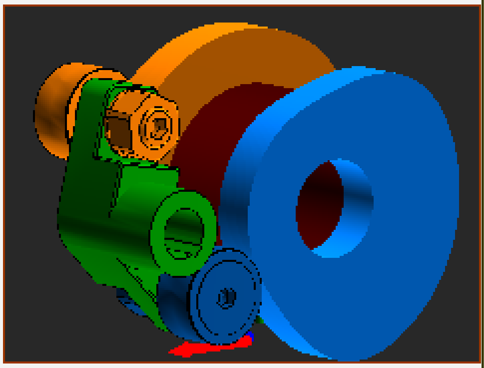
1.5.5.2.3.11 Add Conjugate Cam FB

Add Conjugate Cam FB

See also Conjugate-Cam dialog 436

Other names for "Conjugate cams" are "cognate cam", "double cams", "complementary cams", "main and counter cams", "working and return cam".

What is a Conjugate Cam? What are the advantages of a Conjugate Cam?


A Conjugate Cam pair

Typically, **Conjugate Cams** are at least two Cams that rotate on one cam-shaft, with each cam in contact with one **Follower-Roller**, and in which the two **Follower-Rollers** are rigidly attached to one **Follower-Part**.

For example: In the image, the blue and orange Cams rotate together on one axis (the shaft is not in the image). The blue Cam-Profile is in continuous contact with the blue Follower-Roller, and the orange Cam-Profile is in continuous contact with the orange Follower-Roller. The Follower-Rollers are rigidly attached to the green Follower-Part, The green Follower-Part oscillates on an axis that is parallel with the rotating axis of the Cams.

Why Advantages of Conjugate Cams:

- does not need a Spring or Cylinder to make sure the Follower-Roller does not 'jump' off the Cam. This reduces the load on the
- eliminate backlash, with an eccentric on one Follower-Roller, or by reducing the distance between the Cam-Shaft and Follower axis.

Conjugate Cams

The design of all cam-systems must make sure a **Follower-Profile** is in contact with the **Cam-Profile** for the machine-cycle, at all machine-speeds.

There are two designs:

A. **Force-Closed** - an **external force** pushes or pulls the Follower-Part and Follower-Profile against the Cam-Profile.

Example external forces are: Spring, Air-Cylinder, Gravity, Magnet, ...

B. **Body-Closed** - a design in which two (or more) **Follower-Profiles** (e.g. Rollers) are rigidly mounted to a **Follower-Part** such that the **Follower-Profiles** cannot move away from two **Cam-Profiles** that are rigidly mounted to a **Cam-Part** (e.g. a Cam-Shaft).

Example Body-Closed cam-systems are: Groove-Cams (Track-Cams), Rib-Cams, Globoidal Indexers, Parallel Indexers, ...

Body-Closed cam-systems are examples of **Conjugate Cams**.

Why use a Conjugate Cam FB?

You need to add a CONJUGATE CAM FB to analyze **Forces** when two or more 2D-CAMS drive, in a Body-Closed design arrangement, two or more **Follower-Profiles**. mounted to one **Follower-Part**.

Cam Terminology and Typical Work-Flow.

Cam Terminology

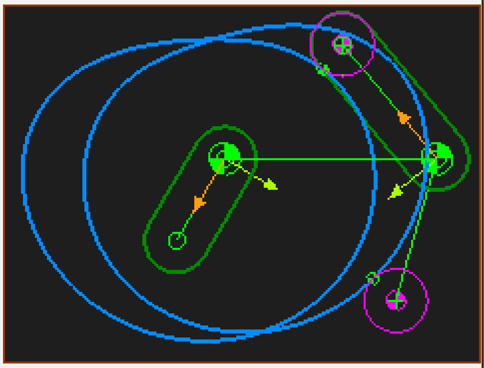
Terms :	Definitions
Cam (or **Cam-Part**) :	The PART to which you add the (2D-CAM) to generate the shape of the **Cam-Profile.**
Cam-Shaft :	The most common **Cam-Part**. It is a **rotating-Part** (a shaft), to which you add the 2D-CAM (or 3D-CAM) as a **Cam-Profile**. A **Cam-Shaft** usually rotates with a constant angular-velocity.
Cam-Profile :	The Cam-Flank and surface that is an extrusion of a 2D-CAM (or 3D-CAM) which is in continuous contact with the **Follower-Profile**.
Track-Cam or **Groove-Cam** :	A groove that is cut into a **Cam-Blank** with an Outer and an Inner **Cam-Profile**. A **Follower-Roller** fits in the groove.
Follower (or **Follower-Part**) :	The PART that supports the **Follower-Profile**.
Follower Kinematic-Chain (or **Kinematic Mechanism**) :	The **Follower-Part** and the other PARTS that you join to the **Follower-Part**, to move the **Tooling** or **Tool-Part**.
Follower-Profile :	The surface of a machine component that is rigidly connected to the **Follower-Part**. The surface is in continuous contact with the **Cam-Profile**.
Follower-Roller :	A **Follower-Profile** that is cylindrical or barrel-shaped that is rigidly connected to the **Follower-Part**.
Flat-faced Follower :	A **Follower-Profile** that is a flat surface that is rigidly connected to the **Follower-Part**.
Translating Follower :	A **Follower-Part** that that moves along a straight axis.

Terms :	Definitions
Reciprocating Motion :	A **Translating Follower** with a non-progressive motion.
Rotating Follower :	A **Follower-Part** that rotates about a fixed axis.
Oscillating Motion :	A **rotating-Part** with a non-progressive motion.
Progressive Motion :	A motion, usually followed by a Dwell, that moves the **Follower-Part** progressively in one direction.
Non-Progressive Motion :	A motion that returns the **Follower-Part** to its original position after each machine cycle.
Indexing :	A **progressive motion**, usually rotating.
Indexer :	A device whose input is a constant-speed (usually) **Cam-Shaft** and output is a rotating-Part with a **progressive motion**. The input rotates one time to index the output one time. The index-angle is such that 360º/(Index-Angle) is an integer.
Cam-Blank :	The material from which you cut the shape of the **Cam-Profile**.

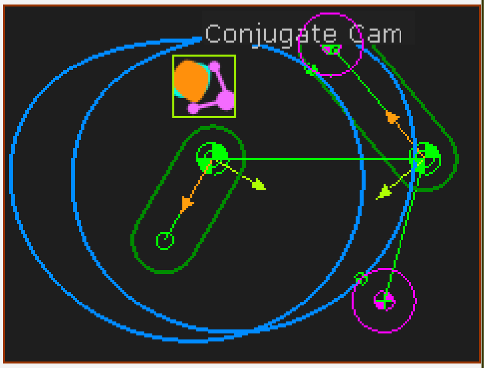
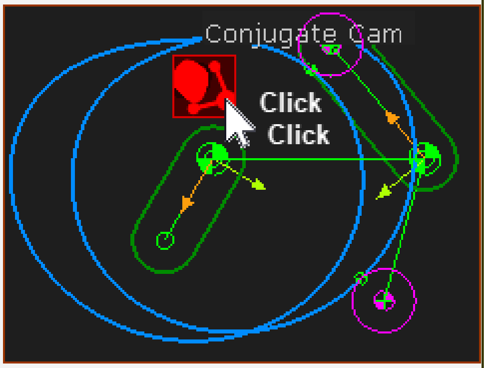
Cam Work-flow

Action	Help Topic
1. Add a **2D-Cam**	**see** Add 2D-Cam 128
If the new **2D-CAM** is one of a pair of **Conjugate-Cams**, or it is one flank of a **Groove-Cam**:	
1.a. Add a **CONJUGATE-CAM FB**	**see** Add Conjugate Cam FB 165
1.b. Edit the **CONJUGATE-CAM FB** to select the two **2D-CAMS**.	**see** Conjugate-Cam dialog 436
2. Select a **2D-CAM** or a **CONJUGATE-CAM FB** as the Power Source for the kinematic-chain that includes the Follower	**see** Configure-Power Source 589
3. Review the **2D-CAM** : **Display, Properties, Roller-Life, Cam-Life, ...**	**see** 2D-Cam dialog 401
4. Add a **Cam-Data FB**	**see** Add Cam-Data FB 199
5. Edit the **CAM-DATA FB** to link it to a **2D-CAM** - close the dialog	**see** Cam-Data dialog 440
6. Connect wires from the output-connectors of the **CAM-DATA FB** to a **GRAPH FB**	
7. Analyze the **2D-CAM**	**see** Cam-Data dialog : Cam Analysis 440
8. Edit the **CAM-DATA FB** again to calculate the Cam's Coordinates	**see** Cam-Data dialog : Cam-Coordinates 446

Prepare to Add Conjugate Cam FB

	**Preparation Example:** • Two(2) **2D-CAMS** in one kinematic-chain - e.g. a **Cam-Shaft** • Two(2) or more **Follower-Profiles*** in a different kinematic-chain - e.g. a **Rocker** • Edit each **2D-CAM** to display one **Cam-Profile** - the **INNER** or the **OUTER** - **see** [2D-Cam dialog > Display tab][407] * **Follower-Roller** and/or **Flat-Faced Follower**. See also Follower-Profile Shapes.

Add Conjugate Cam FB

	**STEP 1: Add the Conjugate-Cam FB** 1. **Mechanism menu > Conjugate-Cam** **OR**  1. **Machine-elements toolbar > Add Conjugate-Cam FB** The **CONJUGATE-CAM-FB** is now in the graphics-area.
	**STEP 2: Edit the Conjugate-Cam FB**  1. Double-click the **CONJUGATE-CAM FB** in the graphics-area **OR** 1. See [How to open a dialog][627] The **CONJUGATE-CAM DIALOG** is now open. **STEP 3: See** [Conjugate-Cam dialog][436]

1.5.5.3 Forces

Forces

The commands in the **Forces menu** and **Forces toolbar** add, measure, and configure kinetostatic forces*. We will use the generic term **Forces**.

In MechDesigner, to calculate correctly the **Forces** that act on a **PART**:

- the kinematic-chain that is kinematically-defined,
- a minimum of one **PART** in the kinematic-chain has **Mass**, and usually a **Mass Moment of Inertia** - see **Mass Properties**, below
- the Power flows correctly through the kinematic-chain from the correct Power Source - see Configure Power Source [232].

---

* **Norton** calls it the "**Inverse Dynamics Problem**".

Mass Properties

PARTS have three sources of **Mass** and a **Mass Moment of Inertia**. The sources are:

- PROFILE / EXTRUSIONS - **see** **Extrusion > Mass Properties** [363]
- USER MASS PROPERTIES - **see** **CAD-Line > Mass Properties tab > User Mass Properties** [368]
- SOLIDWORKS MASS PROPERTIES - **see** **CAD-Line > Mass Properties tab > SOLIDWORKS Mass Properties** [369]

We add together the three sources of **Mass Properties**.

Note:

If a **PART** has **Mass** but does not have **Mass Moment of Inertia**, it is called a **Point-Mass** (or a **Black Hole!**). In reality, a **Mass** is distributed, and so the body must also have a **Mass Moment of Inertia**.

However, you can, if you wish, add a **Point-Mass** to a **PART** without a **Mass Moment of Inertia**. For very slow moving machines, or for **PARTS** that mainly translate (rotate only a small amount), this may provide the accuracy you need.

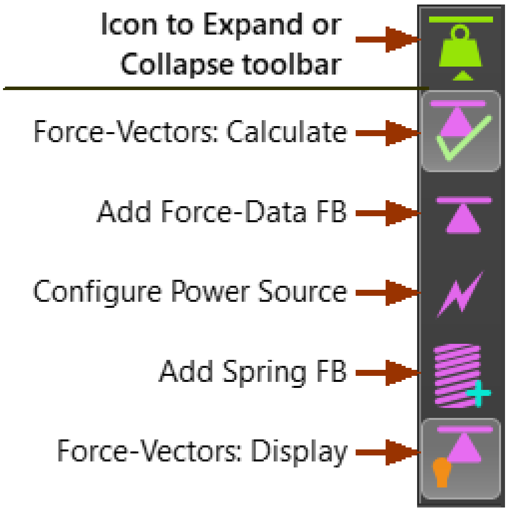
On-line Tutorial: Tutorial 13: Forces Introduction

Force menu

Forces menu (MD17)

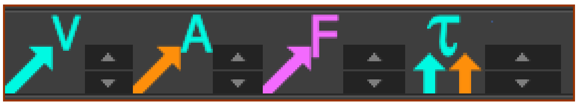
Force toolbar

The **Force toolbar** is to the **right** of the graphics-area.



Forces toolbar

Buttons to Scale Force and Torque Vectors in the graphics-area.



Vector scaling
F: Force Vectors, T: Torque Vectors

"Force Vectors" include both the Force Vectors and Torque Vectors.

If, after you display **Force Vectors**, the arrowheads of the vectors are outside of the graphics-area, you must use the **Scale buttons** to decrease the length of the **Force Vectors** and/or **Torque Vectors** - **see** **Feedback Area > Vector Scaling buttons** 327

Force definitions - as defined by IFTOMM International Federation on the Theory of Machines and Mechansims :

FORCE
Action of its surroundings on a body tending to change its state of rest or motion.
LINE OF ACTION OF A FORCE
The line along which the vector that represents a given force lies.
MAGNITUDE OF A FORCE
Number of units of force obtained by comparing a given force with a standard, taken as unit force -(SI units : Newtons)
ACTIVE [APPLIED] FORCE
Force capable of producing motion.
REACTION
Force arising in a constraint and acting upon a constrained body due to the action of an active force upon that body.
CENTRIPETAL FORCE

FORCE
Force causing the centripetal acceleration of a particle.
INERTIA FORCE
Product of the mass of a particle and the negative of its acceleration. Following D'Alembert, the inertia force can be regarded as being in equilibrium with the resultant of all the forces acting on the particle.
CENTRIFUGAL FORCE
Inertia force of a particle moving uniformly along a circular path.
CORIOLIS FORCE
Inertia force equal to the product of the mass of a particle and the negative of its Coriolis component of acceleration.
GRAVITATIONAL FORCE
Force equal to the product of the mass of a particle and the Gravitational Acceleration on Earth - taken as 9.806m/s/s.

Acceleration Definitions:

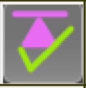
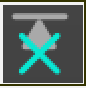
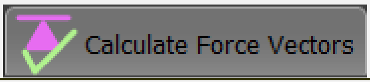
We calculate for you those Forces that result from these Accelerations :

CORIOLIS ACCELERATION
Component of the absolute acceleration of a point due to its velocity relative to a rotating frame of reference. It equals twice the vector product of the angular velocity of the moving frame of reference and the relative velocity of the given moving point.
CENTRIPETAL ACCELERATION
Acceleration of a point towards the center of curvature of its path as it moves along a fixed curve.
TANGENTIAL ACCELERATION
Component of acceleration of a point collinear with its velocity.
NORMAL ACCELERATION
Component of acceleration of a point normal to its velocity.
ANGULAR ACCELERATION
Rate of change of angular velocity with respect to time.

1.5.5.3.1 Calculate Force-Vectors

Calculate Forces-Vectors:

Click to toggle “Calculate” and “Do not Calculate” the **Force Vectors**.

	Forces toolbar > Force Vectors: Calculate
	Forces toolbar > Force Vectors: Do not Calculate
	Forces menu > Force Vectors: Calculate

Note:

To calculate **Forces Vectors**:

- The kinematic-chains must be kinematically-defined.
- A minimum of one **PART** has a Mass and/or a Mass Moment of Inertia
- Select the correct element as the **Power-Source** - see Configure Power Source [589] .

AND / OR

- A **SPRING FB** applies an external force to the kinematic-chain

See also:

Force-Vectors: Display [237]

Kinetostatic Servomotor and Gearbox selection [592]

1.5.5.3.2 Add Force-Data FB

Why add a Force-Data FB?

See also: Force-Data FB dialog [541]

Use a **FORCE-DATA FB** to measure, over a machine-cycle, the **force*** that acts ON a **POINT** at a **JOINT**, **SPRING**, **2D-CAM**, **PULLEY**, or **RACK-PINION**.

Use a **GRAPH FB** to plot **force** over a machine-cycle.

See also:

Configure the Power Source [589]

* **Force**:

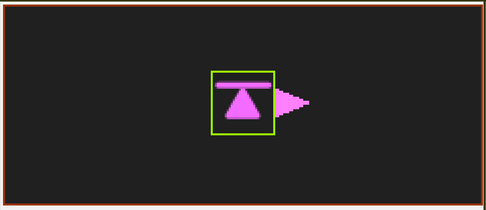
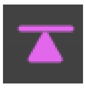
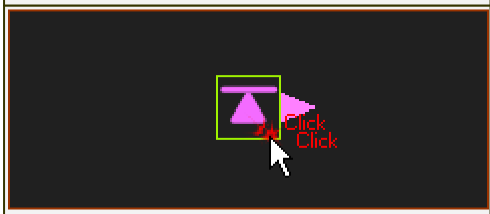
The term we use for Kinetostatic Force and Torque data.

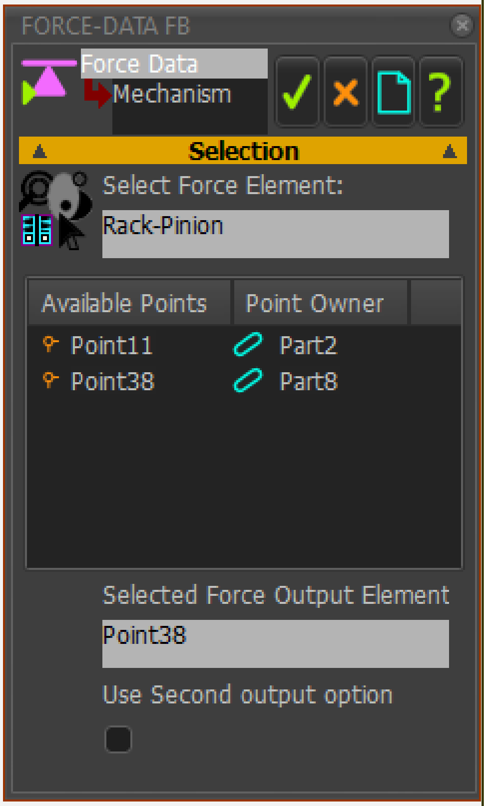
Kinetostatic Forces are those that arise in parts and at joints that have mass and mass moment of inertia, when the parts move with a prescribed motion. The moving parts and machine frame are perfectly rigid, there is no backlash in the joints, and the pre-scribed motion is followed perfectly.

Dy

See also: Dynamics for Dynamic Forces and Torques.

Add Force-Data FB

 Force-Data FB in graphic-area	**STEP 1: Add the Force-Data FB to the graphics-area.** 1. Click **Forces menu > Force-Data** **OR**  1. Click Forces toolbar [226] > **Add Force-Data FB** Then: 2. Click the graphics-area The **FORCE-DATA FB** is now in the graphics-area.
 Doube-click to edit Force-Data FB	**STEP 2. Open the Force-Data FB dialog** 1. Double-click the **FORCE-DATA FB** to open the **FORCE-DATA DIALOG**. **OR** **See 'How to open a dialog'** [627]



Force-Data FB dialog

STEP 3. Link the Force-Data FB to a Force-Element and a Point

A. Select a Force-Element

1. Click a Force-element in the graphics-area or the ASSEMBLY-TREE

Force-elements include: JOINT, 2D-CAM, SPRING, PULLEY, RACK-PINION,

A list of AVAILABLE POINTS shows in the box below.

B. Select a Point in the box of Available Points

Even if a POINT shows in the SELECTED FORCE OUTPUT ELEMENT box:

1. Click a POINT in the box below AVAILABLE POINTS

If you select a:

- PIN-JOINT - there are two(2) AVAILABLE POINTS
  One POINT on each PART of the PIN-JOINT
- SLIDE-JOINT - there are four(4) AVAILABLE POINTS
  Two POINTS on each LINE of the SLIDE-JOINT
- 2D-CAM 128 - zero(0) AVAILABLE POINTS
  CONTACT POINT is selected
- SPRING FB 234 - two(2) AVAILABLE POINTS
  The SPRING'S Anchor POINTS
- RACK-PINION 136 - two(2) AVAILABLE POINTS
  The CONTACT-POINTS between the RACK AND PINION

C. Complete the command

3. Click ✓ to close the FORCE-DATA FB

1.5.5.3.3 Configure Power Source

Why Configure Power Source?

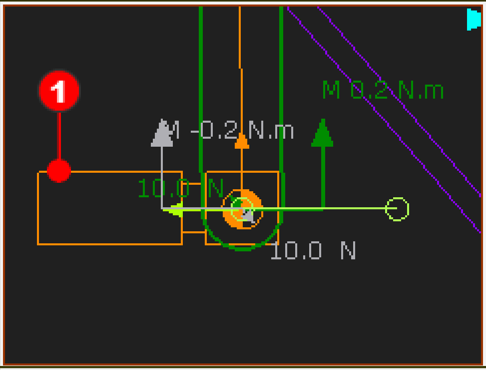
Each degree-of-freedom in a kinematic-chain has a power-source.

In the default case, the power-source is a motor at the joint whose motion you control with a MOTION-DIMENSION FB. Frequently, the motor is at a different joint, or a Cam provides the power to move a kinematic-chain.

If the power-source for a degree-of-freedom is not the correct element, you must use the CONFIGURE POWER SOURCE DIALOG to move it to the correct element.

The elements that can be a power-source are: PIN-JOINTS, SLIDE-JOINTS, 2D-CAMS, SPRINGS, and PULLEYS.

To identify the Power-Source



In the default case, the **Power-Source** is at the joint whose position and motion you control with a MOTION-DIMENSION FB.

A **Motor-Symbol**1 represents a **Power-Source** at the joint.

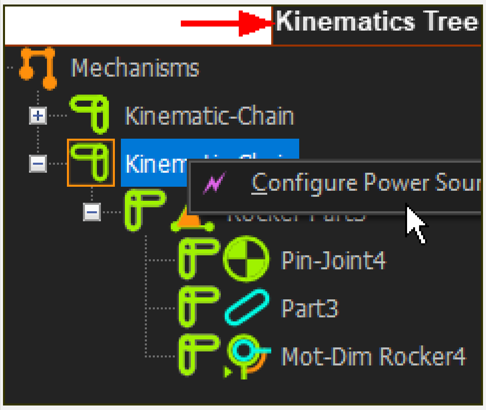
To see the **Motor-Symbol**, toggle on:

- Forces toolbar > Force-Vectors: Calculate 229
- Force toolbar > Force-Vectors: Display 237

To open the Configure Power-Source dialog

There are two methods to open the CONFIGURE POWER-SOURCE DIALOG.

METHOD 1 - shortcut menu or keyboard



Configure Power Source from Kinematics-Tree

1. Click the **KINEMATICS-TREE** in the Element-Explorer [315]
2. Click the **Kinematic-Chain** for which you want to control the Power-Source.

The Kinematic-Chain should be Blue.

3. Right-click the Kinematic-Chain in the **Kinematics-Tree**
4. Click **Configure Power Source** in the shortcut menu (see image, left)

OR

3. Press the **ALT+P** keyboard short-cut

The **CONFIGURE POWER SOURCE DIALOG** is now open.

See Configure Power Source dialog [589].

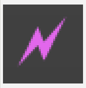
METHOD 2 - command icon

In the **Kinematics-Tree:**

1. Click the **KINEMATICS-TREE** in the Element-Explorer [315]
2. Click the **Kinematic-Chain**

The Kinematic-Chain should be Blue.

3. Click Force toolbar [226] **(or menu) > Configure Power Source** icon.



OR

3. **Forces menu > Configure Power Source**

The **CONFIGURE POWER SOURCE DIALOG** is now open.

See Configure Power Source dialog [589].

1.5.5.3.4 Add Spring FB

Why add a Spring FB?

See also: Spring FB dialog 538

Use a SPRING FB to add a force between two POINTS*. The POINTS* are usually in different PARTS.

* POINT, START-POINT, END-POINT, CENTER-POINT.

One SPRING FB can superimpose these forces:

- SPRING FORCE - a force proportional to the dimensional difference between the Spring's ANCHOR-POINTS and its FREE-LENGTH.
- CONSTANT FORCE - a constant force that pulls or pushes the Spring's ANCHOR-POINTS, throughout the machine-cycle.
- COULOMB CONSTANT-FORCE - a constant force that acts in the direction that is opposite to the relative velocity between the SPRING'S ANCHOR-POINTS.
- DRAG-FORCE - a force that is proportional to the relative velocity between the Spring's ANCHOR-POINTS.
- DRAG FORCE-SQUARED - a force that is proportional to the square of the relative velocity between the Spring's ANCHOR-POINTS.
- FORCE-FUNCTION - a force-function that you add to the input-connector of the SPRING FB.

The **Forces values** are superimposed (added) together to give the **Total-Force** at the output-connector of the SPRING FB.

Terminology:

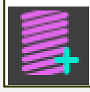
Anchor-Points :	The two(2) POINTS that define the axis through which the SPRING FB applies its Force. You select the two POINTS when you add a SPRING FB.
Force element :	A SPRING FB is a **Force-Element**.
Linear Motive Force :	The SPRING FB can be a Power-Source. It calculates the Application Load. **A Linear Motor would provide the Linear Motive Force equal to the Application Load.**

Add Spring FB

STEP 1: Start the Add Spring FB command

1. Click **Forces menu > Spring FB**

OR



1. Click **Forces toolbar**[226] **> Add Spring FB**

STEP 2: Select the Anchor-Points

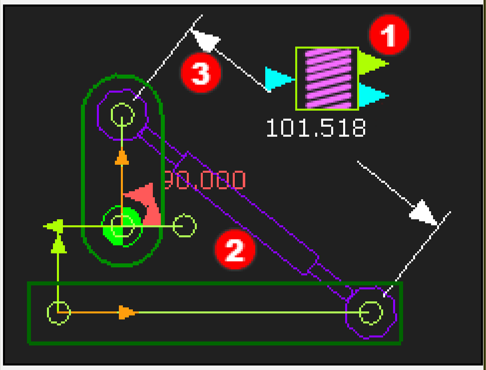
1. Click two different **POINTS** - the **ANCHOR-POINTS** - in two different **PARTS**.

The distance between the two **POINTS** shows next to your mouse-pointer.

2. Click the graphics-area to place the dimension and the **SPRING FB**.

The **SPRING FB** is now in the graphics-area.

STEP 3: Open the Spring FB dialog[538]



Spring FB in the graphic-area

SPRING FB in the graphics-area:

SYMBOL ❶ **FB** - see **SPRING FB CONNECTORS**

SYMBOL ❷ **SPRING** between the **ANCHOR-POINTS**

❸ **DIMENSION** between the **ANCHOR-POINTS**

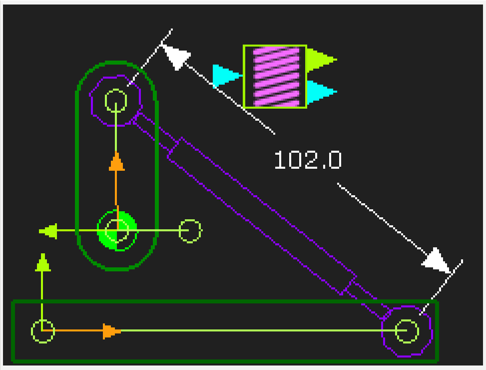
NOTE: Positive (Negative) force values Pull (Push) the Anchor-Points together (apart).

Spring FB States:

The **SPRING FB** can be in three different **states.**

STATE 1: The Spring FB is enabled.

The default state. The **SPRING FB** exerts a Force that is defined by the parameters in the **Spring FB dialog**[538] .



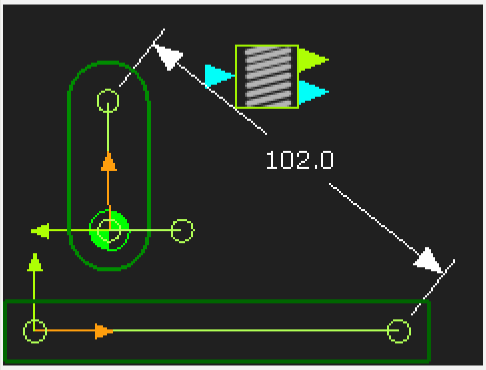
Spring FB - Enabled

STATE 2: The Spring FB is not enabled

To enable/disable the SPRING FB

1. Edit the SPRING FB to open the SPRING FB DIALOG 538

   In the SPRING FB DIALOG
2. Select / deselect the ENABLE CHECK-BOX.
3. Click ✅ to close the dialog.



Spring FB > Not enabled

STATE 3: The Spring FB is a Linear Motor

To change the SPRING to a **Linear-Motor**

1. Open the **Configure Power Source dialog** of the kinematic-chain for which the SPRING FB will be **Linear-Motor.**

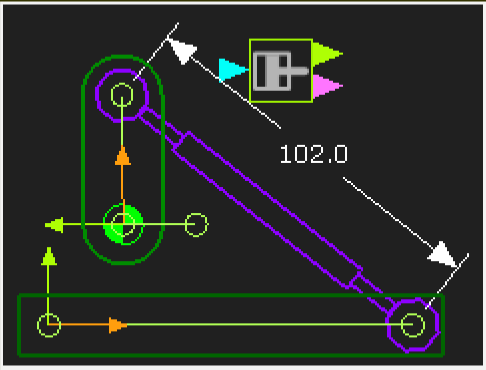
In the CONFIGURE POWER SOURCE DIALOG:

2. Click the MOTION-DIMENSION FB that applies the motion to the kinematic-chain
3. Click the SPRING FB as the POWER SOURCE,

The SPRING FB is now a **Linear Motor**.

4. Close the CONFIGURE POWER SOURCE DIALOG.

See - Configure Power Source 232

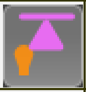
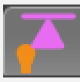


Spring FB > Linear Motor

1.5.5.3.5 Display Force-Vectors

Display Force-Vectors

Click the button to toggle “Display” and “Do not Display” **Force Vectors**.

	Forces toolbar > Force-Vectors: Display
	Forces toolbar > Force-Vectors: Do not Display
 Display Force Vectors	Forces menu > Force-Vectors: Display: Enable or Disable

Force-Vectors show ONLY when...

- You enable: Force toolbar > Force-Vectors: Calculate[229]

AND

- You enable: Force toolbar > Force-Vectors: Display

AND

- A minimum of one PART is **kinematically-defined** and it has a mass(kg) - see CAD-LINE DIALOG | MASS PROPERTIES[367] .

AND/OR

- A SPRING FB[234] applies a Force between two POINTS and the PARTS are kinematic-defined.

AND

- You enable: Display Filters toolbar > Display Part-Outlines (default)

Force-Vectors in the graphics-area

Each **Force-Vector** is the **Force** that ACTS-ON a PART at a Joint in a kinematic-chain.

Vector Location: rays from POINTS at PIN-JOINTS, SLIDE-JOINTS, SPRINGS, CAM CONTACTS, GEAR CONTACTS, BELTS.

Vector Direction: in the direction of the **Force-Vector**

Vector Length: scaled to the magnitude of the Force - **see** Vector Scale buttons[327]

Vector Magnitude: that acts on the **POINT** is at the arrowhead at the end of each Force vector

Vector Color: **see below** **Colors: Part-Outlines and Force-Vectors** 238 .

Rotary Driving Moment / Driving Torque

The **Torque-Vector** is the **Application-Torque** that a motor and gear-box must be able to drive.

Location: at a PIN-JOINT that you select to drive the kinematic-chain - **see** **Configure Power Source** 232

Length: proportional to the magnitude of the Torque.

IMPORTANT:

The **Torque-Vector** does **NOT** include the torque to accelerate the inertia of a **Servomotor** or **Gearbox**

To select and include a **Servomotor** and **Gearbox** - **see** **Kinematic Servomotor and Gearbox Sizing** 592 .

Linear Driving-Force

The **Driving-Force** is the instantaneous **Force** to drive the kinematic-chain.

Location: at a SLIDE-JOINT that you select to drive the kinematic-chain **- see also: Configure Power Source** 232 **)**

Length: proportional to the magnitude of the Driving-Force.

IMPORTANT:

The **Driving-Force** does **NOT** include a **Linear Servomotor** to drive the kinematic-chain.

There is **NOT** a database of **Linear Servo-motors.**

Colors: Part-Outlines and Force-Vectors

When you enable **Force-Vectors: Display**, we color of each PART-OUTLINE is changed.

The color of the PART-OUTLINE of each PART is the same color as the **Force-Vectors** that ACTS-ON the PART, at a POINT in the PART.

TOP-TIP

To help identify which **Force-Vectors** act on a PART:

1. Hover above a PART-OUTLINE

The PART-OUTLINE AND the **Force-Vector** that ACTS-ON the PART change to the selected color, usually RED.

Use **Configure Power Source** 232 to edit the color of each **Force-Vector**, and/or to hide **Force-Vectors** that act on different PARTS.

See also: Kinetostatic Torque and Speed dialog 592

1.5.5.4 MD-Solids

MD-Solid

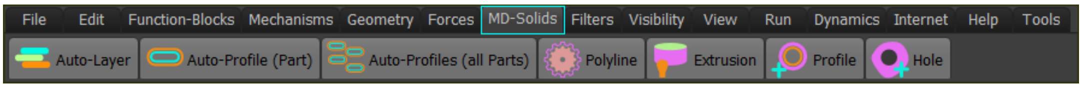
The commands in the **MD-Solids menu** and **MD-Solids toolbar** relate to **MD-SOLIDS** only.

Terminology and Definitions

SOLIDS :	Generic name for **MD-SOLIDS** and **CAD-SOLIDS**.
MD-SOLIDS :	Those **SOLIDS** that you add to a **PART** with the **Add Profile** and **Add Auto-Profile** commands.
CAD-SOLIDS :	Those **SOLIDS** that you import from your 3D-CAD onto a **CAD-LINE**.

To see **MD-SOLIDS** and **CAD-SOLIDS**, you must enable Visibility toolbar > Show Solids in Mechanisms 66

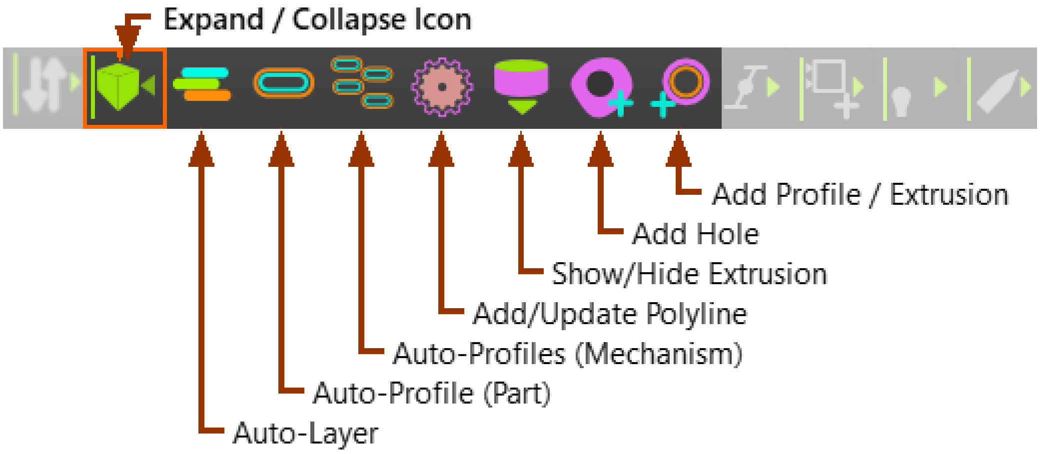
MD-Solids menu



Solids menu (MD17)

MD-Solids toolbar

The **MD-Solids toolbar** is **above** the graphics-area



Solids toolbar

1.5.5.4.1 Auto-Layer

What is 'Auto-Layer'?

The **Auto-Layer** commands edits for you, by different values, the **EXTRUSION-OFFSET** and **PART-OFFSET** parameters (in **EXTRUSION DIALOGS**) to move **ALL EXTRUSIONS** in the active **MECHANISM-EDITOR** along the Z-axis, by different distances.

After you do **Auto-Layer**, **EXTRUSIONS** should not collide with each other when you cycle the model.

Auto-Layer should save you time. However, **Auto-Layer** is not perfect! If, after you use **Auto-Layer**, **EXTRUSIONS** do collide, you need to edit manually the **EXTRUSION-OFFSET** and **PART-OFFSET** parameters for each **EXTRUSION** that collides.

Warning: The **Auto-Layer** command is not a toggle - the offset distances do not **UNDO** if you click **Auto-Layer** again.

See also: **Auto-Profiles (Mechanism)** 244 , **Auto-Profile (Part)** 242 , **Profile**, **Extrusion dialog** 360

Note:

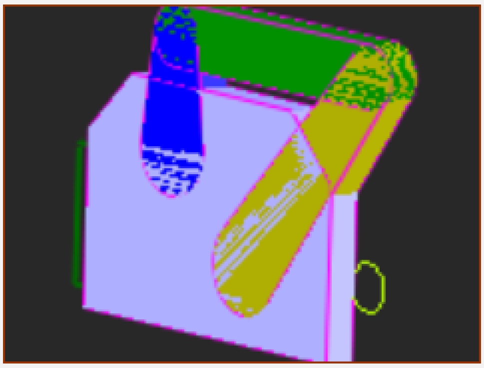
Before you do **Auto-Layer**, you usually add **AUTO-PROFILES** and/or **PROFILES**. See:

- MD-Solids menu > Auto-Profile (all Parts) 244
- MD-Solids menu > Auto-Profile (Part) 242
- MD-Solids menu > Profile 253

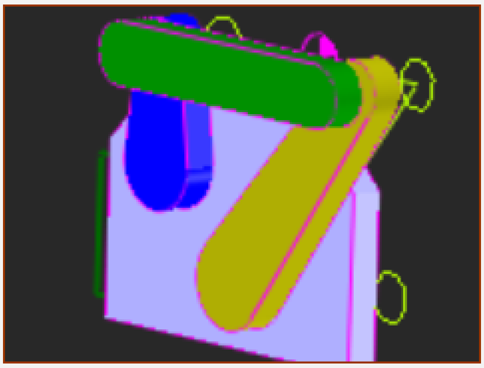
To see **MD-SOLIDS**

- Enable **Visibility menu** > Show Solids in Mechanisms 66

Auto-Layer



Before 'Auto-Layer'



After 'Auto-Layer'

STEP 1: Do the Auto-Layer command.

1. Click **MD-Solids menu** > **Auto-Layer**

OR

1. Click **MD-Solids toolbar** > **Auto-Layer**

Video:

Double-click to watch Solids menu > Auto-Layer

1.5.5.4.2 Auto-Profile (Part)

What is an Auto-Profile?

An **AUTO-PROFILE** is an **MD-SOLID**.

When you do **Add Auto-Profile (Part)** and/or **Auto-Layer (all Parts),** we add or remove for you a **quasi-sketch-loop** and an **AUTO-PROFILE / EXTRUSION** to one **PART**.

See also

Auto-Profile (all Parts) [244]

Notes:

To see **MD-SOLIDS** in **MECHANISM-EDITORS**, enable **Visibility toolbar** > Show Solids in Mechanisms [66]

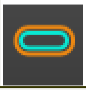
To edit an **EXTRUSION**, see How to open the Extrusion dialog [244] .

Auto-Profile (Part)

STEP 1: Start the Add Auto-Profile command:

1. Click MD-Solids menu [239] > **Add Auto-Profile (Part)**

OR



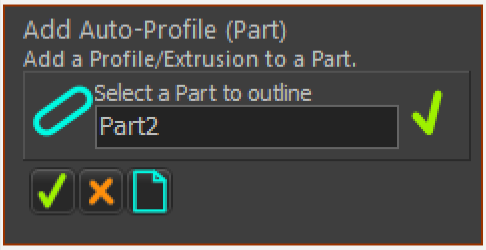
1. Click **MD-Solids toolbar > Add Auto-Profile (Part)**

STEP 2: Select a Part:

The **COMMAND-MANAGER** has one selection-box.

In the graphics-area or **ASSEMBLY-TREE**:

1. Click the **PART-OUTLINE** to add or delete an **AUTO-PROFILE** to or from a **PART**.

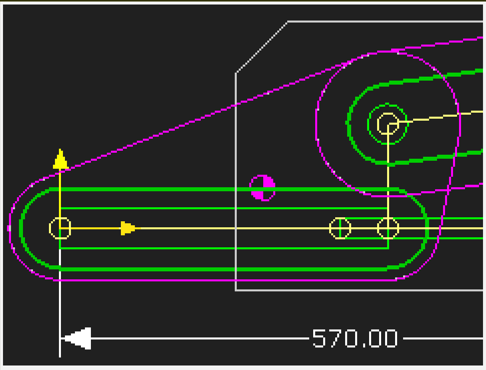


Command-Manager
Add Auto-Profile

STEP 3: Complete the Command:

1. Click ✓ in the **COMMAND-MANAGER**.

RESULT



Auto-Profile in Mechanism-Editor

The shape of the quasi-**sketch-loop** is a function of the JOINTS in the PART and the Bearing Sizes in the APPLICATION-SETTINGS > AUTO-PROFILE DIALOG

The image shows the AUTO-PROFILE (Pink) around a SLIDE-JOINT and a PIN-JOINT.

RULE:

IF the PART does not have an AUTO-PROFILE:

> Add a **quasi-Sketch-loop** and AUTO-PROFILE / EXTRUSION to the SKETCH-LOOP ...
>
> ... to the ONE PART

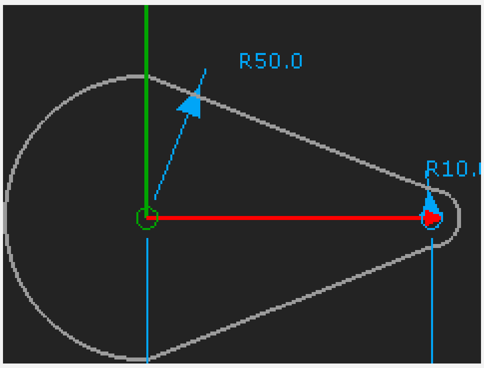
ELSE

IF the PART has an AUTO-PROFILE:

> Delete the AUTO-PROFILE and **quasi-sketch-loop** ...
>
> ... from the ONE PART

Quasi-Sketch-Loops

Original quasi-Sketch-Loop after Add Auto-Profile



Increased Radius of a quasi Arc.

Quasi-sketch-loops control the shape of the AUTO-PROFILES.

They have these properties:

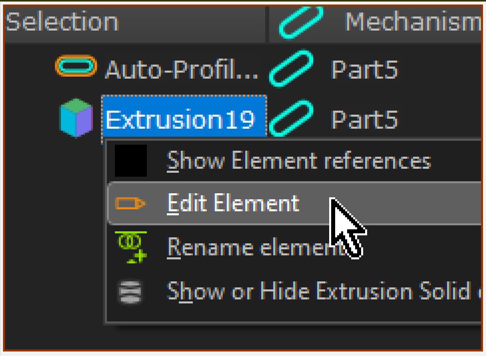
- They do not have **START-POINTS** or **END-POINTS**.
- You **cannot** select, edit, delete **quasi-Arcs** or **quasi-Lines**.
- You **cannot** add a joint between a PART and a **quasi-Line**.
- There is **no Tangent** constraint between the **quasi-Arc** and **quasi-Line** sketch-elements.

However,

- You **can** edit the **Radius** (dimension) of each **quasi-Arc**.

Image above: after you edit the **Radius** of a **quasi-Arc** you can see the **Tangent** constraint is missing between the **quasi-Arc** and **quasi-Line**.

To edit an Extrusion - Special-Case



Edit Extusion and shortcut menu

To edit an Extrusion when you cannot see the Extrusion in the model.

1. SHIFT + Click the AUTO-PROFILE in the graphics-area

The AUTO-PROFILE and EXTRUSION are in the SELECTION-WINDOW.

2. Right-click the EXTRUSION in the SELECTION-WINDOW

A shortcut menu shows next to your pointer.

3. Click **Edit element** in the shortcut menu

The EXTRUSION DIALOG opens.

See Extrusion dialog[360] for more information.

1.5.5.4.3 Auto-Profiles (all Parts)

Auto-Profiles (all Parts)

Add Auto-Profile (all Parts) to ADD AUTO-PROFILES to all PARTS in the MECHANISM-EDITOR.

OR

Add Auto-Profile (Mechanism) to DELETE AUTO-PROFILES from all PARTS in the MECHANISM-EDITOR.

Notes:

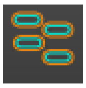
- Enable **Visibility toolbar** > Show Solids in Mechanisms[66] to see **MD-SOLIDS** in MECHANISM-EDITORS.

- The **sketch-loops** that control the shape of each **AUTO-PROFILE** have limited properties - see Quasi Sketch-Loop.
- **AUTO-PROFILES** have Mass and Mass Moment of Inertia properties.

Add Auto-Profiles (all Parts)

STEP 1: Do Add Auto-Profile (all Parts)

1. Click MD-Solids menu[239] > Add Auto-Profile (all Parts)



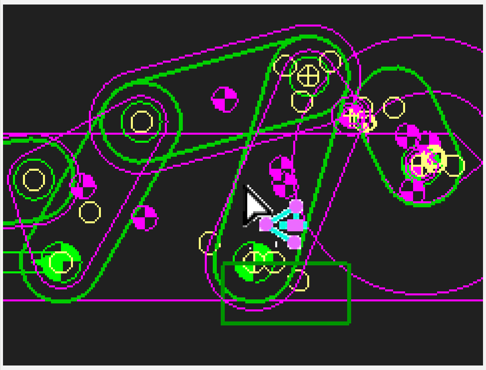
OR

1. Click MD-Solids toolbar[239] > Add Auto-Profiles (all Parts)

Then:

2. Click the graphics-area

RESULT



Parts with Auto-Profiles.

RULE

IF # of **PARTS** with **AUTO-PROFILES** ≤ 50%

Add quasi-**sketch-loops** and **AUTO-PROFILES** / **EXTRUSIONS** ...
... to **ALL PARTS** in the active **MECHANISM-EDITOR**.

ELSE

IF # of **PARTS** with **AUTO-PROFILES** > 50%

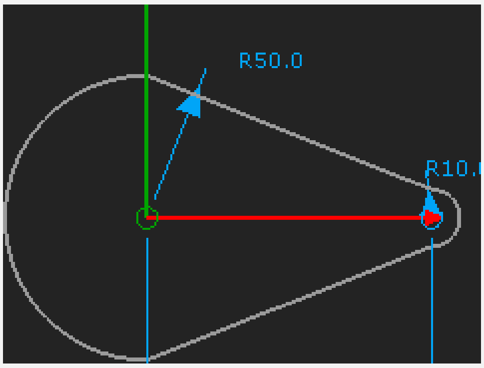
Delete **AUTO-PROFILES** and quasi-**sketch-loops** ...
... from **ALL PARTS** in **ALL** kinematic-chains in the active **MECHANISM-EDITOR**.

Video : Add Profiles (all Parts)

Double-click for a Video

Quasi-Sketch-Loops

Original quasi-Sketch-Loop after Add Auto-Profile



Increased Radius of a quasi Arc.

Quasi-sketch-loops control the shape of the AUTO-PROFILES.

They have these properties:

- They do not have START-POINTS or END-POINTS.
- You **cannot** select, edit, delete **quasi-Arcs** or **quasi-Lines**.
- You **cannot** add a joint between a PART and a **quasi-Line**.
- There is **no Tangent** constraint between the **quasi-Arc** and **quasi-Line** sketch-elements.

However,

- You **can** edit the **Radius** (dimension) of each **quasi-Arc**.

Image above: after you edit the **Radius** of a **quasi-Arc** you can see the **Tangent** constraint is missing between the **quasi-Arc** and **quasi-Line**.

1.5.5.4.4 Add / Update Polyline

Why add a Polyline?

A POLYLINE sketch-element is a sketch-loop* that is a copy of the shape of a 2D-CAM and GEAR-PAIR.

You can add PROFILE/EXTRUSIONS to a sketch-loop.

Therefore, you can model 2D-CAMS and GEAR-PAIRS as **MD-SOLIDS**.

---

* If a 2D-CAM is “Open”, or the gears in a GEAR-PAIR are “Gear-Segments”, you must edit the PARTS after you add a POLYLINE to add sketch-elements to close the sketch-loop.

Add Polyline / Update Polyline

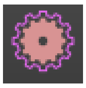
STEP 1: Put the MMA to Zero degrees

1. Press **ALT+H** or the **Home** key on your keyboard

STEP 2: Start the Add Polyline command:

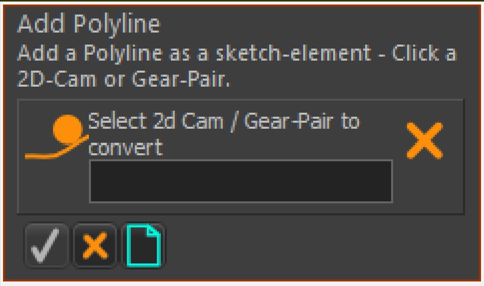
2. Click MD-Solids menu [239] > **Add Polyline**

OR



2. Click MD-Solids toolbar [239] > **Add Polyline**

The **COMMAND-MANAGER** has one selection-box.

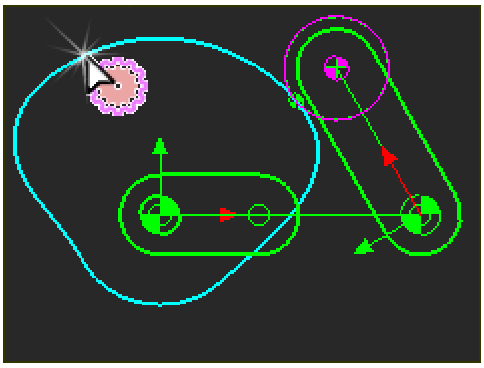


Command-Manager

STEP 3: Select a 2D-Cam or Gear-Pair

To **ADD** a **POLYLINE** to a **2D-CAM** or **GEAR-PAIR**:

1. Click a **2D-CAM** or **GEAR-PAIR** in the graphics-area or **ASSEMBLY-TREE**

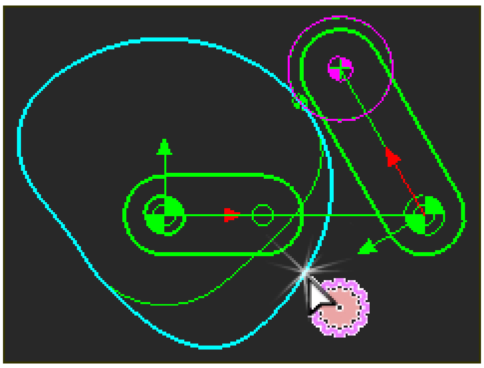


Add Polyline

OR ...

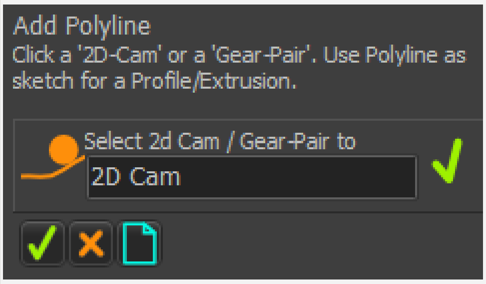
To **UPDATE** the shape of the **POLYLINE** to the new shape of a **2D-CAM** or **GEAR-PAIR**:

1. Click the **new shape** of a **2D-CAM** or **GEAR-PAIR** in the graphics-area or **ASSEMBLY-TREE**



Update Polyline

The **2D-CAM** or **GEAR-PAIR** is in the **COMMAND-MANAGER** selection-box.



2D-Cam element in the Selection-Box

STEP 4: Complete the command

1. Click in the **COMMAND-MANAGER**

If necessary:

2. Click Rebuild Now[50] to make sure the **POLYLINE** is correct.

The **POLYLINE** is now a sketch-element in the **PART** that is the shape of the **2D-CAM** or **GEAR-PAIR**.

1.5.5.4.5 Show/Hide Extrusion

What does this tool do?

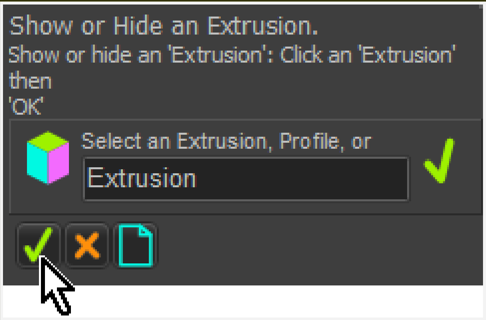
You can show or hide an **EXTRUSION** element with the **EXTRUSION DIALOG**.

Also, you can use this tool as a shortcut to show or hide an **EXTRUSION**.

To see **EXTRUSIONS** in the graphics-area, you must enable:

- Visibility toolbar [60] > Show Solids in Mechanisms [66]

Show-Hide Extrusion



Toggle Visibility of Extrusion

If you **CANNOT** see the **EXTRUSION**, but you can see the **PROFILE**, in the graphics-area:

1. **SHIFT + CLICK** the **PROFILE** in the graphics-area
2. Click MD-Solids menu [239] > **Show-Hide Extrusion**

The **COMMAND-MANAGER** has one selection-box - the **EXTRUSION** is selected.

Click ✓ in the **COMMAND-MANAGER**

Now, you **can** see the **EXTRUSION**

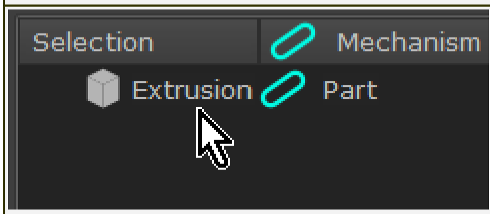
If you **CAN** see the **EXTRUSION** in the graphics-area.

1. **CLICK** the **EXTRUSION** in the graphics-area
2. Click MD-Solids toolbar [239] > **Show-Hide Extrusion**

The **COMMAND-MANAGER** has one selection-box - the **EXTRUSION** is selected.

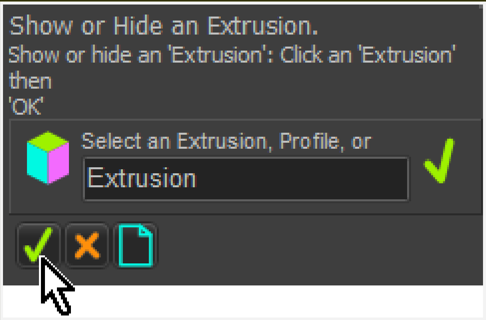
Click ✓ in the **COMMAND-MANAGER**

Now, you **cannot** see the **EXTRUSION**



Element icon for Hidden Extrusion

Note:



Toggle Visibility of Extrusion

If you CANNOT see the **EXTRUSION**, but you can see the **PROFILE**, in the graphics-area:

1. SHIFT + CLICK the **PROFILE** in the graphics-area
2. Click MD-Solids menu [239] > **Show-Hide Extrusion**

The **COMMAND-MANAGER** has one selection-box - the **EXTRUSION** is selected.

Click ✓ in the **COMMAND-MANAGER**

Now, you **can** see the **EXTRUSION**

If you CAN see the **EXTRUSION** in the graphics-area.

1. CLICK the **EXTRUSION** in the graphics-area
2. Click MD-Solids toolbar [239] > **Show-Hide Extrusion**

The **COMMAND-MANAGER** has one selection-box - the **EXTRUSION** is selected.

Click ✓ in the **COMMAND-MANAGER**

Now, you **cannot** see the **EXTRUSION**

When you hide the **EXTRUSION** the color of the **EXTRUSION** element-icon in the **ASSEMBLY-TREE** and the **SELECTION-WINDOW** is **gray.**

Note:

Other methods to control the Visibility of an Extrusion:

1. SHIFT + Click a **PROFILE** in the graphics-area.

The **EXTRUSION** shows in the **SELECTION-WINDOW**

2. **RIGHT-CLICK THE EXTRUSION**

In the shortcut menu

3. Select **Show or Hide Solid Elements**

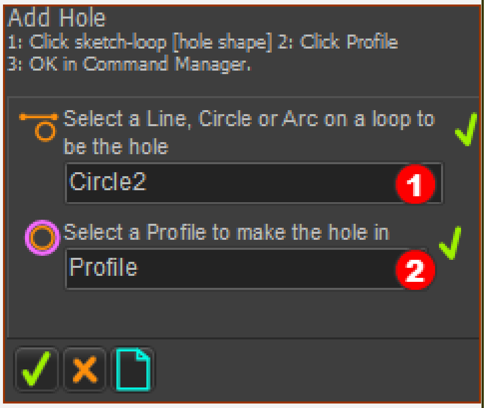
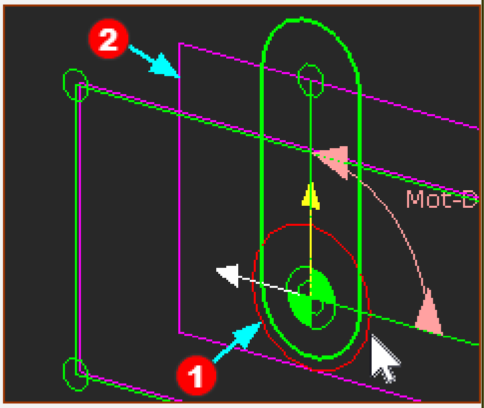
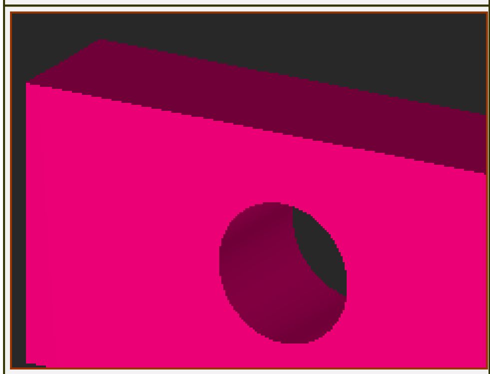
1.5.5.4.6 Add Hole

What is a Hole?

A **HOLE** cuts the shape of a **SKETCH-LOOP** through a **PROFILE / EXTRUSION** (MD-Solid) that is in the model.

Note: To see the **HOLE** through the **PROFILE / EXTRUSION**, enable **Visibility toolbar** > Show Solids in Mechanisms 66

Add Hole

	**STEP 1: Start the command Add Hole:** 1. Click MD-Solids menu 239 > **Add Hole** OR 1. Click **MD-Solids toolbar > Add Hole** The **COMMAND-MANAGER** starts. There is one selection-box.
	**STEP 2: Select the two elements for the Command-Manager** 1. Click a **SKETCH-LOOP** ❶, **all** of which is inside the bounds of **PROFILE** ❷ 2. Click **PROFILE** ❷ through which you want to cut the **HOLE** The **SKETCH-LOOP** and the **PROFILE** are now in the selection-boxes in the **COMMAND-MANAGER**
 Hole through Profile / Extrusion	**STEP 3: Complete the Command** 1. Click ✓ in the **COMMAND-MANAGER** **RESULT:** **Assembly-Tree**: the **HOLE** element is a child to the **PROFILE** element. **Graphics-area**: the **HOLE** cuts through the **PROFILE / EXTRUSION**. <<< image, in the **MODEL-EDITOR**, of the **HOLE** that is cut through the **MD-SOLID**.
See also: **Sketch-Loop, Profile, Command-Manager**	

Video:

Double-click to watch 'Add Hole'

1.5.5.4.7 Add Profile / Extrusion

What is a Profile / Extrusion?

A **PROFILE/EXTRUSION** is an **MD-SOLID**.

Use **Add Profile/Extrusion** to add a **PROFILE** to a **sketch-loop**. We also add for you an **EXTRUSION** element as a child to the **PROFILE**.

You can add many **PROFILE/EXTRUSIONS** to the same **sketch-loop**.

Note:

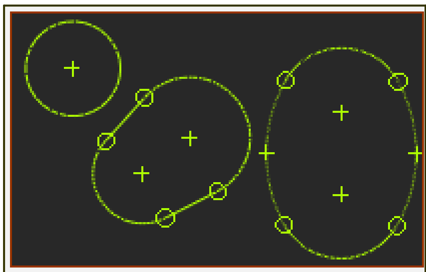
The **Follower-Profile** you select when you **Add 2D-Cam / Add 3D-Cam** is a **PROFILE** element.

See also: Shape of the Follower-Profile.

Terminology:

Sketch-Loop :	A series of sketch-elements, that you join end to end to form a closed loop. The **START-POINTS** and **END-POINTS** where the sketch-elements join together must be merged to one **POINT**. **Sketch-loops** cannot cross over each other and the cannot branch.
PROFILE :	Two offset contours that are a copy of the **sketch-loop** you select when you do **Add Profile.**
EXTRUSION :	The **SOLID** between the two offset contours.

Preparation for Add Profile / Extrusion

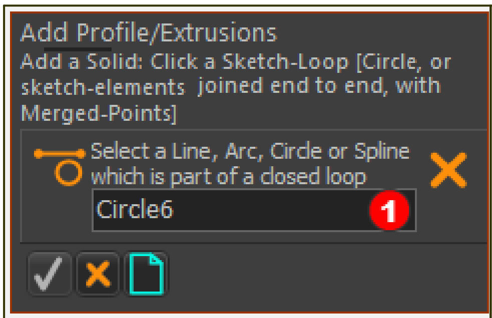


3x Sketch-Loops in a Part

Three example sketch-loops in the model before you do **Add Profile:**

A **SKETCH-LOOP** is in a **PART**

Add Profile / Extrusion



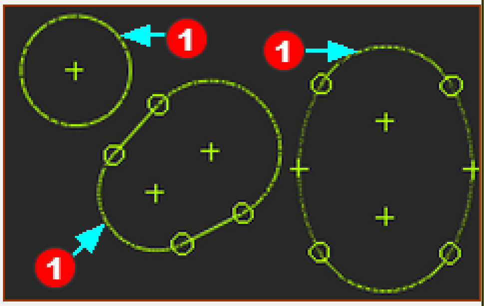
STEP 1: Start the Add Profile command

1. Click **MD-Solids menu > Add Profile**

OR

1. Click **MD-Solids toolbar > Add Profile**

The **COMMAND-MANAGER** starts.

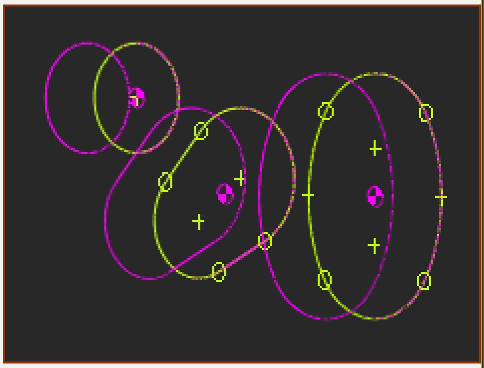


3x Sketch-Loops in a Part

STEP 2: Select a sketch-element that belongs to a sketch-loop

1. Click a **SKETCH-ELEMENT** ❶ that is in one **sketch-loop**, or a **POLYLINE**

The name of the sketch-element is in the **COMMAND-MANAGER**.



3 x Profile Contours in graphic-area

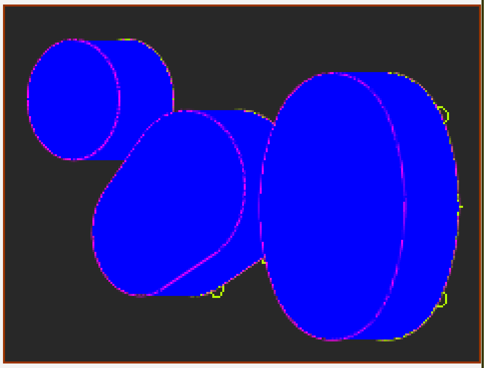
STEP 3: Complete the command:

1. Click ✅ in the **COMMAND-MANAGER.**

We add for you a **PROFILE** and **EXTRUSION** to the sketch-loop that you select.

Do 1 - 3 again to add a **PROFILE** to a different, or the same, sketch-loop.

RESULT : graphics-area



3 x Extrusions in graphic-area

We add for you the Primary and Secondary contours of the **PROFILE** element, which are copies of the **sketch-loop**, and the **EXTRUSION**, which is the **SOLID** between the **PROFILE** contours.

The default position of the Primary Contour is coplanar with the sketch-loop that you select.

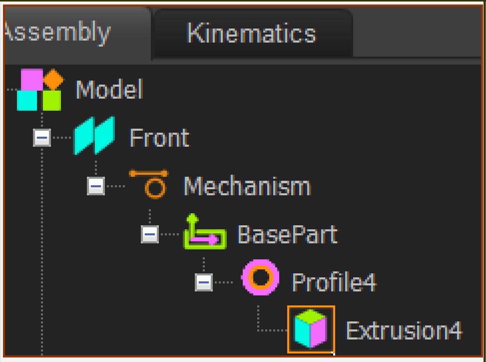
Use the **EXTRUSION DIALOG** to move the contours and **EXTRUSION** relative to the sketch-loop, as required.

To see the **EXTRUSION**, enable Visibility toolbar[60] > Show Solids in Mechanisms[66]

See also How to open the Extrusion dialog[255]

The image shows 3 **PROFILE** and **EXTRUSION** elements.

The default color of the **EXTRUSION** is Blue.



Profile and Extrion elements in the Assembly-Tree

RESULT : Assembly-Tree

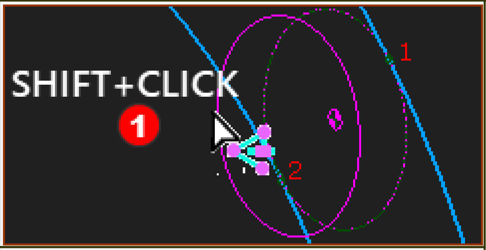
The PROFILE is a child to the PART in which there is the **sketch-loop**.

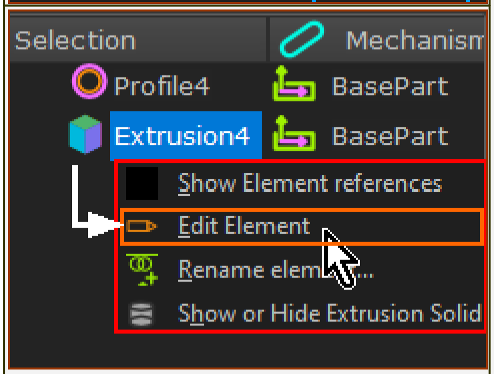
The EXTRUSION is a child to the PROFILE.

See also :
Tutorial 4: Add Profile (external link)
Add Auto-Profile, Add Auto-Profiles, Polyline Sketch-Loop

Video Add Profile:Double-click to watch the Video

How to edit an Extrusion





SELECTION-WINDOW: Right-Click

To EDIT an EXTRUSION ELEMENT - with the SELECTION-WINDOW.

In the graphics-area:

1. SHIFT + CLICK the PROFILE

The PROFILE and EXTRUSION show in the SELECTION-WINDOW.

In the SELECTION-WINDOW:

2. Right-click the EXTRUSION

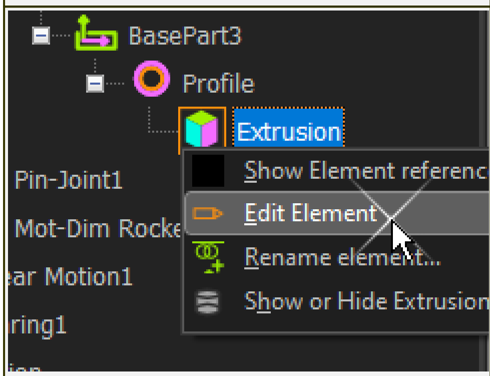
In the shortcut menu

3. Click **Edit element**

The EXTRUSION DIALOG opens.

See Extrusion dialog

OR



ASSEMBLY-TREE - Right-click Extrusion

To EDIT an EXTRUSION ELEMENT - in the ASSEMBLY-TREE

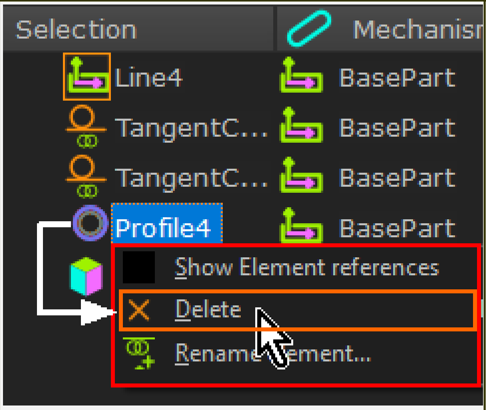
In the ASSEMBLY-TREE

1. Click the PROFILE to expand and see the EXTRUSION element - a child to the PROFILE element
2. Click the EXTRUSION to make sure it has a square ORANGE box around the EXTRUSION icon
3. Right-click the EXTRUSION

In the shortcut menu

	4. Click **Edit element**.

How to delete a Profile

 ASSEMBLY-TREE - **Delete Profile**	To DELETE a PROFILE ELEMENT In the graphics-area 1. CLICK the PROFILE The PROFILE shows in the SELECTION-WINDOW. In the SELECTION-WINDOW: 2. Right-click the PROFILE In the shortcut menu 3. Click **Delete** We delete for you the PROFILE and the EXTRUSION elements from the model.

1.5.6 2.3 Part-Editor

② Part-Editor

What is a Part?

A PART represent any rigid-body in your machine.

PARTS in **MechDesigner** include the:

- BASE-PART : the fixed frame of each **MECHANISM-EDITOR**.
- PARTS : the PARTS you add to the model.

Derived names for PARTS include:

- **Connecting-Part** : a PART in a spatial mechanism
- **Free**, **Completely-Free**, **not kinematically-defined**, or **not solved** : a PART whose **Mobility** > **0**
- **Kinematically-defined** and **solved** : a PART whose **Mobility** = **0**
- **Motion-Part**, **Rocker**, and **Slider** : a PART whose motion you control with a MOTION-DIMENSION FB

What is the Part-Editor?

The **PART-EDITOR** is the workspace to edit a PART.

It includes the **Part name-tab**, the **graphics-area**, and the **XY-axes** at the origin of the PART.

The commands are in the Geometry menu (New MD17), the Geometry toolbar, and the Constraints toolbar.

Why edit a Part?

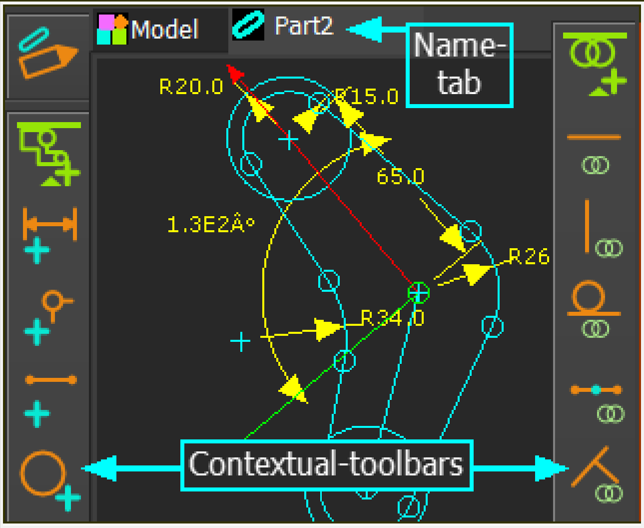
Use the **PART EDITOR** to add sketch elements, constraints, and dimensions to a PART.

See more: Why edit a Part[674] .

See also: How to start the Part-Editor[259] and How to exit the Part-Editor[263]

Part-Editor workspace

When you edit a PART, the **PART-EDITOR** workspace replaces the **MECHANISM-EDITOR** workspace in which the PART is a child. To edit a different PART, you must first close the **PART-EDITOR**, and then edit the different PART.



Part-Editor: Example

Graphics-area : shows the **XY-Axes** of the PART, the sketch-elements, and dimensions that you add to the PART.

Name-tab : is above the graphics-area. The name of the tab changes from the name of the **MECHANISM-EDITOR** to the name of the PART.

Note:

We do not show in the graphic-area the Constraints you add to or between sketch-elements - **see** **How to delete a constraint**[297].

Menus and Toolbars:

See also: How to start the Part-Editor[259] and **How to exit the Part-Editor**[263]

Geometry menu

Geometry menu : Add sketch-elements, constraints, and dimensions

The **Geometry menu** has the commands that are in the Geometry toolbar and Constraints toolbar.

Geometry toolbar[265] (left (<<) of workspace and graphics-area)

The commands to add sketch-elements and dimensions

Constraints toolbar[296] (right (>>) of workspace and graphics-area)

The commands to add constraints to and between sketch-elements.

1.5.6.1 How to start (open) the Part-Editor

How to start (open) the Part Editor

Use the **PART-EDITOR** to edit **one PART** at a time.

To edit a different **PART**:

1. Exit (close) the **PART-EDITOR** - **see also** [How to exit (close) the Part-Editor][263]
2. Select and edit a different **PART**.

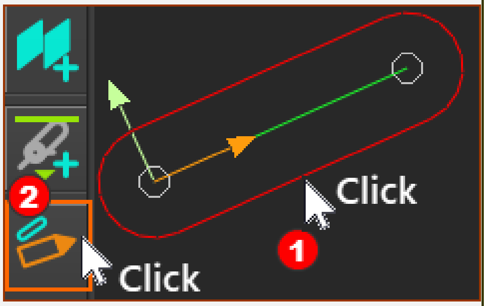
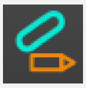
Video: How to start the Part-Editor:

Double-click to watch

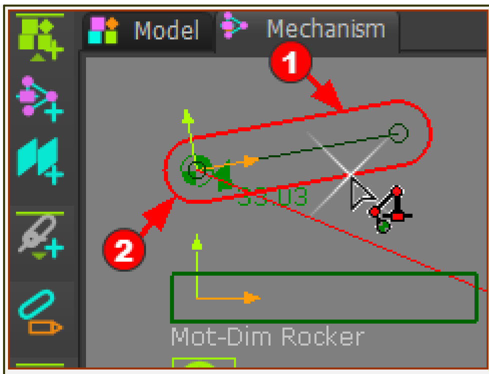
How to start the Part-Editor - more details

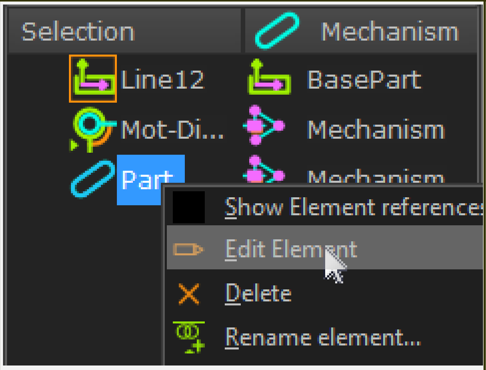
Do one these methods.

METHOD 1: Edit-Part tool

	**STEP 1:** Click a **PART-OUTLINE** ❶ in the graphics-area **STEP 2:** Click **Edit toolbar > Edit Part** ❷ (**MD17: Toggle "Part-Editor"**) You can now use the **PART-EDITOR** to add, edit, or delete sketch-elements and constraints in the **PART-EDITOR**. See How to delete Constraints[672]
	**Note:** The (**MD17: Toggle "Part-Editor"**) icon is to the left of the graphics-area. **See also:** [How to close the Part-Editor: Method 1][263]

METHOD 2: Selection-Window

STEP 1: Click a Part-Outline	**STEP 1:** **Select the Part** **In the graphics-area:** 1. Click the **PART-OUTLINE** ❶ (or at ❷ with some graphic-cards). OR **Assembly-Tree:** 1. Click the **PART** element **STEP 2:** **In the Selection-Window** 1. Find the **PART** from the list of elements in the **SELECTION-WINDOW**

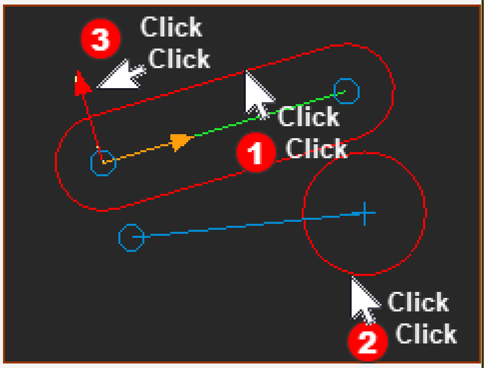


STEP 2: Right-click the Part in the Selection-Window, Click Edit element

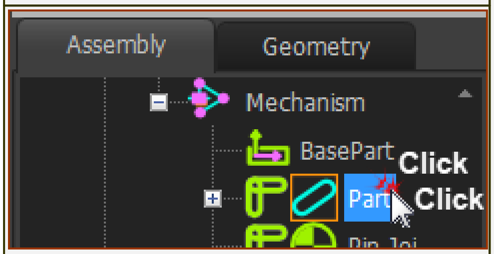
2. Right-click the **PART** element
   In the shortcut menu
3. Click **Edit Element**

The **PART** is now open in the **PART-EDITOR**.

METHOD 3: Double-Click



Double-click a Part-Outline in the graphic-area



Double-click a Part in the Assembly-Tree

STEP 1:

Double-click ... in the graphics-area:

1. Double-click the **PART-OUTLINE** ❶

OR

1. Double-click a **LINE**, **ARC**, or **CIRCLE SKETCH-ELEMENT**❷ that is in the **PART**

OR

1. Double-click the **Y-AXIS**❸ of the **PART**

The **PART** is now open in the **PART-EDITOR**.

OR

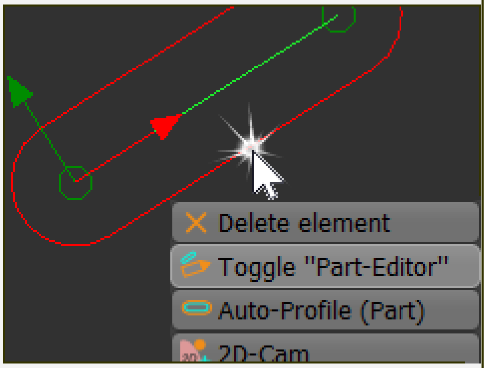
Double-click ... in the Assembly-Tree:

1. Double-click the **PART** element

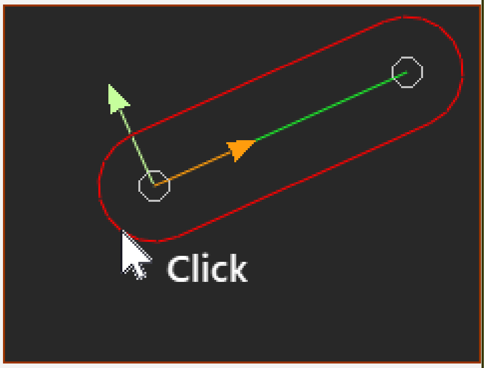
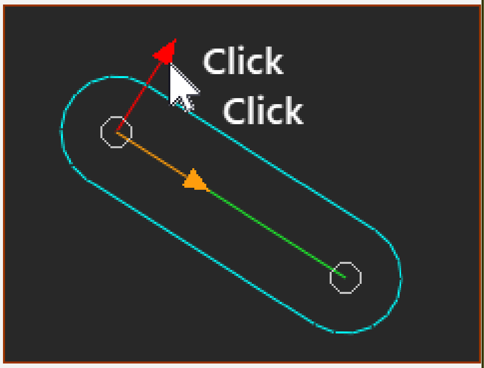
The **PART** is now open in the **PART-EDITOR**.

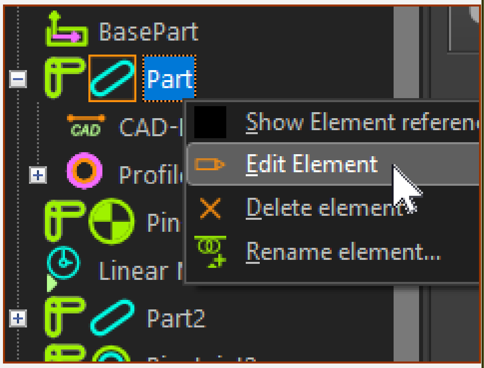
If you double-click a:	
CAD-Line	... the CAD-Line dialog[364] opens
Blend-Curve	... the Blend-Curve dialog[549] opens
Point	... the Point Properties dialog[543] opens
More than one element	... nothing happens.

METHOD 4: Right-Click

 Hover+ Right-click a Part-Outline in the graphic-area	**In the graphics-area:** 1. Move your mouse above the **PART-OUTLINE** **Note**: With some graphic-cards, move your mouse to the arc at the end of the **PART-OUTLINE** near to the **START-POINT** of the **PART** and **CAD-LINE**. 2. Right-Click the **PART-OUTLINE** 3. Click **Toggle "Part-Editor"** (MD16: **Edit in Part-Editor**) from the shortcut menu. The **PART** is now open in the **PART-EDITOR**.

Occasionally, there is a problem with a Graphic-Card

With **some** graphics cards, you cannot select the **PART-OUTLINE** to edit a **PART**. Try these methods:	
 Select the Part-Outline near start-Point.	**METHOD 1: Graphics-area** 1. Move your mouse-pointer above the **arc** of the **PART-OUTLINE** near to the Part-axes -(see image) 2. Double-click your mouse **METHOD 2: Selection-Window** 1. Move your pointer above the **arc** of the **PART-OUTLINE** - see image 2. Click your mouse one time. In the **SELECTION-WINDOW**: 3. Right-Click the **PART** 4. Click **Edit element**
 OR Double-click the Y-axis	**METHOD 3:** OR 1. Double-click the **Y-axis.**

<table>
<tr>
<td>

Select a Part in the Assembly-Tree</td>
<td>Method 4:
OR
In the ASSEMBLY-TREE
1. Right-Click the PART
2. Select Edit element in the short-cut menu.</td>
</tr>
</table>

1.5.6.2 How to exit (close) the Part-Editor

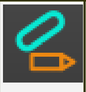
How to exit (close) the Part-Editor

See also : How to Start the Part-Editor[259]

When you close the **PART-EDITOR**, you return to the **MECHANISM-EDITOR**.

To close the **PART-EDITOR**, do one of these methods.

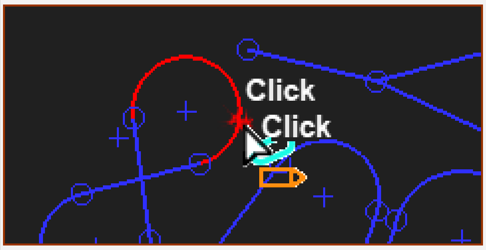
METHOD 1: Deselect the Edit-Part icon



1. Click the Geometry toolbar > Edit Part (MD17: Toggle "Part-Editor") icon, at the left of the graphics-area.

METHOD 2: Double-click a sketch-element

1. Double-click a LINE, CIRCLE, or ARC sketch-element that is a child to the PART that is open in the **PART-EDITOR**.



Note: If you double-click a...

CAD-Line	...the CAD-Line dialog[364] opens
Blend-Curve	...the Blend-Curve dialog[549] opens
Point	...the Point Properties dialog[543] opens
More than one element:	... nothing happens.

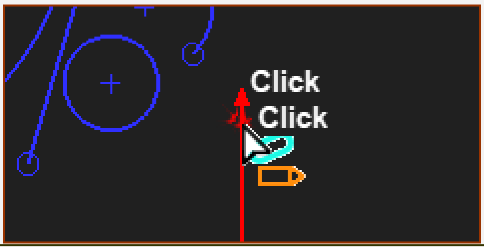
METHOD 3: Double-click the Y-axis

1. Double-click the **Y-axis**.

Note:

We recommend the **Y-axis** because the **X-axis** is collinear with the CAD-LINE element.

And, if you double-click the CAD-LINE, then the **CAD-LINE DIALOG** opens.

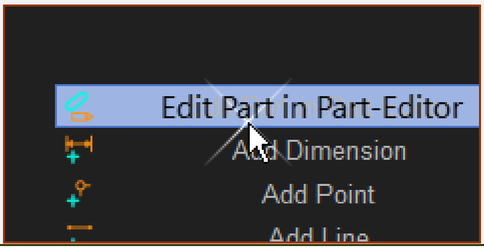


METHOD 4: Right-click

1. Right-click the graphics-area

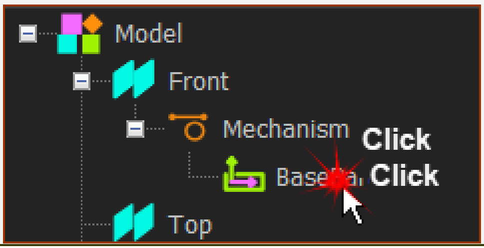
The shortcut menu shows.

2. Click the **Edit Part** (MD17: **Toggle "Part-Editor"**) in the shortcut menu.



METHOD 5: Double-click element in Assembly-Tree

1. Double-click the PART in the ASSEMBLY-TREE.



1.5.6.3 Geometry

Part-Editor - Geometry menu and toolbar

Use the commands in the **Geometry menu** and **Geometry toolbar**:

- to edit the length of a PART
- to add sketch-elements to a PART
- to add dimensions to, or between, sketch-elements
- to import a SOLIDWORKS sketch onto a PART
- to use the Merge-Points command to merge two POINTS into one

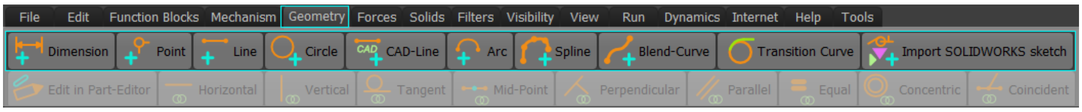
TOP-TIP:

Add each sketch-element so that it is clearly not constrained (other than for a sketch-loop) For example, add a LINE that is not **Horizontal**. Then add the **Horizontal** constraint.

See also: Constraints menu and toolbar 296

Geometry menu > Geometry commands

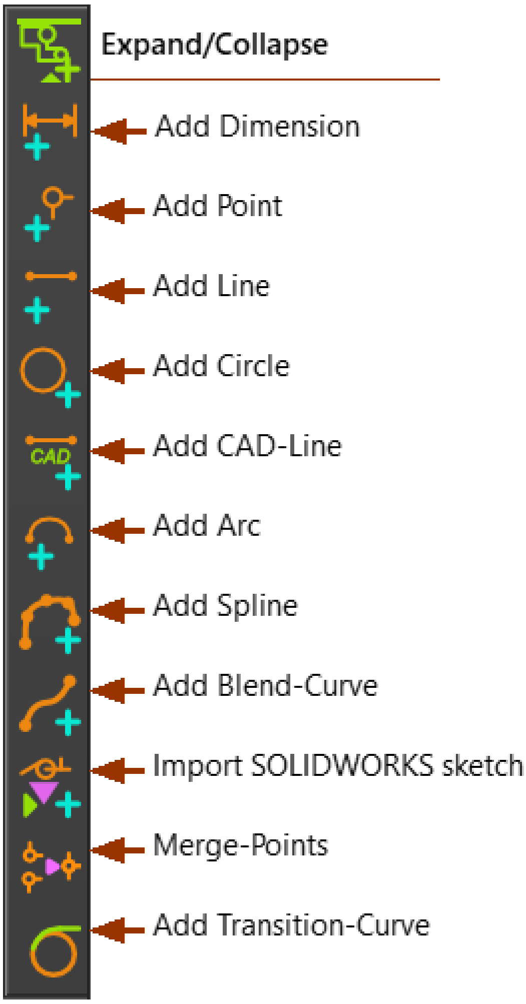
The Geometry menu has the commands to add sketch-elements to a PART.



Geometry menu > Geometry elements (MD17)

Part-Editor: Geometry toolbar

The Geometry toolbar is to the left of the graphics-area.



Geometry toolbar
[Click text to see more...]

SKETCH-ELEMENTS and the BASE-PART

Before you can add a joint between the BASE-PART and a PART, you **must** edit the BASE-PART to add to it a minimum of one sketch-element.

The first sketch-element in the BASE-PART?

Add a **LINE** as the first sketch-element.

Why?

A **LINE** gives you the most flexibility.

Why?

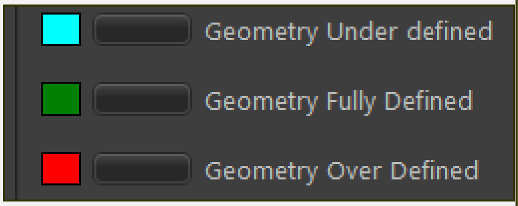
After you add a **PART** to the model:

- You can select the **START-POINT** or **END-POINT** of the LINE to add a PIN-JOINT. Then, you can reference the LINE to add a MOTION-DIMENSION FB for a **Rocker**.
- You can select the LINE to add a SLIDE-JOINT. Then, you can reference the **START-POINT** or **END-POINT** of the LINE to add a MOTION-DIMENSION FB for a **Slider**.

ABOUT GEOMETRY

Different names for POINTS:

- POINT - the SKETCH-ELEMENT you add to the PART with **Add Point**.
- START-POINT - the POINT where you **mouse-button down** at the start of the drag action to add a LINE, CAD-LINE, ARC, or BLEND-CURVE.
- END-POINT - the POINT where you **mouse-button up** at the end of the drag action to add a LINE, CAD-LINE, ARC, or BLEND-CURVE.
- CENTER-POINT - the POINT where you **mouse-button down** at the start of the drag action to add a CIRCLE.
- CENTER-POINT - the POINT at the center of an ARC after you **mouse-button up** at the end of the drag action to add an ARC.

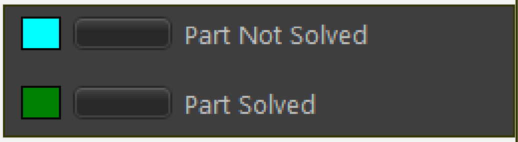


Colors of sketch-elements in the Part-Editor

Typical Colors of Sketch-Elements

Part-Editor

- Blue (typically) sketch-elements are under defined
- Green**:** (typically) sketch-elements are fully defined
- Red: (typically) sketch-elements that are over defined.



Colors of sketch-elements in the Mechanism-Editor

Mechanism-Editor:

- **Green:** PART is solved, is kinematically-defined
- **Blue:** PART is not solved (not kinematically-defined

Trouble-shoot - Geometry

- CTRL+Z should return the geometry to the previous state.
- If a sketch-element is Green but it should be Blue: delete the sketch-element, and add the sketch-element again.

Trouble-shoot - Constraints

To delete a Constraint that you think is a problem:

1. SHIFT + Click a **sketch-element**, or POINT, with a **Constraint**

The sketch-element, or POINT, and all **Constraints** that you have added to the sketch-element show in the SELECTION-WINDOW.

2. **Delete** the **Constraint** from the SELECTION-WINDOW.

Trouble-shoot - Dimensions

- **Delete** an angle dimension if you cannot edit to be more than 180º. Move the sketch-element, and add the angle dimension again.
- **Delete** a dimension if it does not pass through 0, (angular or linear dimension), and add the dimension again.

Fix Constraint

To **FIX** a **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**: use the **LOCK AND SPECIFY** check-box in the Point Properties dialog[543] .

However, you **cannot** **FIX** a **POINT** with the **LOCK AND SPECIFY** check-box if the **POINT** is constrained with a Constraint or a Dimension.

1.5.6.3.1 Add Dimension

Add Dimension

Dimensions you can add:

- **Distance** between **POINTS***
- **Length** of a **LINE****
- **Radius** of a **CIRCLE** or **ARC**
- **Perpendicular (shortest) Distance** from a **POINT*** to a **LINE****, **X-AXIS**, or **Y-AXIS**
- **Angle** between two **LINES**, or the **Angle** from the **X-AXIS** or **Y-AXIS** to a **LINE****
- **Angle** between three **POINTS***

---

* **POINT**, **START-POINT**, **END-POINT**, and **CENTER-POINT**.

** **LINE** or **CAD-LINE**

Notes:

Usually, do not make a dimension zero. It is better to add a constraint. **See** **Sketch-Constraints** 296

See **How to add dimensions** 270, **How to edit a dimension** 270.
See also: **Number-Format: Precision and Digits** 343, **Dimension Font Size** 343, **Show Dimension Names** 343

Add Dimension - menu or toolbar

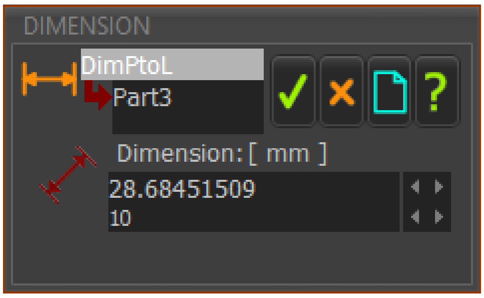
To Add a Dimension:

1. Click **Geometry toolbar** > **Add Dimension** (left of graphics-area)

OR

1. Click **Geometry menu** > **Dimension**
2. Click the sketch-element, or sketch-elements, to add a linear or angular dimension - **see below** **How to Add a Dimension** 270

   The DIMENSION shows near to your mouse-pointer.
3. Click in the graphics-area to place the dimension-line and extension-lines next to your mouse-pointer.



The DIMENSION DIALOG opens.

4. Edit the DIMENSION in the DIALOG

> **Negative Dimensions?**
>
> **Do not delete the negative sign from a negative dimension.**
>
> **See: Why a dimension is negative** 678 **.**

5. Click ✓ to close the DIMENSION DIALOG

The DIMENSION is now in the graphics-area.

How to EDIT a dimension:

1. Disable all other commands
2. Double-click the arrowhead of a **dimension-line**

Why the arrowhead?

- It is easier to click the **arrowhead** than the **dimension-line** or **extension-line**.

AND

- nothing happens if you click the **dimension-number**

Add dimension:

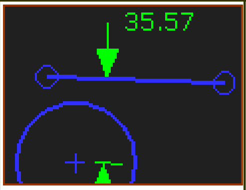
* POINT, START-POINT, END-POINT, and CENTER-POINT

** LINE or CAD-LINE

Locate a Point

There are two methods to locate a POINT.

METHOD 1: Add Dimensions

Examples	Dimension	How?	Selection-Window / Geometry-Tree
 **Between 2 Points**	• Minimum distance between two POINTS*	• Click each POINT*	DimPtoP*n*
 **Perpendicular Distance**	• Perpendicular distance between a POINT* and a LINE**, X–AXIS, or Y–AXIS	• Click the POINT* then the LINE**	DimPtoL*n*

METHOD 2: Use the Point Properties dialog

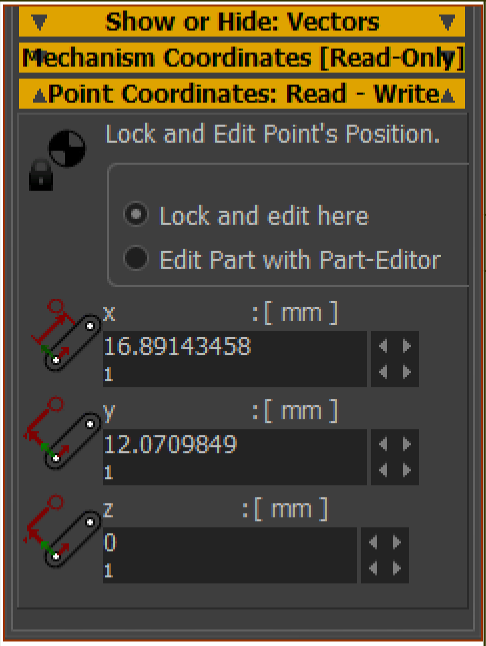
This method is possible:

- ONLY with a POINT sketch-element

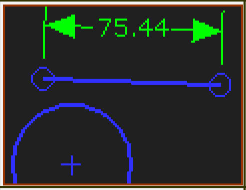
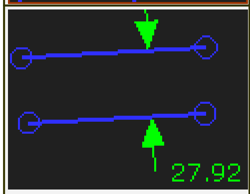
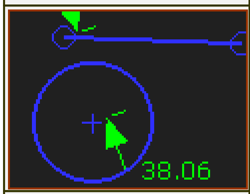
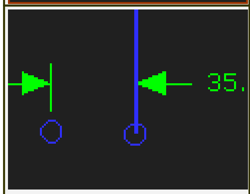
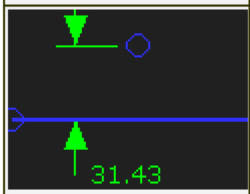
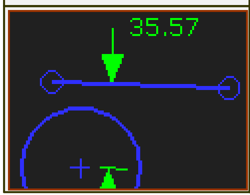
  It is not possible with a START-POINT, CENTER-POINT, CENTER-POINT

AND

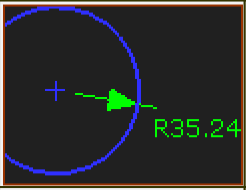
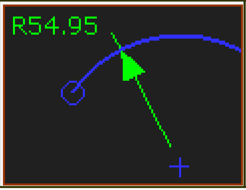
- NOT possible if the POINT has a dimension or constraint

Example	Dimension	Selection-Window / Geometry-Tree
 Point Properties dialog	• LOCK AND SPECIFY the exact location of a POINT* in a PART.	Pointn
	How?	
	1. Double-Click a POINT* in the PART-EDITOR OR 1. Double-Click a POINT* in the MECHANISM-EDITOR The **Point Properties dialog** [543] opens - see left Expand POINT COORDINATES 2. Select the LOCK AND SPECIFY check-box. 3. Enter 'x' and 'y' values for the POINT*, with **Part Coordinates** * in this case, ONLY a POINT sketch-element.	

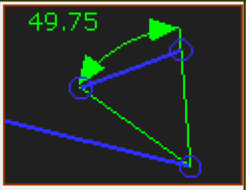
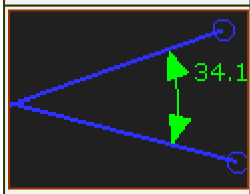
Distance

Example	Dimension:	How?	Selection-Window / Geometry-Tree
	• Length of a LINE**	1. Click the LINE**	Dimn
	• Distance between two parallel LINES** • Distance from Y-axis (or X-axis) to a Vertical (or Horizontal) LINE**	1. Click a POINT* at one end of the LINE** 2. Click the other LINE** (or axis).	DimLtoLn
	• Shortest distance between two POINTS*	1. Click each POINT*	DimPtoPn
	• Horizontal Distance between two POINTS*	1. Add a Vertical LINE** from one of the POINTS* 2. Click the POINT** and then the Vertical LINE**	
	• Vertical Distance between POINTS*	1. Add a Horizontal LINE** from one of the POINTS* 2. Click the POINT* then the Horizontal LINE**	
	• Shortest distance between a POINT* and a LINE** (or axis)	1. Click the POINT* then the LINE** (or axis)	DimPtoLn

Radius

Example	Dimension:	How?	In Selection-Window as:
	• Radius of a CIRCLE	• Click the Circum-ference of a CIRCLE	DimRadiusn
	• Radius of an ARC	• Click the Radius of an ARC	DimRadiusn

Angle

Example	Dimension:	How?	In Selection-Window as:
	• Angle between three POINTS*	• Click the POINT* that is the apex of the angle, fol-lowed by the other two POINTS*. The angle is the clockwise angle from the second POINT* to the third POINT* you click.	DimAngPPPn
	• Angle between two LINES** • Angle between an axis and a LINE** The LINES** do not need to cross.	• Click each LINE** The angle that we display for you has rules. See RULES, below	DimAngLtoLn

RULES: There are eight possible angle dimensions:

Before you click your mouse again to fix the angle dimension between the LINES**, you can select which angle to display.

- Move your mouse **counter-clockwise** around the apex of the two LINES**, to show the **acute**, **obtuse**, **supplementary**, or the **vertical** angle <180°.
- Move your mouse **clockwise** around the apex of the two LINES**, to show the **reflex** angles to the other angles.

Video: Double-click to watch Add an Angle

1.5.6.3.2 Add Point

Add Point

1. Click **Geometry toolbar** > **Add Point** (left of graphics-area)

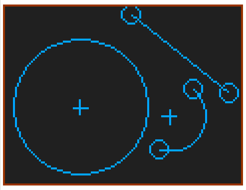
OR

1. Click **Geometry menu** > **Point**

2. Click the graphics-area

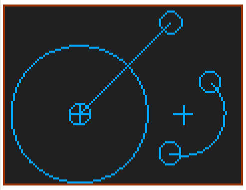
The **POINT** is now in the graphics-area.

DIFFERENT POINT SYMBOLS



: **POINT** sketch-element

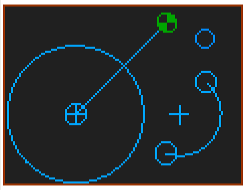
: **START-POINT** or **END-POINT** - at the end of an **ARC** or a **LINE**



+ : **CENTER-POINT** - at the center of an **ARC** or a **CIRCLE**

+ : **CENTER-POINT** - **merged** with a **START-POINT** or **END-POINT** of an **ARC** or **LINE**

⊕ : **CENTER-POINT** - **coincident** with a **START-POINT** or **END-POINT**



: **LOCKED-POINT** - see POINT PROPERTIES DIALOG[543]

: **MOTION-POINT** - added with Add Motion-Path FB[191].

: **MOTION-POINT** - coincident with a **POINT**, **START-POINT** or **END-POINT**.

To locate the position of a Point in a Part:

Part-Editor:

Add dimensions and/or constraints - see Add Dimension[270]

OR

Edit the **POINT**, edit the x,y coordinates in the Point Properties dialog[545] > LOCK AND EDIT HERE

OR

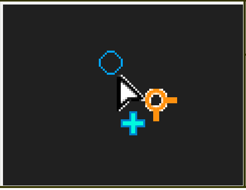
Mechanism-Editor

Edit the **POINT**, edit the x,y coordinates in the Point Properties dialog[545] > LOCK AND EDIT HERE

OR

SPECIAL-CASE: Add a **TRACE-POINT** to a **POINT**, that is free from constraints and dimensions, and **Drag the Point** (see Add Trace-Point[122]).

Example

	How:	Selection-Window
	• Click the graphics-area to add the **POINT**.	Pointn

1.5.6.3.3 Add Line

Add Line

1. Click **Geometry toolbar** > **Add Line** (left of graphics-area)

OR

1. Click **Geometry menu** > **Line**

2. Drag in the graphics-area from the START-POINT to the END-POINT of the LINE.

Drag: mouse-button-down (START-POINT), move your mouse-pointer, mouse-button-up (END-POINT).

The LINE is now in the graphics-area.

To **Add Line** with a **free START-POINT** and/or **END-POINT**.

> Do NOT HOVER above a different POINT* before you **mouse-button-down** or **mouse-button-up** to add the LINE.
>
> **See also:** How to Delete a Constraint 297

To **Add Line** with a **merged START-POINT** and/or **END-POINT**.

> Do HOVER above a different POINT* before you **mouse-button-down** or **mouse-button-up** to add the LINE.
>
> **See:** Hover+Drag Video 291

* POINT, START-POINT, END-POINT, CENTER-POINT.

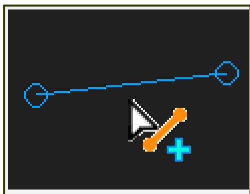
Coordinate System of a Line / CAD-Line

The **Origin** (0,0,0) of the **Coordinate-System** is the START-POINT of the LINE / CAD-LINE

The +**X–AXIS** is from the START-POINT to the END-POINT of the LINE / CAD-LINE

The +**Y-AXIS** is at +**90º** from the +**X-AXIS,** and on the MECHANISM-PLANE.

Example

	How:	Selection-Window:
	• **Drag** from the START-POINT to the END POINT of the LINE	• **Linen** + • **PointN** at each end of the LINE

1.5.6.3.4 Add Circle

Add Circle

1. Click **Geometry toolbar** > **Add Circle** (left of graphics-area)

OR

1. Click **Geometry menu** > **Circle**

2. Drag in the graphics-area from the **CENTER-POINT** to approximate its radius

Drag: mouse-button-down (**CENTER-POINT**), move your mouse-pointer, mouse-button-up

The **CIRCLE** is now in the graphics-area.

To **Add Circle** with a **FREE CENTER-POINT**

> **Do NOT** HOVER above a **POINT*** before you **mouse-button-down**
>
> **See also: How to Delete a Constraint** 297

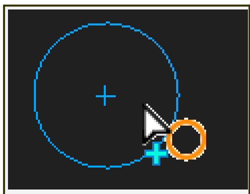
To **Add Circle** with a **MERGED CENTER-POINT**

> **Do** HOVER above a different **POINT*** before you **mouse-button-down**
>
> **See: Hover+Drag Video** 291

* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**.

Notes :	A **CIRCLE** is a **sketch-loop**. A **CIRCLE** is the most basic shape of a **Follower-Profile**.
Top tip :	Add the **dimension** to define the **Radius** of the **CIRCLE** before you add other **constraints**.

Example

	How...	Selection-Window
	1. Mouse-button-down at its **CENTER-POINT**... 2. Drag to estimate the radius of the **CIRCLE**, and ... 3. Mouse-button-up	Circle*n* + Point*n* at the **CENTER-POINT**

1.5.6.3.5 Add CAD-Line

Add CAD-Line

See also CAD-Line dialog 364

We add for you a **CAD-LINE** between the **START-POINT** and the **END-POINT** of each **PART** you add to the model.

You can also edit a **PART*** to add one or more **CAD-LINES** to the **PART** in the **PART-EDITOR**.

* **PART** and **BASE-PART**.

Use the **CAD-LINE DIALOG** to:

- Import and display a SOLIDWORKS Part 365
- Import and display an STL File 365
- Import SolidWorks Mass-Properties 369
- Edit the User Mass-Properties 368 of the **CAD-LINE**
- Display a DXF-Drawing 371 - before you can display the **DXF-Drawing**, you must File menu > Open DXF File 36
- Change how to display the **CAD-SOLID**

Add CAD-Line

1. Click **Geometry toolbar** > **Add CAD-Line** (left of graphics-area)

OR

1. Click **Geometry menu** > **CAD-Line**

2. Drag in the graphics-area from the **START-POINT** to the **END-POINT**.

Drag: mouse-button-down (**START-POINT**), move your mouse-pointer, mouse-button-up (**END-POINT**).

The **CAD-LINE** is now in the graphics-area.

See CAD-Line dialog 364

To **Add CAD-Line** with a free **START-POINT** and/or **END-POINT**.

> **Do NOT** HOVER above a different **POINT*** before you **mouse-button-down** or **mouse-button-up** to add the **LINE**.
>
> **See also: How to Delete a Constraint** 297

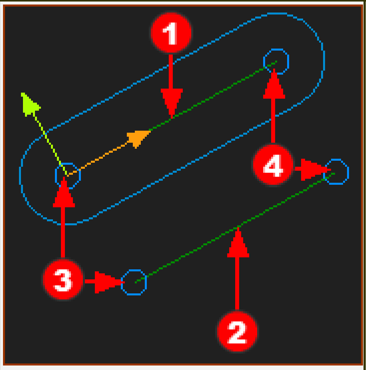
To **Add CAD-Line** with a merged **START-POINT** and/or **END-POINT**.

> **Do** HOVER above a different **POINT*** before you **mouse-button-down** or **mouse-button-up** to add the **LINE**.
>
> **See: Hover+Drag Video** 291

* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**.

Note :	You can open the **CAD-LINE DIALOG** from the: • **PART-EDITOR**, the **MECHANISM-EDITOR**, and, if you import a **CAD-SOLID** to the **CAD-LINE**, the **MODEL-EDITOR**

The CAD-Line in the graphics-area and Assembly-Tree



CAD-Lines in an Added-Part

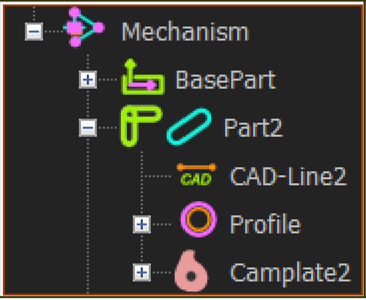
In the graphics-area:

MECHANISM-EDITOR : Add-Part - a CAD-Line❶ along the center of the Part.

PART-EDITOR : Add CAD-Line to add one or more CAD-LINE❷ to a PART

CAD-LINES have a COORDINATE SYSTEM, which is important to orientate CAD files that you import

- +X–AXIS: from its START-POINT❸ to its END-POINT❹
- +Y–AXIS: at +90º from the +X–AXIS
- +Z-AXIS: perpendicular to the MECHANISM PLANE (towards you in the default view (FRONT-VIEW))



In the Assembly-Tree:

- The CAD-LINE is the only SKETCH-ELEMENTS that show in the ASSEMBLY-TREE.
- The CAD-LINE is a child to a PART.

1.5.6.3.6 Add Arc

Add Arc

1. Click Geometry toolbar > Add Arc

OR

1. Click Geometry menu > Arc
2. Drag in the graphics-area from the **START-POINT** of the ARC to the **END-POINT** of the ARC
3. Drag again between the **START-POINT** and **END-POINT** to approximate the radius of the ARC

Drag: mouse-button-down (**CENTER-POINT**), move your mouse-pointer, mouse-button-up

The ARC is now in the graphics-area.

To Add Arc with a free **START-POINT** and/or **END-POINT**.

> Do NOT HOVER above a different **POINT*** before you **mouse-button-down** or **mouse-button-up** to add the ARC.
>
> **See also: How to Delete a Constraint** 297

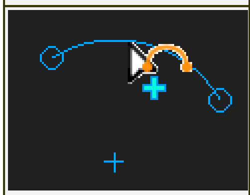
To Add Arc with a merged **START-POINT** and/or **END-POINT**.

> Do HOVER above a different **POINT*** before you **mouse-button-down** or **mouse-button-up** to add the ARC.
>
> **See: Hover+Drag Video** 291

* POINT, **START-POINT**, **END-POINT**, **CENTER-POINT**.

Top tip :	Add a Dimension 269 to define the **RADIUS** of the ARC before you drag it or add other CONSTRAINTS 306

Example

Example	How:	Selection-Window
	**You must Drag Two times.** Refer to the image to the left: 1. **FIRST DRAG**: from the **START-POINT** to the **END-POINT** of the ARC, then release you mouse. 2. **SECOND DRAG**: Position your pointer between the **START-POINT** and **END-POINT** of the ARC, and Drag towards the apex of the ARC as you	Circle*n* + Point*n* At each end of the ARC.

Example	How:	Selection-Window
	intend it to be drawn, then release your mouse. The **ARC** has a **CENTER-POINT**, a **START-POINT** and **END-POINT**.	

Video

Double-click to watch 'How to Add an Arc'

1.5.6.3.7 Add Spline

Add Spline

1. Click **Geometry toolbar** > **Add Spline**

OR

1. Click **Geometry menu** > **Spline**

2. Click in the graphics-area to add the **first Nodes** for the **SPLINE**
3. Continue to click at different places* to add more **nodes**

To end **Add Spline**:

4. Click the **first node** again to add a **CLOSED SPLINE**
   OR
   Click the **last node** again to add an **OPEN SPLINE.**

---

* Click a **POINT** (**POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**) of a different sketch-element to merge it with a **node**.

The **SPLINE** curve is now in the graphics-area.

Edit a Node's Position

PART-EDITOR: Add dimensions 269 or Constraints

OR

PART-EDITOR: Drag the node

OR

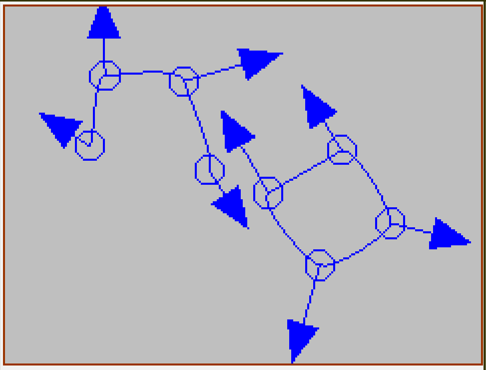
MECHANISM-EDITOR or **PART-EDITOR** : **Use the Point Properties dialog** 543

Edit the Spline's Angle at a Node

1. **MECHANISM-EDITOR** or **PART-EDITOR** : Click the **SPLINE** to show the **SPLINE-HANDLES**
2. **MECHANISM-EDITOR** or **PART-EDITOR** : Drag the arrowhead of a **SPLINE-HANDLE** around its **NODE**
3. **MECHANISM-EDITOR** or **PART-EDITOR** : Click the **SPLINE** again to hide the **SPLINE-HANDLES**

Edit the Spline's Curvature at a Node

1. **MECHANISM-EDITOR** or **PART-EDITOR** : Click the **SPLINE** to show the **SPLINE-HANDLES**
2. **MECHANISM-EDITOR** or **PART-EDITOR** : Drag the arrowhead of a **SPLINE-HANDLE** further from or nearer to a **NODE**
3. **MECHANISM-EDITOR** or **PART-EDITOR** : Click the **SPLINE** again to hide the **SPLINE-HANDLES**

<table>
<tr>
<td>
Spline-Handles of an Open-Spline and a Closed-Spline</td>
<td>Notes:

The direction of the SPLINE at a NODE is normal to its SPLINE-HANDLES
The Radius-of Curvature of the SPLINE at a NODE is proportional to the length of its SPLINE-HANDLE
The Radius-of-Curvature of the SPLINE at a NODE is symmetrical to the two sides of its SPLINE-HANDLE.
You can add Constraints to Nodes, but not the SPLINE'S curve.

</td>
</tr>
</table>

1.5.6.3.8 Add Blend-Curve

Add Blend-Curve

See also: Blend-Curve dialog 549

1. Click **Geometry toolbar** > **Add Blend-Curve**

OR

1. Click **Geometry menu** > **Blend-Curve**

2. Drag in the graphics-area from the **START-POINT** to its **END-POINT**.

Drag: mouse-button-down (**START-POINT**), move your mouse-pointer, mouse-button-up (**END-POINT**).

The **BLEND-CURVE** is now in the graphics-area.

To **Add Blend-Curve** with a free **START-POINT** and/or **END-POINT**.

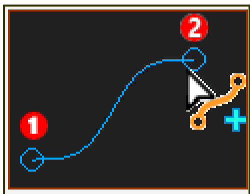
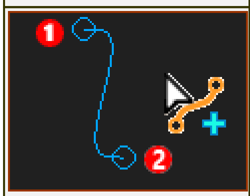
> Do NOT **HOVER** above a **POINT*** before you **mouse-button-down** or **mouse-button-up**.
>
> **See also:** How to Delete a Constraint 297

To **Add Blend-Curve** with a merged **START-POINT** and/or **END-POINT**.

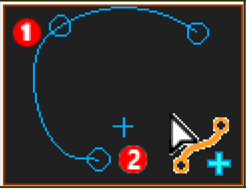
> Do **HOVER** above a **POINT*** before you **mouse-button-down** or **mouse-button-up**.
>
> **See:** Hover+Drag Video 291
>
> **Note:**
>
> The **BLEND-CURVE** automatically adjusts its **ANGLE**, **CURVATURE**, and **CURVATURE-RATE** to equal those of the sketch-element with which you merge the **BLEND-CURVE**.

* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**.

Example

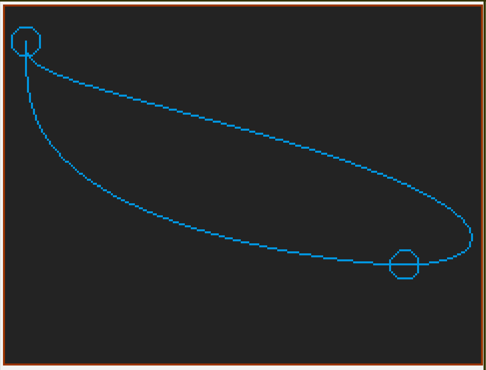
	How:	Selection-Window Assembly-Tree
	• Drag from the **START-POINT** 1 to the **END POINT** 2 of **BLEND-CURVE**	Blend-Curve*n* Point*n* at each end of the CAD-Line The Blend-Curve is a child to the Part.
	The default **ANGLE**, **CURVATURE** and **CURVATURE RATE** at the **START-POINT** and **END-POINT** of the **BLEND-CURVE** are zero. The images to the left and above are default **BLEND-CURVES**. • The **BLEND-CURVE** in the upper image has been added by dragging from lower-left to upper-right.	

- The BLEND-CURVE in the image to the left has been added by dragging from upper-left to lower-right.



- **Hover+Drag** from the END-POINT of a different sketch-element to merge the START-POINT of a new BLEND-CURVE.
- The BLEND-CURVE matches the ANGLE, CURVATURE and CURVATURE RATE with the other sketch-element.

What is a Blend-Curve?

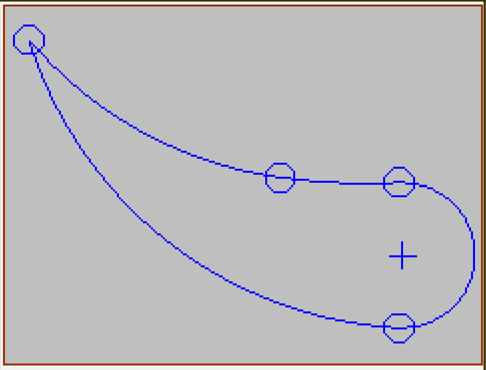

Continuous Curvature AND Curvature Rate

A BLEND-CURVE is a useful sketch-element for smooth sketch-paths.

You can control these parameters at its START-POINT AND END-POINT:

- ANGLE
- CURVATURE
- CURVATURE-RATE
- VELOCITY SCALING

Why use a Blend-Curve?


ARCS: Tangent Arcs are NOT Smooth

This path is NOT smooth - Tangent ARCS (with different Radii) have discontinuous CURVATURE.

Use a Blend-Curve to give a smooth sketch-path. **See also** **Smoothness** 287.

If the **Blend-Curve** is to guide a MOTION-POINT which also guides a PART, it is important that:

- The motion along a **sketch-path** does not have discontinuities in position, velocity, acceleration, and jerk.

AND

- The **shape** of the sketch-path does not have discontinuities in angle, curvature, and rate-of-change of curvature.

Smoothness definitions

Smoothness of Sketch-elements. You are frequently concerned with the smoothness of a sketch-path. The smoothness at the transition between sketch-element is important when a **MOTION-POINT** moves along the sketch-elements.			
	Angle	**Curvature**	**Curvature Rate**
Line joins a Line	Can 'kink', be the same angle (why two Lines?)	NA	NA
Arc joins a Line	Keep the same Angle	Keep the same Curvature (or Radius)	NA
Arc joins an Arc	Keep the same Angle	Keep the same Curvature (or Radius)	NA
Blend-Curve joins a Line	Keep the same Angle	Keep the same Curvature=0 (infinite Radius)	Keep at 0
Blend-Curve joins an Arc	Keep the same Angle	Keep the same Curvature; Radius	Keep at 0
Blend-Curve joins a Blend-Curve	Keep the same Angle	Keep the same Curvature; Radius	Keep the same Curvature Rate

1.5.6.3.9 Add Import SOLIDWORKS Sketch FB

Import a SOLIDWORKS sketch

To save you time, you can import a SOLIDWORKS sketch directly onto a **PART**.

Limits:

- Imports Lines and Arcs
- Cannot import Blocks, Parabolas, Ellipses, ...
- Maximum of approximately 20 sketch-elements
- Construction and center-lines import as Lines
- Constraints do not import
- By default, we lock the points at the ends and center of Lines, and Arcs. To unlock the Points, see Point Properties dialog[545].

Note:

If you do not have SOLIDWORKS, you can open a DXF file[36], link it to a CAD-Line, and convert the **DXF-Entities** to **LINES** and **ARCS**.

See also : Import SW Sketch dialog[555]

Add Import SOLIDWORKS Sketch FB

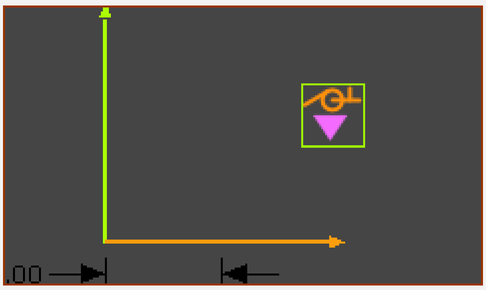
1. Click **Geometry toolbar** > **Add Import SOLIDWORKS sketch FB**

OR

1. Click **Geometry menu** > **Import SW sketch FB**

2. Click the graphics-area

The **IMPORT SOLIDWORKS SKETCH FB** is now in the graphics-area.



See : Import SW Sketch dialog[555]

1.5.6.3.10 Merge Points

About Merge-Points

Merge-Points is a command that combines two **POINTS*** at the ends of different sketch-elements into one **POINT**.

When do you need to Merge-Points?

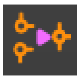
- To sketch a sketch-loop for a **PROFILE / EXTRUSION** (**MD-SOLID**).
- To sketch a sketch-path for a **MOTION-POINT** (with **Add Motion-Path FB**).
- To merge the **POINTS*** at the ends of different Lines-of-Centers so that you can add two or more **GEAR-PAIRS** as a Gear-Train.

---

* **START-POINTS**, **END-POINTS**, **CENTER-POINTS**, and/or **POINTS**.

Merge-Points - menu or toolbar

Merge-Points :



1. Click **Geometry toolbar** > **Merge-Points**

OR

1. Click **Geometry menu** > **Merge-Points**

IF the **POINTS*** are not coincident:

2. Click a **POINT*** at the end of a sketch-element
3. Click a **POINT*** at the end of a different sketch-element

---

IF the **POINTS*** are coincident, you must first delete the **Coincident-Constraint**.

1. **SHIFT + Click** the coincident **POINTS***

In the **SELECTION-WINDOW** :

2. Right-click the **Coincident Constraint**
3. Click **Delete element** in the shortcut menu

Now: start the **Add Merge-Points** command, and click the **POINTS***.

The two **POINTS*** are now one **POINT**.

---

* **POINTS** : **START-POINT, END-POINT, CENTER-POINT**

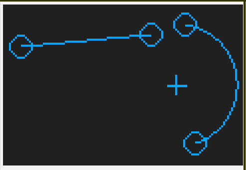
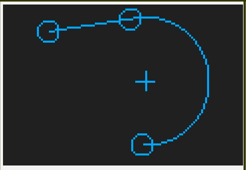
Notes:

- You CANNOT merge a **POINT*** with the **START-POINT** (origin) of the **CAD-LINE** along the **X-axis** of a **PART**.
- You CAN, however, merge a **START-POINT** or **END-POINT** of a sketch-element if you drag to or from the **START-POINT** or **END-POINT** of the **CAD-LINE**.

Merge-Points - video of Hover Technique.

[Video of 'Efficient Hover Technique to Merge-Points']

Merge-Points - example

Before	After	Select:	In Selection-Window / Geometry-Tree
 Free Points	 Merged Points	Note: we recommend the Hover-Technique. Or, • Start the **Geometry menu** or **toolbar > Merge-Points** command • Click a **POINT** and then a **POINT** in a different sketch-element. **RESULT:** The **POINTS** move together and then we delete one **POINT** (Compare with Coincident PtoP) 306	PointN

1.5.6.3.11 Add Transition Curve

The Transition-Curve is not available with the Trial License.

It is ONLY available with the Premium License.

About Transition-Curve

The **PSMotion Transition-Curve**© is used to eliminate the:

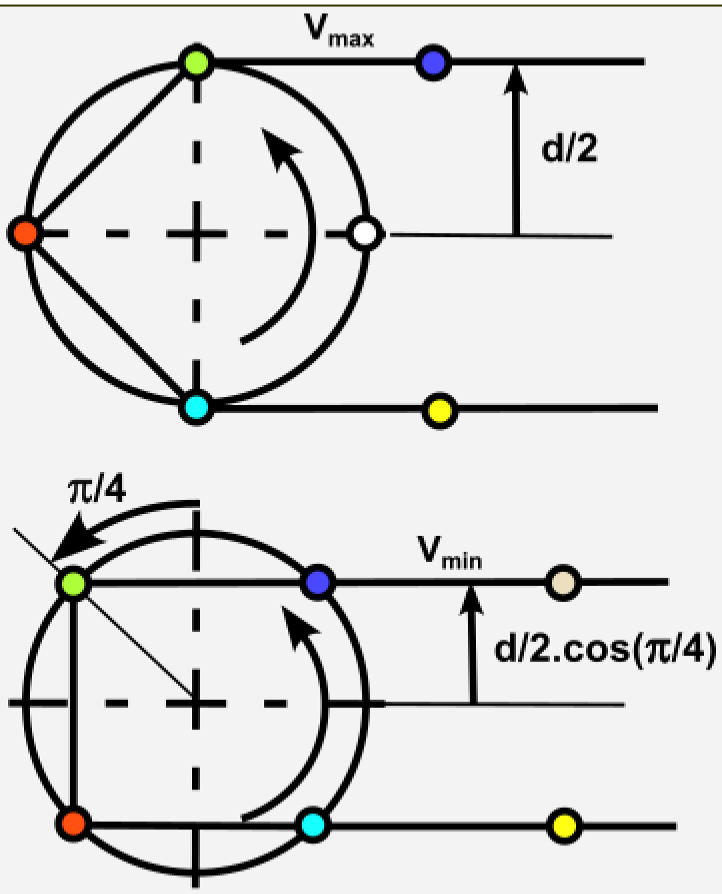
- Polygonal-Action, also referred to as Chordal-Action

AND

- Linear velocity discontinuity

as a chain-link moves onto the chain-sprocket from the span between chain-sprockets.

Polygonal-Action (Chordal Action) and Chains



4-Tooth Sprocket and Polygonal Action

The image shows a schematic of a chain wrapped around a sprocket with 4 teeth.

Radius:

In the top image, the chain is tangent with the Pitch-Circle of the Sprocket - at a radius of $d/2$

As the sprocket rotates, the component of horizontal velocity reduces.

The minimum the chain gets to the center of the sprocket is $d/2\,.\cos(\alpha/2)$.

Therefore, as the chain moves up and down, the effective radius of the sprocket changes to give an uneven, non-constant chain velocity.

Linear Speed (horizontal)

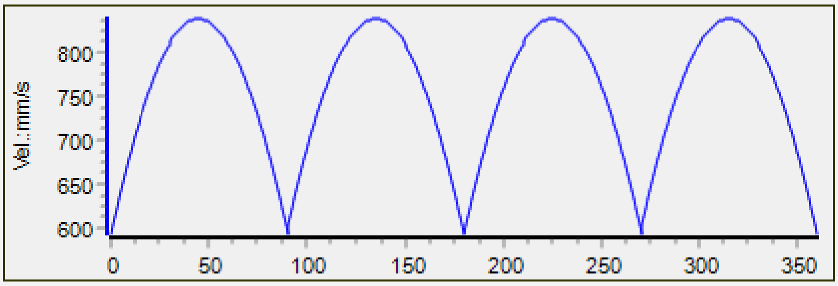
The linear speed of the chain is a maximum in the top image:

$$V_{max} = r.\omega = \ d.\omega/2$$

The linear speed of the chain is a minimum in the bottom image:

$$V_{min} = \frac{d.\omega}{2}\cos(\pi/4)$$

With 4 teeth, the minimum to maximum velocity changes by approximately 30% !



Linear Velocity Variation with 4 Teeth

Linear Velocity Discontinuity

As each new chain-link engages with a sprocket tooth, the linear-acceleration of the chain is discontinuous.

You can see that the slope of the velocity instantly changes as each new tooth engages with the sprocket.

This is an acceleration-discontinuity.

Polygonal-Action: Problems

The main problems are:

- Tension variation in the Chain

As a chain link engages with a tooth, the chain suffers a step change in acceleration. Thus, there is a tension variation.

- The pitch of the chain link is not constant.

Usually, it is recommended that you use more than 17 teeth on a standard sprocket. Bicycle sprockets have fewer, rarely less than 11 teeth. Also, the derailleur compensates for the tension-variation.

Add Transition-Curve

Toolbar :	Geometry toolbar > Transition-Curve
Menu :	Geometry menu > Transition-Curve

To add a Transition-Curve

1. Click **Geometry toolbar > Transition-Curve**
2. Drag to add a **LINE**

You can see that the Transition Curve is easy to add. However, it is used with Pulleys or Chains.

A Tutorial will show you how to apply the Transition Curve to a Long-Link Chain.

1.5.6.4 Constraints

Part-Editor - Geometry menu and Constraint toolbar

Use the commands in the Geometry menu or Constraints toolbar to add **Constraints**:

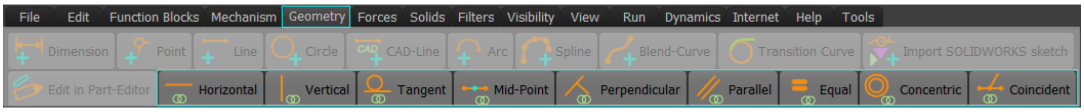
- to a sketch-element
- between two sketch-elements
- between a sketch-element and the X-axis or Y-axis

See also: How to Delete a Constraint 297
See also: Why cannot I add another Constraint? 297

See also: Geometry toolbar 265

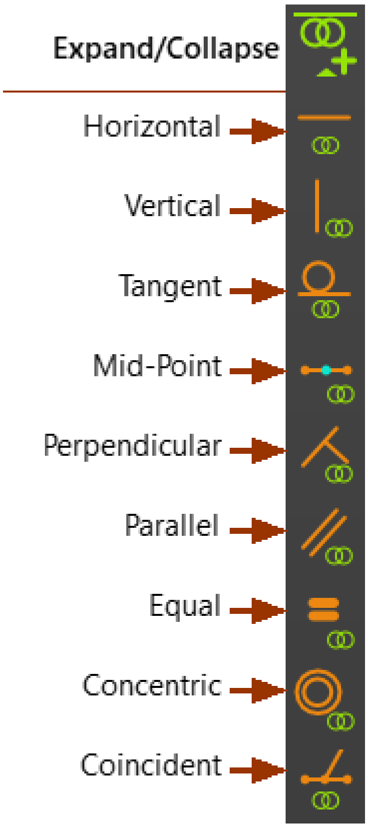
Geometry menu

The Geometry menu includes the commands to add **Constraints** to or between sketch-elements.



Constraints toolbar

The Constraints toolbar is to the right of the graphics-area.



Constraints toolbar

How to Delete a Constraint

You cannot see **Constraints** in the graphics-area.

To DELETE a **Constraint**:

1. SHIFT + CLICK a sketch-element or a POINT* that has a constraint you want to delete.

All of the **Constraints** that apply to the sketch-element or POINT* are now in the SELECTION-WINDOW

In the SELECTION-WINDOW:

2. Right-click the **Constraint** you want to delete
3. Click **Delete element** in the shortcut menu

---

* POINT, START-POINT, END-POINT, or CENTER-POINT

About Merge-Points and Coincident Constraint between Points

Add MERGE-POINTS moves two POINTS* together, and deletes one of the POINTS.

Add Coincident Constraint is between two POINTS*. The command does NOT delete one of the POINTS*.

You CAN delete a **Coincident constraint**- see How to delete a constraint 297 .

Usually, add a **Coincident constraint** for construction geometry.

---

* POINTS, START-POINTS, END-POINTS, CENTER-POINTS.

Why cannot I add a Constraint to a sketch-element?

You cannot OVER-constrain a sketch-element.

For example, a POINT* has only two degrees-of-freedom.

If you:

1. Add a **Coincident constraint** between a POINT* and a LINE

You cannot:

2. Also add a **Coincident constraint** between the same POINT* and the START-POINT or END-POINT of the same LINE.

Why?

You cannot remove three degrees-of-freedom from a POINT.

You remove **one** degree-of-freedom from the POINT. when you do '1'.

You attempt to remove **two** more degrees-of-freedom from the POINT in '2'.

What do I need to do?

1. Delete the **Coincident constraint** between the POINT* and the LINE - see How to Delete Constraint 297
2. Add the **Coincident constraint** between the POINT* and the START-POINT or END-POINT of the LINE.

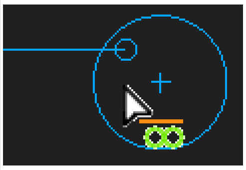
1.5.6.4.1 Add Horizontal Constraint

Add Horizontal

There are two types of Horizontal constraint.

Two Points (HorizontalPtoP)

1. Click **Constraints toolbar** > **Add Horizontal** (right of graphics-area)

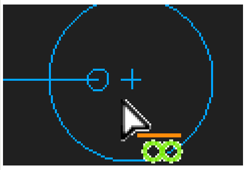


OR

1. Click **Geometry menu** > **Horizontal**

Then:

2. Click a **POINT***



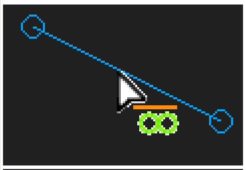
3. Click a different **POINT***

The two **POINTS*** are **Horizontal** with each other - parallel with the **X-axis**

* **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**

Line (HorizontalL)

1. Click **Constraints toolbar** > **Add Horizontal**

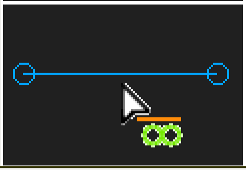


OR

1. Click **Geometry menu** > **Horizontal**

Then:

2. Click a **LINE****



The **LINE**** is now **Horizontal** - parallel with the **X-axis**

** **LINE** or **CAD-LINE**

Delete Horizontal

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **POINT** or **LINE**in the graphics-area.

If the sketch-element has a **HorizontalL** or **HorizontalPtoP** constraint, it shows in the **SELECTION-WINDOW**.

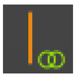
2. Right-click the **HorizontalL** or **HorizontalPtoP** constraint in the **SELECTION-WINDOW**
3. Click **Delete element** in the shortcut menu

1.5.6.4.2 Add Vertical Constraint

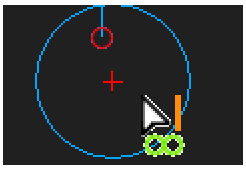
Add Vertical

There are two types of Vertical constraint.

Two Points (VerticalPtoP)



1. Click **Constraints toolbar** > **Add Vertical** (right of graphics-area)

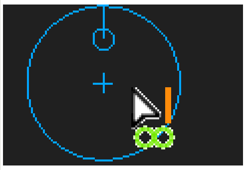


OR

1. Click **Geometry menu** > **Vertical**

Then:

2. Click a **POINT***

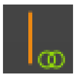


3. Click a different **POINT***

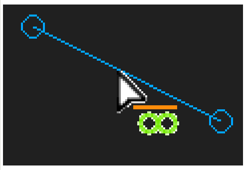
   The two **POINTS*** are now **VERTICAL**, and parallel with the **Y-AXIS**

* **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**

Line (VerticalL)



1. Click **Constraints toolbar** > **Add Vertical**

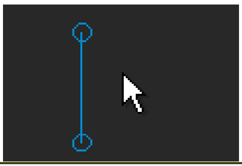


OR

1. Click **Geometry menu** > **Vertical**

Then:

2. Click a **LINE****



   The **LINE**** is now **VERTICAL**, and parallel with the **Y-AXIS**

** **LINE** or **CAD-LINE**.

Delete Vertical

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **POINT** or **LINE** in the graphics-area.

If the sketch-element has a **VerticalL** or **VerticalPtoP** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **VerticalL** or **VerticalPtoP** constraint in the **SELECTION-WINDOW**
3. Click **Delete element** in the shortcut menu

1.5.6.4.3 Add Tangent Constraint

Add Tangent

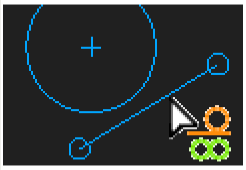
There are two types of Tangent constraint.

Line and Circle / Arc (TangentCtoL)

1. Click **Constraints toolbar** > **Add Tangent** (right of graphics-area)

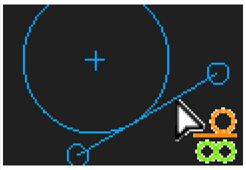
OR

1. Click **Geometry menu** > **Tangent**



Then:

2. Click a **CIRCLE** or **ARC**
3. Click a **LINE***



The **CIRCLE/ARC** is now tangent with the **LINE*** or **axis.**

They have a **TangentCtoL** constraint.

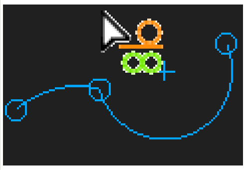
* **LINE**, **CAD-LINE**, **X-AXIS**, or **Y-AXIS**

Circle/ Arc and Circle / Arc (TangentCtoC)

1. Click **Constraints toolbar** > **Add Tangent**

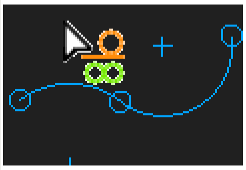
OR

1. Click **Geometry menu** > **Tangent**



Then:

2. Click a **CIRCLE** or **ARC**
3. Click a different **CIRCLE** or **ARC**



The **CIRCLES** and/or **ARCS** are Tangent with each other

They have a **TangentCtoC** constraint.

Delete Tangent

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **CIRCLE**, **ARC**, or **LINE** in the graphics-area.

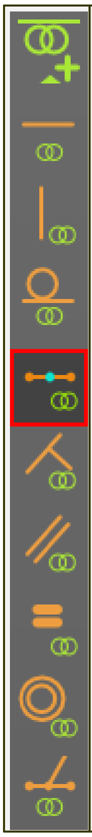
If the sketch-element has a **TangentCtoL** or **TangentCtoC** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **TangentCtoL** or a **TangentCtoC** constraint in the **SELECTION-WINDOW**
3. Click **Delete element** in the shortcut menu

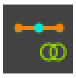
1.5.6.4.4 Add MidPoint Constraint

Add Mid-Point

There is one type of Mid-Point constraint.

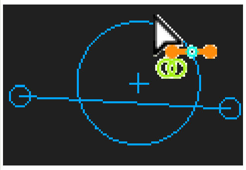


Point and Line (MidPoint)



1. Click **Constraints toolbar** > **Add Mid-Point** (right of graphics-area)

OR

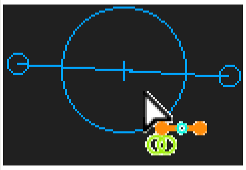


1. Click **Geometry menu** > **Mid-Point**

Then:

2. Click a **POINT***

3. Click a **LINE****



The **POINT*** is at the Mid-Point of the **LINE****.

They have a **MidPoint** constraint.

* **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**

** **LINE** or **CAD-LINE**

Delete Mid-Point

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **LINE** or **POINT** in the graphics area

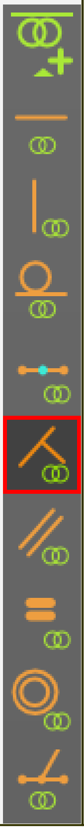
If the sketch-element has **MidPoint** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **MidPoint** constraint in the **SELECTION-WINDOW**
3. Click **Delete element** in the shortcut menu

1.5.6.4.5 Add Perpendicular Constraint

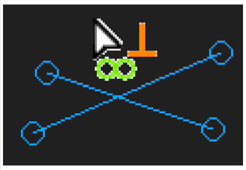
Add Perpendicular

There is one type of Perpendicular constraint.



Line and Line (Perpendicular)

1. Click **Constraints toolbar** > **Add Perpendicular** (right of graphics-area)



OR

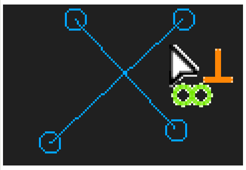
1. Click **Geometry menu** > **Perpendicular**

Then:

2. Click a **LINE***
3. Click a different **LINE***

   The two **LINES** are perpendicular with each other.

   They have a **Perpendicular** constraint.



* **LINE**, **CAD-LINE**, **X-AXIS**, or **Y-AXIS**

Delete Perpendicular

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **LINE** or **POINT** in the graphics area.

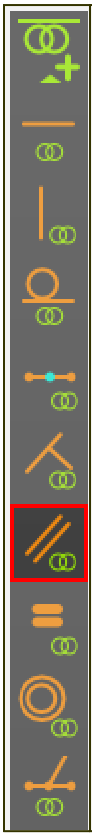
If the sketch-element has a **Perpendicular** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **Perpendicular** constraint in the **SELECTION-WINDOW**.
3. Click **Delete element** in the shortcut menu.

1.5.6.4.6 Add Parallel Constraint

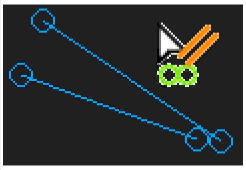
Add Parallel

There is one type of Parallel constraint.



Line and Line (Parallel)

1. Click **Constraints toolbar** > **Add Parallel** (right of graphics-area)

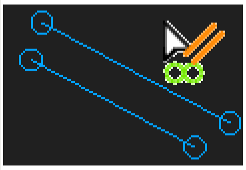


OR

1. Click **Geometry menu** > **Parallel**

Then:

2. Click a **LINE*** sketch-element
3. Click a different **LINE*** sketch-element



The two **LINES**, or a **LINE** and an **axis**, are parallel with each other.

They have a **Parallel** constraint.

* **LINE**, **CAD-LINE**, **X-axis**, or **Y-axis**

Delete Parallel

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **LINE** or **POINT** in the graphics area.

If the sketch-element has a **Parallel** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **Parallel** constraint in the **SELECTION-WINDOW**.
3. Click **Delete element** in the shortcut menu.

1.5.6.4.7 Add Equal Constraint

Add Equal

Line and Line (Equal)

1. Click **Constraints toolbar** > **Add Equal** (right of graphics-area)

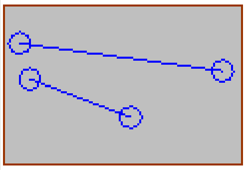
OR

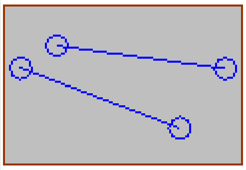
1. Click **Geometry menu** > **Equal**

Then:

2. Click a LINE*
3. Click a different LINE*

The **Lengths** of the two LINES are now **Equal**





* LINE or CAD-LINE

Circle or Arc and Circle or Arc (Equal)

1. Click **Constraints toolbar** > **Add Equal**

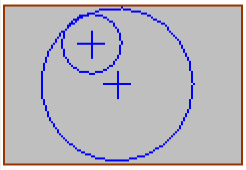
OR

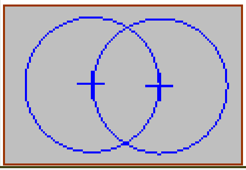
1. Click **Geometry menu** > **Add Equal**

Then:

2. Click a CIRCLE* sketch-element
3. Click a different CIRCLE* sketch-element

The **Radii** of the two CIRCLES* are now **Equal**





* CIRCLES or ARCS

Delete Equal

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

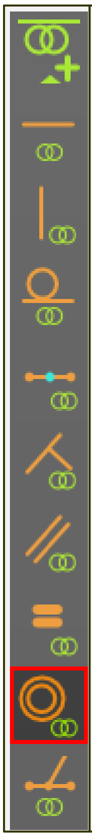
1. SHIFT + Click a CIRCLE, ARC, or LINE in the graphics area.

If the sketch-element has an **Equal** constraint, it shows in the SELECTION-WINDOW.

2. Right-click the **Equal** constraint in the SELECTION-WINDOW.
3. Click **Delete element** in the shortcut menu.

1.5.6.4.8 Add Concentric Constraint

Add Concentric



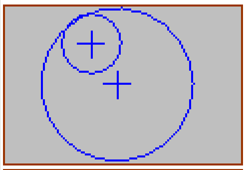
Circle or Arc and Circle or Arc (Concentric)

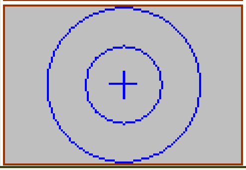
1. Click **Constraints toolbar > Add Concentric** (right of graphics-area)

OR

1. Click **Geometry menu > Concentric**

Then:





2. Click a **CIRCLE** (or **ARC**)
3. Click a different **CIRCLE** (or **ARC**)

   The **CIRCLE** and/or **ARC** are **Concentric**

Delete Concentric

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **CIRCLE** or **ARC** in the graphics area.

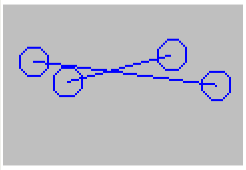
If the sketch-element has a **Concentric** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **Concentric** constraint in the **SELECTION-WINDOW**.
3. Click **Delete element** in the shortcut menu.

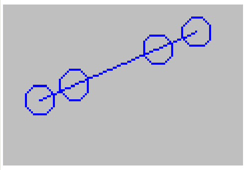
1.5.6.4.9 Add Coincident Constraint

Add Coincident

Line and Line (CoincidentLtoL)



Before Coincident LtoL



After: CoincidentLtoL

1. Click **Constraints toolbar** > **Add Coincident** (right of graphics-area)

OR

1. Click **Geometry menu** > **Coincident**

Then:

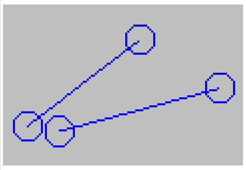
2. Click a **LINE***
3. Click a different **LINE***

The **LINES*** are now **Collinear.**

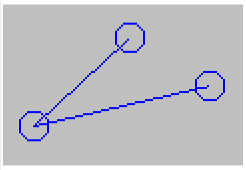
---

* **LINE, CAD-LINE, X-AXIS**, or **Y-AXIS**

Point and Point (CoincidentPtoP)



Before CoincidentPtoP



CoincidentPtoP

1. Click **Constraints toolbar** > **Add Coincident**

OR

1. Click **Geometry menu** > **Add Coincident**

Then:

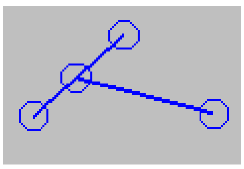
2. Click a **POINT***
3. Click a different **POINT***

The **POINTS*** are now **Coincident.**

---

* **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**

Point and Line (CoincidentPtoL) ; Point and Circle (CoincidentPtoC)



After CoincientPtoL

1. Click **Constraints toolbar** > **Add Coincident**

OR

1. Click **Geometry menu** > **Add Coincident**

Then:

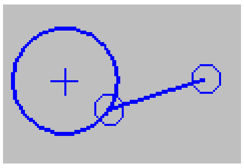
2. Click a **POINT***

Then:

3. Click a **LINE****

   The **POINT*** is now **Coincident** with the ray of the **LINE****

OR

		 After CoincidentPtoC	3. Click a **CIRCLE** or **ARC** The **POINT*** is now **Coincident** with the circumference of the **CIRCLE** or **ARC** * **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT** ** **LINE, CAD-LINE, X-AXIS**, or **Y-AXIS**

Delete Coincident

We do no show constraints in the graphics-area. You must find the constraint you want to delete.

1. **SHIFT + Click** a **CIRCLE** or **ARC** in the graphics area.

If the sketch-element has a **CoincidentPtoP**, **CoincidentPtoL**, or **CoincidentPtoC** constraint, it shows in the **SELECTION-WINDOW**.

2. Right-click the **CoincidentPtoP**, **CoincidentPtoL**, or **CoincidentPtoC** constraint in the **SELECTION-WINDOW**.
3. Click **Delete element** in the shortcut menu.

Note: Coincident Constraints, Points, Lines, and Degrees-of-Freedom

COINCIDENT CONSTRAINT, POINTS, and **DEGREES-OF-FREEDOM**

A **POINT*** has two degrees-of-freedom. You cannot remove three degrees-of-freedom from a **POINT***.

For example:

> You add a **Coincident Constraint** between a **POINT*** and a **LINE**** (**CoincidentPtoL**) you remove 1 degree-of-freedom.
>
> Then, it is not possible to add a **Coincident Constraint** between the same **POINT** and the **START-POINT** or **END-POINT** of the **LINE**** (**CoincidentPtoP**) as that attempts to remove 2 more degrees-of-freedom, a total of three degrees-of-freedom.
>
> It is not possible to remove three(3) degrees-of-freedom from a **POINT***.

To correct the problem, you must delete the **CoincidentPtoL - see** How to delete a Constraint 296

---

* **POINT**, **START-POINT**, **END-POINT**, or **CENTER-POINT**

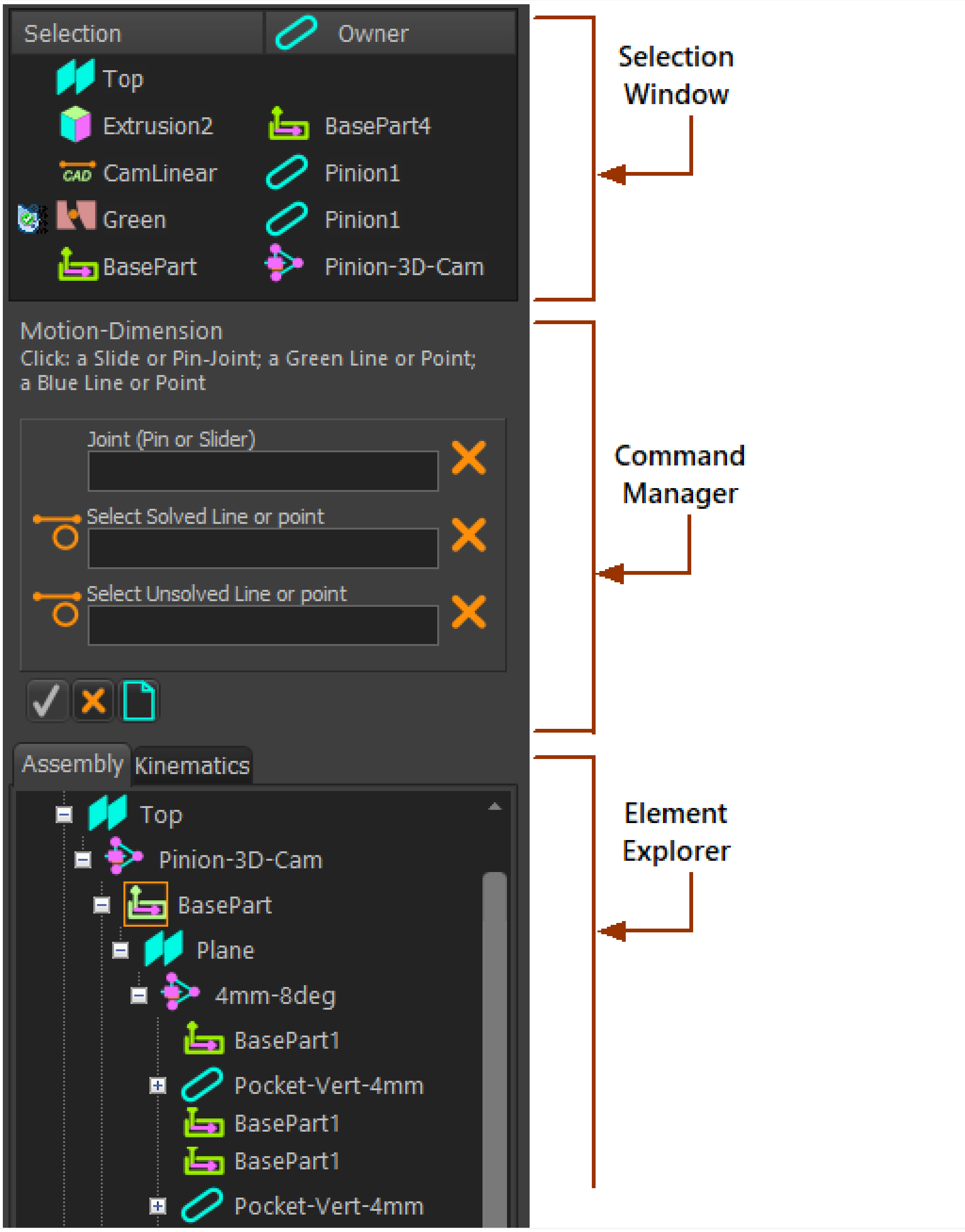
** **LINE, CAD-LINE, X-AXIS**, or **Y-AXIS**

1.5.7 3: Project Explorer

③ Project-Explorer

The panel that is to the left of the graphics-area is the **PROJECT-EXPLORER**.

It has three sections.



SELECTION-WINDOW[310]

The **SELECTION-WINDOW** shows the list of elements that you **CLICK** or **SHIFT + Click** in the graphics-area or **ELEMENT-EXPLORER** (see below).

COMMAND-MANAGER[313]

The **COMMAND-MANAGER** opens when you need to select other elements from the model to add a new element.

It has a selection-box for each element you need to select.

You can select the elements from the graphics-area or the **ELEMENT-EXPLORER** (see below).

ELEMENT-EXPLORER 315

Explore the **ELEMENT-EXPLORER** to see the elements that are in the **MODEL-EDITOR** and **MECHANISM-EDITORS**.

The **ELEMENT-EXPLORER** has three trees. You can see two trees at a time. You can explore one tree at a time.

In the **MODEL-EDITOR** and **MECHANISM-EDITORS**, the two trees you can see are the:

- ASSEMBLY-TREE 316
- KINEMATICS-TREE 318 - if necessary, click Rebuild Now 49 to compile the **KINEMATICS-TREE**

In the **PART-EDITOR**, the two trees are the:

- ASSEMBLY-TREE 316
- GEOMETRY-TREE 324 - if necessary, click Rebuild Now 49 to compile the **GEOMETRY-TREE**

1.5.7.1 Selection-Window

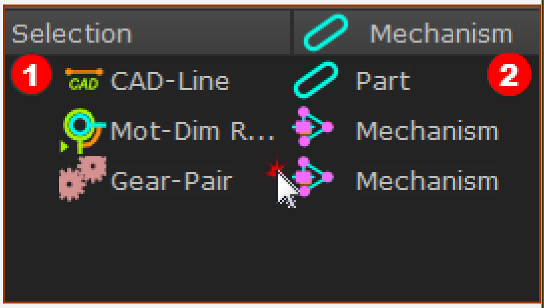
Selection-Window

The **SELECTION-WINDOW** is at the top of the **PROJECT-EXPLORER**.

The **SELECTION-WINDOW** shows the list of the elements that you **Click** or **Shift + Click** in the graphics-area or select in the Element-Explorer[315].

Click ...

... To list elements



Elements in the Selection-Window

Selection list ❶ **(to the left)**

The list of elements that you **Click** with your mouse in the graphics-area or ELEMENT-EXPLORER[315].

Owner list ❷ **(to the right)**

"**Mechanism**": when the element is a child to a **MECHANISM-EDITOR.**

"**Part**": when the element is a child to a **PART**.

Shift + Click ...

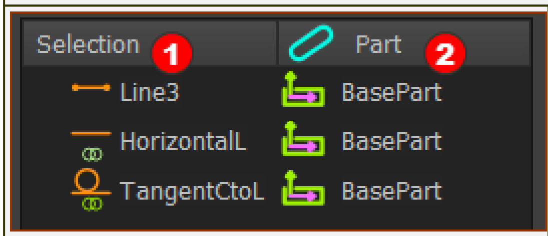
... sketch-elements to list constraints added to them.

You cannot see any **Constraints** in the graphics-area after you add them to sketch-elements.

You can, however, list the **Constraints** in the **SELECTION-WINDOW**.

To list the **Constraints** in the **SELECTION-WINDOW**:

1. SHIFT + Click a sketch-element to list the sketch-element and any **Constraints** that you have added to the sketch-element.



Constraints in the Selection-Window with SHIFT+CLICK

Selection list ❶

The **sketch-element** that you SHIFT + Click, **AND**

Constraints that you have added to the sketch-element - for example **TangentCtoL, AND**

Constraints that you have added between **sketch-elements** - for example, **Perpendicular.**

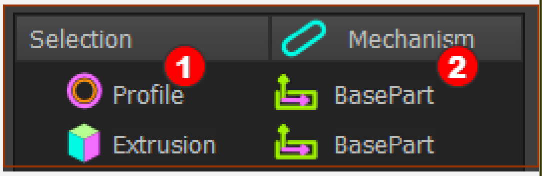
Owner list ❷

Part - the **PART** to which you have added the **sketch-element** or **Constraint**.

... Profiles to list Extrusion

To list an **EXTRUSION** in the **SELECTION-WINDOW**:

SHIFT + CLICK the **PROFILE** to list the **PROFILE** and the **EXTRUSION** that is a child to the **PROFILE**.



You can EDIT the Extusion or DELETE the Profile

Selection list ❶

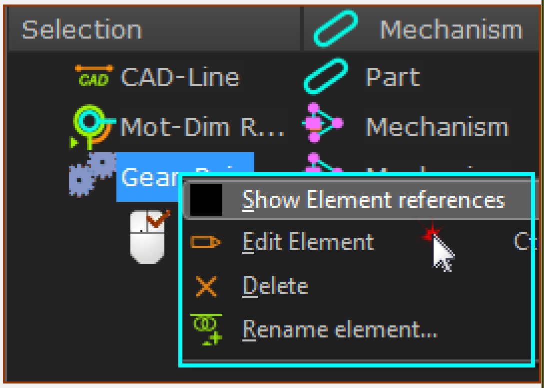
The **PROFILE** that you **SHIFT + Click**

The **EXTRUSION** that is a child to the **PROFILE**.

Owner list ❷

Part: the **PART** to which the **PROFILE** is a child.

Shortcut menu



Shortcut menu in Selection-Window

To show the **shortcut menu**

1. Right-click an element

Use the shortcut menu to:

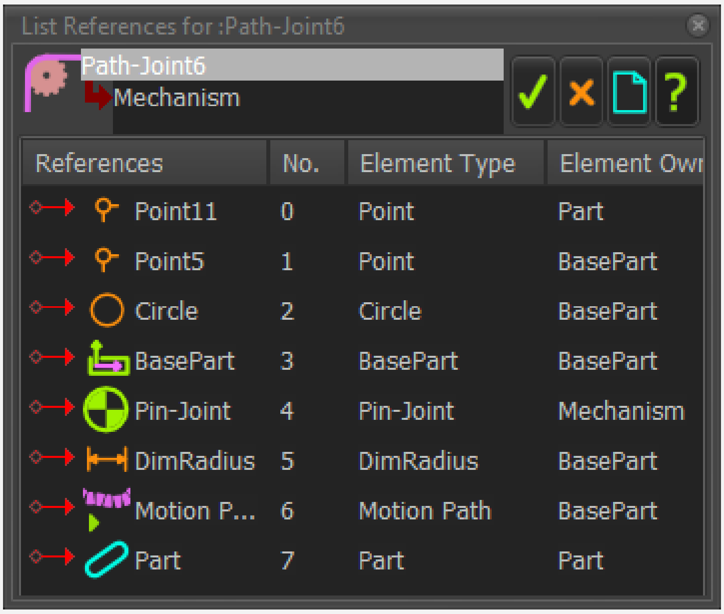
- **Show Element References** - see below 311
- **Edit element**
- **Delete element**
- **Rename element**
- **Show or Hide Extrusion** - if you right-click an **EXTRUSION**

Show Element References

Many elements need **other elements** to exist in the model. The **other elements** are **Reference Elements**.

For example, the **Reference Elements** of a:

- **LINE** are its **START-POINT** and **END-POINT**
- **PIN-JOINT** are two **POINTS**, which may be the **START-POINT** or **END-POINT** of a **LINE** or the **CENTER-POINT** of a **CIRCLE**.



Reference Elements for a Pulley

The columns in the dialog identify the element's:

References - the name of the Reference Elements. For example, **PROFILE**

Element Type - the type of element. For example, **POINT**

Element Owner - to which the **Reference Element** is a child. For example, **PART**

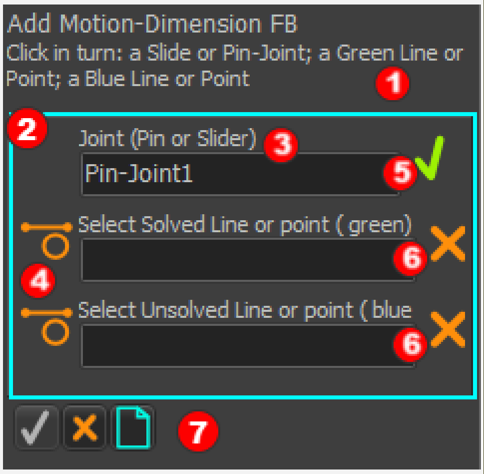
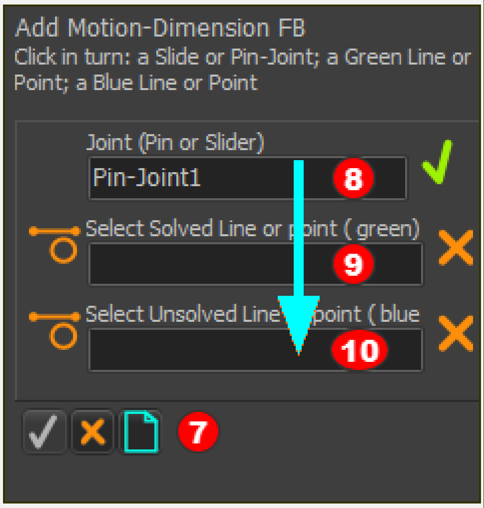
1.5.7.2 Command-Manager

Command-Manager

The **COMMAND-MANAGER** shows in the **PROJECT-EXPLORER** when you select other elements to add a more complex element.

Select the other elements from the graphics-area, ASSEMBLY-TREE316, and/or the SELECTION-WINDOW310.

Command-Manager example :

<table>
<tr>
<td>
Command-Manager -
Before you select elements</td>
<td>Add Motion-Dimension FB
❶ Name of the Command and Short Instruction
❷ Selection-Boxes - each Selection-Box:
❸ Above : the type of the element you must select
❹ Left : an icon to help you identify the type of element
❺ Right : the icon when an element is in the selection-box
OR
❻ Right : the icon when an element is not in the selection-box</td>
</tr>
<tr>
<td>
Command-Manager -
Select elements from top to bottom</td>
<td>continued:
To select the elements for each selection-box:
1. Click an element of the correct type for the top selection-box ❽
The next selection-box❾ is automatically now is active.
2. Continue to click elements of the correct type for each selection-box
To complete the command:
When the bottom selection-box❿ has an element, the ❼ is colorized.
To complete the command:</td>
</tr>
</table>

	1. Click ⑦ OR 1. Right-click in the graphics-area (usually recommended). **To exit or start the command again:** 1. Click ⑦ to exit the command, but do **not** add the new element. OR 1. Click ⑦ to clear the elements from all selection-boxes. You must select all of the element again.

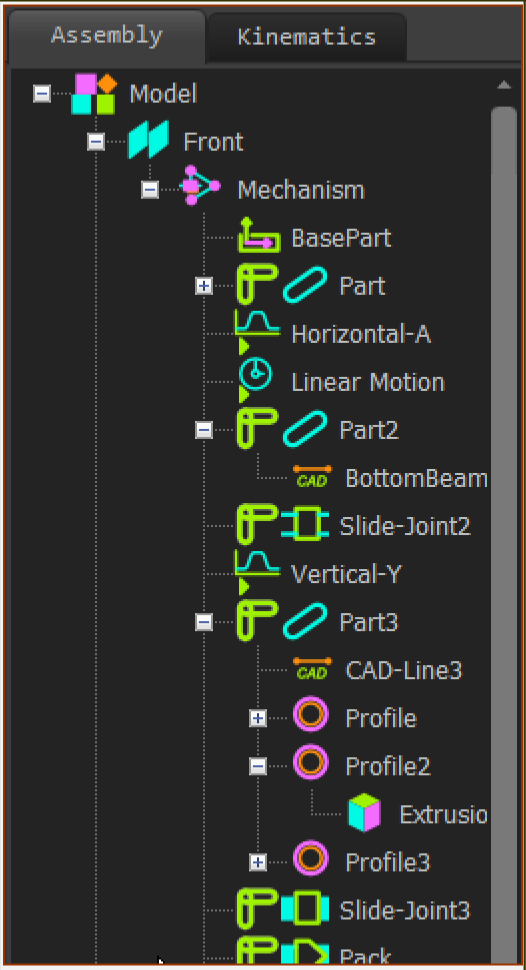
1.5.7.3 Element-Explorer

Element-Explorer

The **ELEMENT-EXPLORER** is at the bottom of the PROJECT-EXPLORER[308].

It shows most of the elements that are in the model.

Element-Explorer example:



Example Elements in the Assembly-Tree

ASSEMBLY-TREE[316]

This tree is available in all editor-types.

It is a chronological and hierarchical list of the elements that you have added to the model.

KINEMATICS-TREE[318]

This tree is available when the **MODEL-EDITOR** or any **MECHANISM-EDITOR** is active.

When possible, it compiles the kinematically-defined **PARTS** into kinematic-chains that consist of Motion-Parts, Dyads, Geared-Rockers, Pulley-Rockers and similar kinematic-elements.

GEOMETRY-TREE[324] (not in image)

This tree is available when the **PART-EDITOR** is active.

It is a list of the constraints and dimensions that you have added to or between sketch-elements.

It does not list the sketch-elements.

Element-Explorer and the Graphics-Area

If you click an element in the **ELEMENT-EXPLORER** it changes to the selected-color in the graphics-area.

If you click an element in the graphics-area, you also select the element in the **ELEMENT-EXPLORER**.

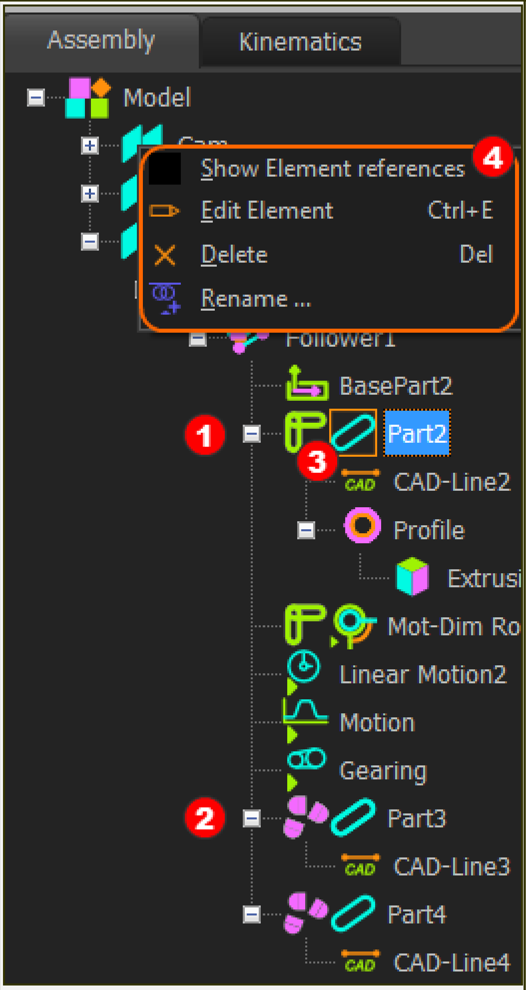
	Open the **Application-Settings dialog** (see Edit menu[49]) to edit the colors of different element-types. **See: Application-Settings dialog > Graphics tab > Display Colors**[341]

1.5.7.3.1 Assembly-Tree

Element-Explorer - Assembly-Tree

Names of the elements you add to the model are in the **ASSEMBLY-TREE.**

Each element has an **Element Icon** and an **Element Name.**



Assembly-Tree in Explorer-Explorer

Element Hierarchy

The elements are in the order you added the elements to the model.

The elements also have a hierarchy. For example:

MECHANISM elements are children to PLANE elements.

PARTS, FUNCTION-BLOCKS, JOINTS, GEARS, BELTS, ... are children to MECHANISM elements.

CAD-LINES, PROFILES, 3D-CAMS, and 2D-CAMS are children to PARTS elements.

PARTS

To the left of each PART, an icon identifies if the kinematic-chain to which it is associated, is solved, broken, or unsolved.

❶ **Solved Part and solved kinematic-chain:** Mobility is zero AND all PARTS remain joined for all positions of the machine-cycle.

❷ **Solved but broken kinematic-chain**. Mobility is zero BUT PARTS cannot remain joined at all positions of the machine-cycle.

Unsolved kinematic-chain. Mobility is greater than zero(0).

Selected Elements

When you click an element ❶ :

	• a **square**❸ shows around the icon, and • the element shows in the SELECTION-WINDOW 310 --- **Shortcut menu:** Right-click an element in the **ASSEMBLY-TREE**, to show a shortcut menu❹. You can use the shortcut menu to: • Show Element References 311 • Edit Element • Delete (element) • Rename ... (element)

1.5.7.3.2 Kinematics-Tree

Element-Explorer - Kinematics-Tree

See also: Kinematic-Symbols [319], and Configure-Power Source/ Change Dyad Closure [323]

The **KINEMATICS-TREE** is the kinematic-structure of each kinematic-chain in the active **MECHANISM-EDITOR**.

Note:

If you cannot explore the elements **KINEMATICS-TREE** , click Rebuild now [49] .

We compile for you the **KINEMATIC-TREE** from the Kinematic and Machine elements that you add to your model.

If you click on any kinematic-chain, and then move your mouse to the graphics-area, the kinematic-chain show as the selected elements in the graphics-area.

You can right-click on any kinematic-chain to Configure the Power Source [323]


This icon is at the top of the **KINEMATIC-TREE** to the left of the name "**Mechanisms**".

Note: If you cannot see "**Mechanisms**", or explore the **KINEMATICS-TREE**, click Rebuild now [49] .

The structure of the Kinematics-Tree is:

⌧ Mechanisms:

⌧ Kinematic-Chains

⌧ Kinematic Sub-assemblies

⌧ Kinematic Elements

⌧ Unsolved Mechs

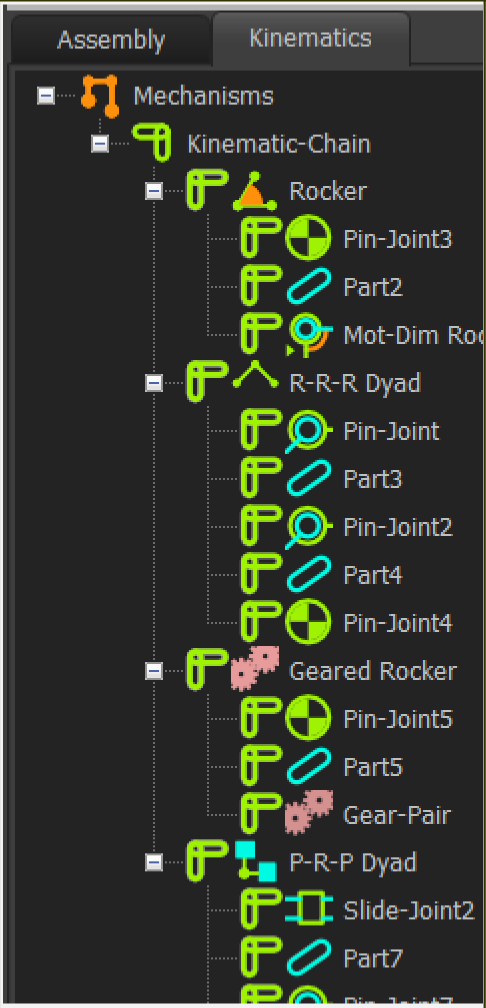
 Kinematic-Chain

The **MOBILITY** of these kinematic-chains is zero(0). They are **kinematically-defined** (**solved**).

You can explore the kinematic-chains to find **Kinematic Sub-Assemblies** and **kinematic elements** (see below)

 Unsolved Mechs

These kinematic-chains have a mobility that is greater than zero(0). The kinematic-chains are not **kinematically-defined**.



Example: Kinematics-Tree in Element-Explorer

KINEMATIC-SUB-ASSEMBLIES (Solved Mechanisms ONLY):

These are compiled as:

1. Motion-Parts
   a. Rockers
   b. Sliders
2. Dyads

The type of Dyad is identified by its three joints, denoted with a letter:

R = Revolute-Joint = PIN-JOINT

P = Prismatic-Joint = SLIDE-JOINT

S = Spherical-Joint = BALL-JOINT

a. R-R-R
b. R-R-P
c. R-P-R
d. P-R-P
e. R-P-P
f. Ram-R
g. Ram-P
h. S-S-R
i. S-S-P

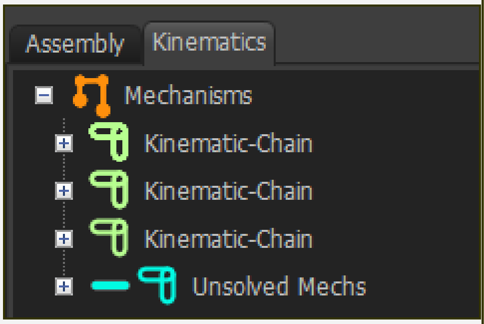
4. Geared-Rockers
5. Rack-Pinion / Pinion-Rack
6. Geared-Pulley

1.5.7.3.2.1 Kinematic-Symbols

Kinematics-Tree Structure and Symbols

 Symbol at top of **KINEMATICS-TREE**

TOP-LEVEL

	Symbol	State	Mobility	
		Kinematic-Chain (Solved Mech)	M = 0	The kin-emati c-chain: - is **solve d** - is **kin-emat-**

				ically-defined
		Unsolved Mechs	M > 0	The kinematic-chain : - is not fully defined - cannot solve its kinematic-data

SUB-ASSEMBLY LEVEL

Kinematic Sub-Assemblies

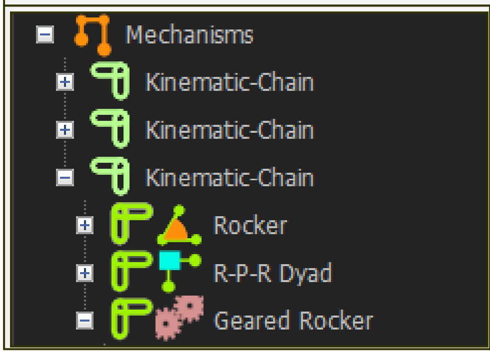
- Motion-Parts (Rockers, Sliders)
- Geared-Rockers
- Dyads
- Pulley-Rockers
- Rack-Pinions

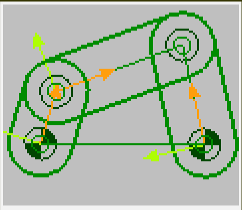
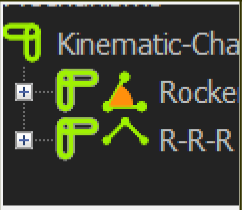
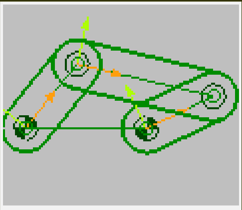
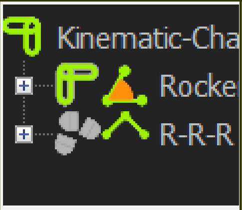
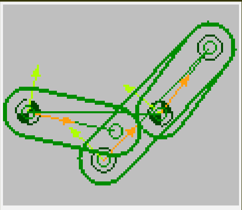
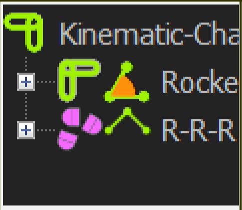
Sub-assembly Symbols:

: the kinematic-chain solves for the complete machine-cycle.

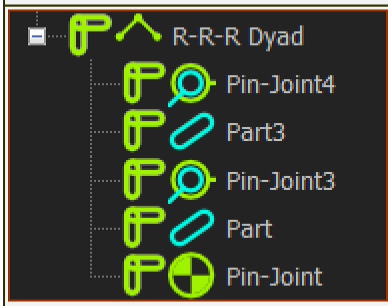
: the kinematic-chain is solved now, but not for the complete machine-cycle.

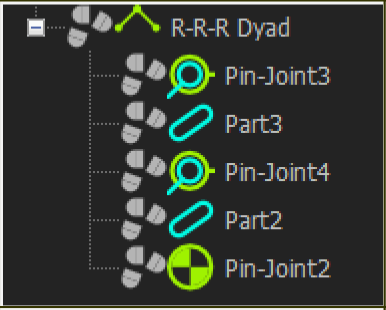
: the kinematic-chain is not solved now, at this machine-angle.

	**Example**. 3 Kinematic-Chains Explored Kinematic-Chain with three sub-assemblies: • Rocker, • R-P-R Dyad • Geared-Rocker

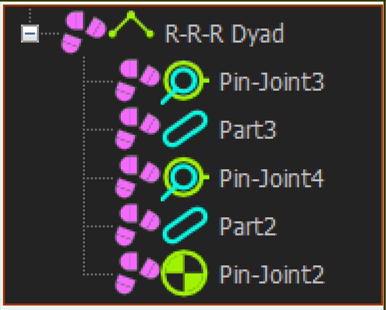
		**EXAMPLE 1 : A Dyad that never Breaks ...** The Symbol is : The Dyad is solved for a machine-cycle (0-360 of the Master Machine Angle).
		**EXAMPLE 2 : A Dyad that Breaks ...** The Symbol is : The Dyad is solved now, but it does **not solve** for **ALL positions** of the machine-cycle (0-360 of the Master Machine Angle).
		**EXAMPLE 3** : -**The Dyad is broken** The Symbol is : The Dyad is **not solved at this position** of the machine-cycle (0-360 of the Master Machine Angle).

ELEMENT LEVEL

You can explore the fundamental kinematic elements of each kinematic-chain. At this level you can see: • Parts • Joints • Motion-Dimensions • Gear-Pairs • Pulley-Joints The symbol, , also shows next to the elements in each sub-assembly.	
	**Example 1 : A Dyad that does not Break** The symbol is to show the Dyad is solved for a machine-cycle. The symbol is next to each element in the dyad to show they are solved for a machine-cycle.

<table>
<tr>
<td>
</td>
<td>Example 2 : A Dyad that does Break

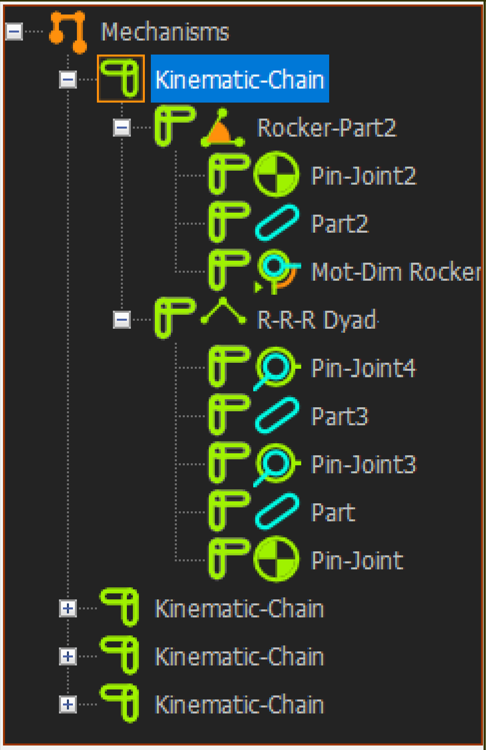
The symbol is to show the dyad does not solve for a period in the machine-cycle.

The symbol also shows next to the elements in the dyad that do not solve for a period in the machine-cycle.</td>
</tr>
<tr>
<td>
</td>
<td>Example 2 : A Dyad that is Broken...

The symbol is to show the joints in the dyad do not solve at this instant in the machine-cycle.

The symbol also shows next to the elements in the dyad that do not solve at this instant in the machine-cycle.</td>
</tr>
</table>

A typical Kinematics-Tree

<table>
<tr>
<td>
</td>
<td>This KINEMATICS-TREE has four(4) Kinematic Defined Chains, identified by the icon.<hr>A Rocker is expanded to show three elements:
PIN-JOINT, PART, MOT-DIM ROCKER
<hr>The R-R-R Dyads is expanded to show it is assembled from:
Three(3) PIN-JOINTS , two(2) PARTS
<hr>Dyad and Joint Symbols:

This symbol is to the left of a Dyad and Joint when it solves for the machine-cycle.

This symbol is to the left of a Dyad and Joint if a Joint does not solve for period of the machine-cycle.

This symbol is to the left of a Dyad and Joint if a Joint does not solve at this instant of the machine-cycle.</td>
</tr>
</table>

1.5.7.3.2.2 Configure Power Source / Change-Dyad-Closure

Kinematics-Tree - shortcut menu

Configure Power Source

See also : Forces toolbar > Configure Power Source 232

To open the **Configure Power-Source dialog:**

1. Click a **kinematic-chain** so that a Red or Orange square encloses the icon
2. Right-click to show 'CONFIGURE POWER SOURCE'
3. Click the 'CONFIGURE POWER SOURCE' text to open the dialog**.**

Change Dyad Closure

See also : Kinematic elements toolbar > Change Dyad Closure 119 - it is more convenient and easier to use.

To change the closure of a dyad from the **KINEMATICS-TREE**:

1. Click the **Dyad** so that a Red or Orange square encloses its icon
2. Right-click the icon to show **Change Dyad Closure** next to you mouse-pointer
3. Click the **Change Dyad Closure** text to change the closure of the Dyad

The SELECT ELEMENTS DIALOG shows - you must select a PART.

4. Click a PART in the SELECT-ELEMENTS DIALOG
5. Close ✅ to close the SELECT-ELEMENTS DIALOG
6. Click ✅ in the COMMAND-MANGER to change the closure of the **Dyad**

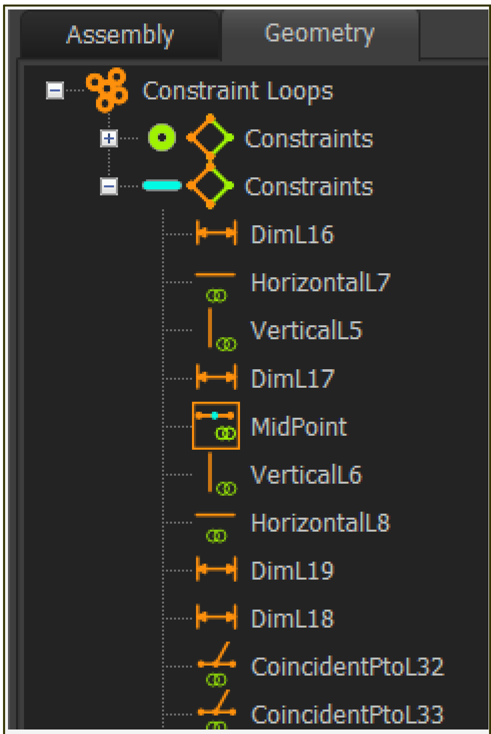
1.5.7.3.3 Geometry-Tree

Element-Explorer - Geometry-Tree

Note: If you cannot explore the **GEOMETRY-TREE**, click Edit menu > Rebuild now[50] .

The **GEOMETRY-TREE** replaces the **KINEMATICS-TREE** when you start the **PART-EDITOR**.

Example Geometry-Tree



Example: Geometry in Element-Explorer

What is a Constraint-Loop?

A **Constraint-Loop** (labeled Constraints) is a list of the constraints that are between a set of sketch-elements.

If you add a Constraint between sketch-elements that are in different Constraint-Loops, they combine to give one Constraint-Loop.

For example:

- Add Horizontal Constraint to Line1 = Constraint Loop #1
- Add Horizontal Constraint to Line2 = Constraint Loop #2
- Add a Horizontal Constraint between a Point in Line 1 and a Point in Line 2 = 1 × Constraint Loop

Constraints and the Selection-Window

If you:

- **Click** a **LINE** :

the **LINE** shows in the **SELECTION-WINDOW**

- **SHIFT + Click** a **LINE** :

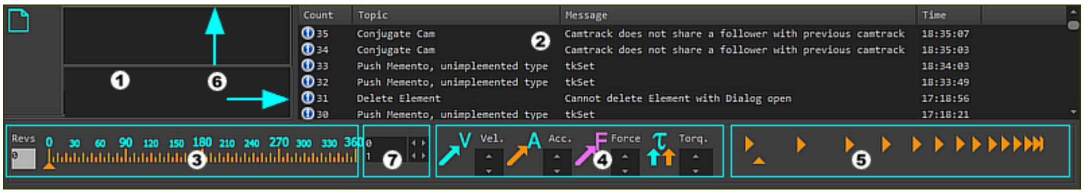
the **LINE AND** any **CONSTRAINTS** that have been added to the **LINE** show in the **SELECTION-WINDOW**.

1.5.8 4: Feedback Area

④ Feedback-Area

The **FEEDBACK-AREA** is below the graphics-area.

It has five areas.



① Extended Hints AND Element Properties

Extended Hints:

When you move your mouse above a command in a toolbar, or many of the Function-Blocks in the graphics-area, a tool-tip shows in the **EXTENDED HINTS** box ①.

Element-Properties:

When you move your mouse above an element in the graphics-area, it shows the element's kinematic-properties and/or kinetostatic-properties.

Notes:

You do **not** need to enable **HINTS AND TOOL-TIPS** to see the **Extended Hints**.

To see all of the **Extended Hint** and/or **Element-Properties**, you may need to drag the separator-bars ⑥ upwards and/or to the right a short distance.

② Messages

The most recent message is at the top of the list.

Message information:

Count :	The message number.
Topic :	Importance Level: – Information; – Warning; – Error - save your work now!
Message :	The message that you should read!
Time :	When the message was displayed.

To clear the messages:

1. Right-Click, with your mouse-pointer in the **Messages** area
2. Click **Clear Messages** in the shortcut menu

Message sounds:

If you enable sounds (Application Options | Accessibility tab 347), you hear a **honk** with each new message.

③ Master-Machine-Angle (MMA): Scale, Digital Angle Indicator, and Revs

MASTER-MACHINE-ANGLE (MMA):

The value of the **MMA** is the independent input to all kinematic-chains in your model.

The **MMA** increases at a constant-rate from 0 to 360, again and again, when you cycle/run the model - see the **Run menu** 58. One machine-cycle is one cycle of the **MMA**, from 0 to 360.

You can read and edit the **MMA** in two ways:

ARROWHEAD + MMA SCALE - Read / "Write" (Drag)

APPROXIMATE Master Machine Angle.

The **orange triangle (▲)** below the scale indicates, approximately, the **MMA** on the scale.

To edit the **MMA** approximately:

Mouse-button-down and move you mouse to the left or right, with your mouse-pointer **INSIDE** the **Master Machine Angle Slider** to change the machine angle.

The **orange triangle (▲)** below the scale moves with your mouse-pointer.

DIGITAL MMA INDICATOR ⑦ - Read / Write

EXACT Master Machine Angle

The value in the **DIGITAL MMA INDICATOR** box is the exact **MMA**.

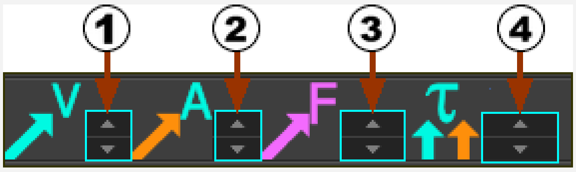
To edit the **MMA** exactly:

To an exact MMA angle:	Enter a value for the **MMA**, from **0** to **360**.
To Inch	**Click the Spin-Box** one time to increase or decrease the **MMA** by one **Spin-Increment**.
To Jog	**Press and Hold the Spin-Box** to continuously increase or decrease the **MMA**.

REVS - Read only

Number of machine-cycles since you reset the model to zero with **Run menu > Home** 58

④ Vector Scale buttons



Click the up / down arrow buttons to increase or decrease the length of the **VELOCITY**, **ACCELERATION**, **FORCE**, and **TORQUE** vectors that you can show in the graphics-area.

Velocity (V)① and **Acceleration (A)**② **Vector buttons**

Click the up /down arrow-buttons to the right of:

- **V** - ① - to increase or decrease the length of **Velocity** vectors
- **A** - ② - to increase or decrease the length of **Acceleration** vectors

See Point Properties dialog 543 to show the **Velocity Vector** and **Acceleration Vector** of a moving POINT.

Force (F)③ **and Torque (**τ**)**④ **Vector buttons**

Click the up /down arrow-buttons to the right of:

- **F** - ③ - to increase or decrease the length of **Force** vectors
- τ - ④ - to increase or decrease the length of **Torque** vectors

See Force-Vectors: Calculate 229 and Force-Vectors: Display 63 to show **Force** vectors and **Torque/Moment** vectors.

See Configure Power Source 589 to make sure the Power flows through the model correctly.

5 Animation-Speed Slider

Use the **ANIMATION SPEED SLIDER** to speed-up or slow-down the **Animation Speed** of the model.

Mouse-button-down and move you mouse to the left or right, with your mouse-pointer INSIDE the **Animation-Speed Slider** to change the animation speed.

The **Animation-Speed** does not change the kinematic or force analysis, or motion synchronization between kinematic-chains.

To edit the **Simulation Speed** or machine-speed: **see** Edit menu > Machine-Settings 56 > CYCLING PARAMETERS.

See also: Run >Cycle 58

1.5.9 5: MotionDesigner

⑤ MotionDesigner

Use **MotionDesigner** to add and design motions for **Motion-Parts** and **Motion-Points**. Each motion you add has a **Motion name-tab**.

Use a **MOTION FB** to link a motion from **MotionDesigner** to a **Motion-Part** or **Motion-Point** that is in your model in **MechDesigner.**

To Link a Motion to a Motion-Part

STEP 1: Add a Motion FB to the graphics-area

1. Click Function-Block menu [165] > Motion FB
2. Click in the graphics-area

The **MOTION FB** is now in the graphics-area and **ASSEMBLY-TREE**.

STEP 2: Open the Motion FB dialog

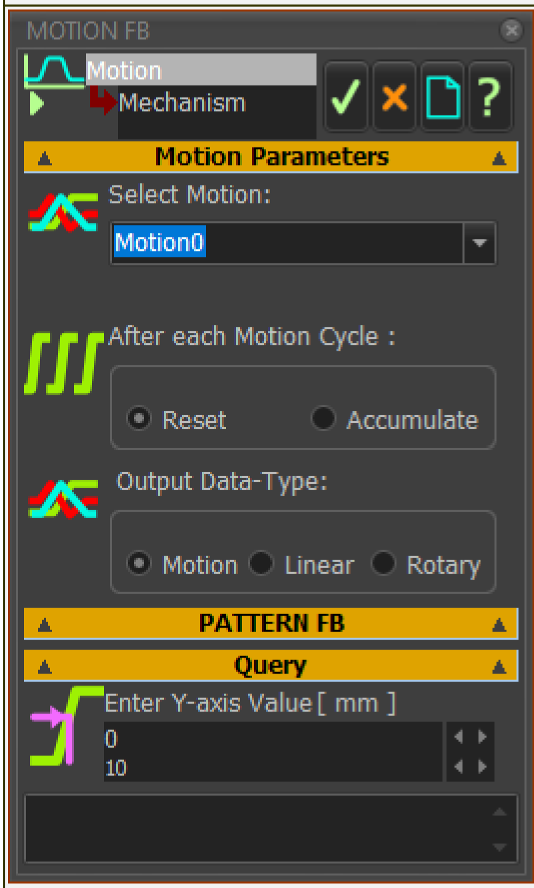
1. Double-click the **MOTION FB** in the graphics-area or **ASSEMBLY-TREE**

OR

1. **See** How to Open a dialog [627]

The **MOTION FB DIALOG** is now open.

STEP 3: Edit the Parameters



MOTION PARAMETERS

SELECT MOTION

Select a Motion from the list of **Motion names** in the **SELECT MOTION** drop-down list box.

Now, the **Motion name** has a link with the **MOTION FB**.

AFTER EACH MOTION CYCLE

- **RESET OUTPUT** : Default (use in most cases)
- **ACCUMULATE OUTPUT** : Select when the motion is a progressive motion - for example, the motion is indexing.

See more details : Motion FB dialog [464]

OUTPUT DATA-TYPE

- **MOTION** : Default (use in most cases)

- **LINEAR** or **ROTARY** : Select one if you connect the **MOTION FB** to a **MOTION-PATH FB** or a **MATH FB.**

PATTERN FB

Not normally used.

QUERY

Enter a **Y-axis** value to find the **X-axis** value(s) for the motion you select in **SELECT MOTION**.

STEP 4: Click ✓ to close the Motion FB dialog

STEP 5: Connect wires to the input-connector and from the output-connector of the Motion FB

1. Connect a wire to the input-connector of the **MOTION FB**

   Usually, (but not always), connect a wire from the output of a **LINEAR-MOTION FB** or a **GEARING FB** to the input-connector of the **MOTION FB**.

   When you cycle the model, motion-data at the input-connector controls the **X-axis** value for the **Motion** you select in **STEP 3** and **SELECT MOTION**, above.

2. Connect a wire from the output-connector of the **MOTION FB**

   Usually (not always), connect a wire from the **MOTION FB** to the input of a **MOTION-DIMENSION FB** or a **MOTION-PATH FB**.

   When you cycle the model, the motion-data at the output-connector is the **Y-axis** value, that corresponds to the **X-axis** value at its input-connector, for the **Motion** you select in **STEP 3**, and **SELECT MOTION**, above.

1.5.10 6: Memo Interface

⑥ Memo Interface

The **Memo** is a **Windows-style NotePad®** interface that opens automatically when you start **MechDesigner**.

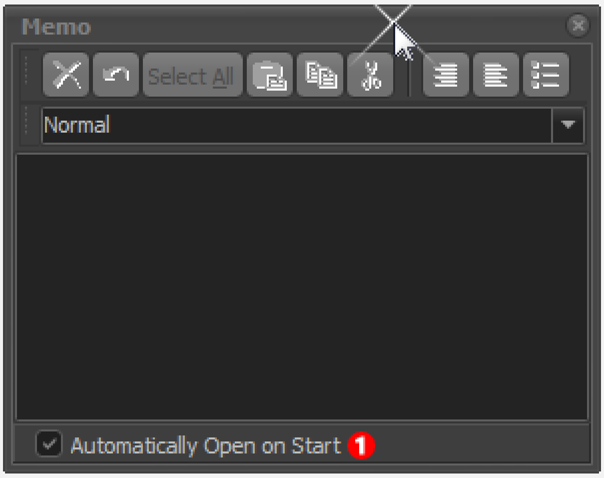
The **MODEL-EDITOR** and each **MECHANISM-EDITOR** can have its own **Memo**. We save the **Memos** for you with the model file.

To open the Memo Interface at another time:

1. Right-click the **MODEL NAME-TAB** or any **MECHANISM NAME-TAB**
2. Click Open Memo in the shortcut menu.

If you do not want the Memo to open automatically:

1. Clear the **Automatically Open on Start** check-box, at the bottom of the interface 1.



Memo dialog

1.5.11 Dialogs

Dialogs

We use dialogs to edit those elements that have parameters to modify its properties.

After you add an element, you can open its dialog immediately or at any time later.

Therefore, the steps to build a model are typically:

STEP 1: Add an ELEMENT	- see Model Editor 79 ; Mechanism Editor 88 ; Part-Editor 257
STEP 2: Open the ELEMENT'S DIALOG	- see How to open a dialog 627
STEP 3: Edit the ELEMENT'S PARAMETERS	- see How to edit a Parameter in a dialog 631
STEP 4: Close the ELEMENTS'S DIALOG	Close the dialog before you start a different command to add a new ELEMENT.
Do Steps 1 to 4, again, and again, ... Two exceptions: Add Dimension and Add Plane. Their dialogs open immediately.	

Dialogs

Element or Dialog name	Dialog Function & Main Parameters
General Purpose Dialogs	
RENAME 335	Replace an "Old Element Name" with a "New Element Name"
MODEL OPTIONS / MECHANISM OPTIONS 337	Lighting, Synchronize CAD-SOLIDS
APPLICATION SETTINGS 341	Working Environment, Number-Format, Auto-Profiles, Accessibility, Element Colors, ...
MACHINE SETTINGS 351	Machine Speed, # Steps in Machine-Cycle, Engineering Units
ELEMENT PROPERTIES 609	Read-only - an element's properties at the Machine Angle, e.g Position, Velocity, Acceleration, Angle, Coordinates,
MODEL-EDITOR	
ADD OR EDIT PLANE 356	Edit X,Y,Z ANGLE OF PLANE or OFFSET OF PLANE
PROFILE / EXTRUSION 360	Edit the EXTRUSION - an MD-SOLID
CAD: DXF, SOLIDWORKS	
DXF-ELEMENT 354	Select a different DXF Drawing File, change the Units of the DXF Drawing
CAD-LINE 364	
> DXF 371	Import DXF File, Convert Entities to MD Sketch-Elements.

>> DXF LAYERS 376	
> SOLIDWORKS 365	> Import SOLIDWORKS file-type - a **CAD-SOLID**
> MASS PROPERTIES 367	> User Mass-Properties, SOLIDWORKS Mass-Properties, Total Mass Properties.
> STL IMPORT 376	> Import an STL file - a **CAD-SOLID**
> DISPLAY OPTIONS 381	> Edit the Color, Transparency, ...
CAMS: 2D and 3D	
2D-CAM 401	2D-Cam:
>> PARAMETERS 403	>> Edit the Start-Angle and Range (defaults are 0 and 360), Enable Lifetime, Edit Life Safety-Factor.
>> DISPLAY 407	>> Display Cam as: Cam-Profile, Pressure-Angle, Contact-Force, Shear-Stress. Edit Color, Line thickness.
>> ROLLER LIFE 411	>> Select Roller bearing, factors for ISO 281 calculations (Lubricant Viscosity, Temperature, Contamination and Reliability)
>> CAM LIFE 428	>> Select Steel type, quality, heat-treatment, hardness - Read Life in Cycles, Hours, Years (Stress)
CONJUGATE CAM FB 436	Required for Force Analysis, Cam-Life, Roller-Life with Conjugate-Cams and Groove-Cams.
CAM-DATA FB 440	Plot Contact-Force, Hertzian Shear-Stress, Radius-of-Curvature, Pressure-Angle, or Sliding-Velocity
CAM-COORDINATES 446	Calculate and Export 2D-Cam Coordinates, Save as STEP, TXT, DXF, SLDCRV
3D-CAM 384	Calculate and Export 3D-Cams - Barrel, Cylindrical, Globoidal. Save as STEP, TXT, SLDCRV
FUNCTION-BLOCKS	
LINEAR-MOTION FB 458	Output is 0 - 360, again and again - a machine clock.
GEARING FB 459	Modify motion-values with a Linear function.
MOTION FB 462	Link a Motion in **MotionDesigner** to a **Motion-Part**.
MOTION-DIMENSION FB 466	Edit the **BASE-VALUE** (angle or position) of a **Motion-Part**.
MOTION-PATH FB 469	Edit the starting position of a **Motion-Point**, Control the length of a sketch-loop
POINT-DATA FB 197	Measure a Point's Position, Velocity, and Acceleration relative to the Mechanism-Plane.
MEASUREMENT FB 193	Measure Linear or Angular Position, Velocity, and Acceleration.
GRAPH FB 477	Plot up to 4 graphs as a function of one X-axis
> GRAPH SETTINGS 480	> Graph Display
SPRING FB 538	Define a force-function for a Spring
FORCE-DATA FB 541	Measure Force or Torque
CAD CONTROL FB 486	Control SOLIDWORKS mates from MechDesigner
MAGNETIC-JOINT 560	Glue Profiles/Curves together
MATH FB 509	User defined functions

STATISTICS FB 488	Statistical values for motion-values or force-values
POLYNOMIAL FIT FB 491	Fit Polynomials to data at its input-connector, save as Poly Coefficients, or export directly to MotionDesigner.
PARAMETER-CONTROL FB 497	Control the length of a 'static-dimension', Extrusion-Depth, Extrusion Offset with motion-values at its input-connector.
CONTINUOUS CRANK FB 535	Make a Crank rotate fully with a modulated speed, as a function of the motion of a different part in the kinematic-chain.
MODELING TOOLS	
DESIGN-SET 528	Add different dimensions and parameters to one dialog
BRIEFCASE FB 518	Put other FBs in a Briefcase - to make you model easier to review
MAKE MOVIE 605	Produce a GIF file, or a series of PNG, JPG, of BMP images for a machine-cycle.
POINT-CLOUD 521	Import XY data, convert to a smooth curve feature.
PATTERN 500	Copy **CAD-SOLIDS** and/or **MD-SOLIDS** multiple times and phase-shift in space and time.
OTHER DIALOGS	
POINT PROPERTIES 543	Read / Write the Position of a **POINT**. Display its Velocity and/or Acceleration Vectors.
BLEND-CURVE 549	Edit the Angle, Curvature, and Curvature-Rate at the **START-POINT** and **END-POINT** of a **BLEND-CURVE**
BALL-JOINT 559	3D Joint for Spatial Mechanisms. Edit its offset from the Mechanism-Plane.
GEAR-PAIR 566	Edit the module, number-of-teeth, mesh, ...
RACK-PINION 577 / **BALL-SCREW**	Edit the module, number-of-teeth, ...
PULLEY 581	Number-of-Teeth on the Pulley
KINETOSTATIC: SERVOMOTOR AND GEARBOX SIZING 592	Size a Gearbox and Servomotor for the Application.
CONFIGURE POWER SOURCE 589	To move a motor or other power source to the correct joint or cam.
DIMENSION 547	Edit an Angular or Linear Dimensional Value.
MISCELLANEOUS	
TUTORIAL VIDEOS 620	Play Tutorial Video
EXAMPLE MODELS	Help menu
SELECT ELEMENTS 616	Choose one or more elements from a list of elements
DEPENDENT ELEMENTS 617	Show those elements that you also delete
VIEW REFERENCES 618	Elements that are referenced by another elements

1.5.11.1 Dialog: Rename Element

Rename

You can rename all elements.

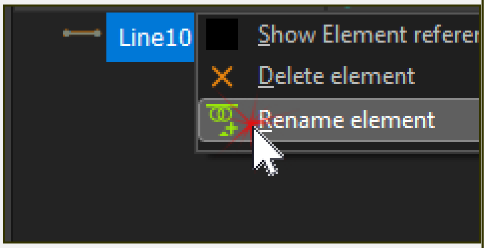
If you rename an element, you must use the element-icon to identify the element-type. In the **SELECTION-WINDOW** and **ASSEMBLY-TREE**, the element-icon is to the left of the element-name.

To Rename an element:

There are three(3) methods to rename an element:

METHOD 1: Rename Element dialog

Use this method if you can select the element in the graphics-area or the **ELEMENT-EXPLORER**.



Selection-Window: shortcut menu

STEP 1: Open the Rename Element dialog:

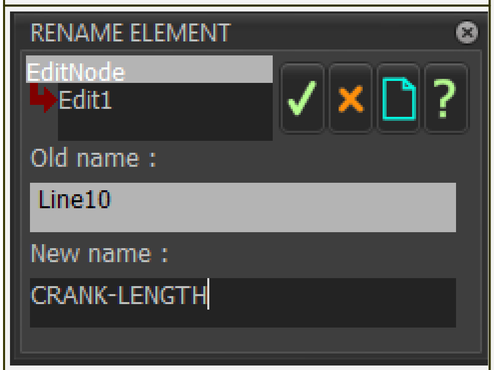
1. Click the element in the graphics-area or the **ASSEMBLY-TREE**.

The element is now in the **SELECTION-WINDOW**.

In the **SELECTION-WINDOW**:

2. Right-click the element that you want to rename
3. Click **Rename element** in the shortcut menu

The **RENAME ELEMENT DIALOG** is now open.



Rename dialog

STEP 2: Enter a "New Name" to replace the "Old Name":

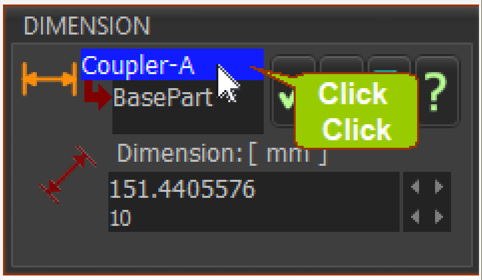
The **Old Name** is **Line10**

1. Enter a **New Name**

The **New Name** is **CRANK-LENGTH**

2. Click ✓ to close the **RENAME ELEMENT DIALOG**.

METHOD 2: Rename the element in its dialog



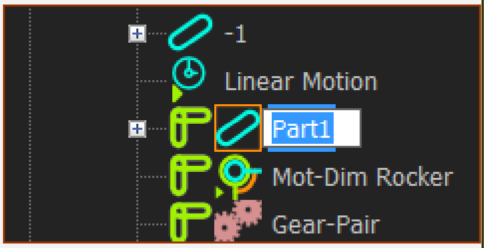
Rename element:
An open dialog

Use this method when a dialog is open:

1. Double-click the element-name at the top of the dialog < see image
2. Enter a new element-name E.g. **Coupler-A**
3. Press the **Enter** key (↵) on your keyboard.

Unfortunately, not all element-types have a dialog with which to rename the element.

METHOD 3: Rename the element in the Element-Explorer



Rename element:
From the Assembly-Tree

Do the Windows® method:

1. Click, pause, and click again the element-name in the **ELEMENT-EXPLORER** or the **SELECTION-WINDOW**
2. Enter a new element-name
3. Press the **Enter** key (↵) on your keyboard

Unfortunately, not all element-types show in the **ASSEMBLY-TREE** or **SELECTION-WINDOW**.

1.5.11.2 Dialog: Model / Mechanism Options

Model / Mechanism Options

See known bugs - 16.1.268[28]

Use the **MODEL-OPTIONS DIALOG** to confirm the file-name and path of **CAD-SOLIDS** that you have imported onto **CAD-LINES** - see Synchronize CAD-Files tab[337]

Also, use the **MODEL-OPTIONS DIALOG** to change the lighting of the graphics-area - see Lighting tab[339]

Terminology:

CAD-SOLID :	A CAD model that you have imported onto a **CAD-LINE** - **see CAD-Line dialog**[364]

How to open the Model Options dialog

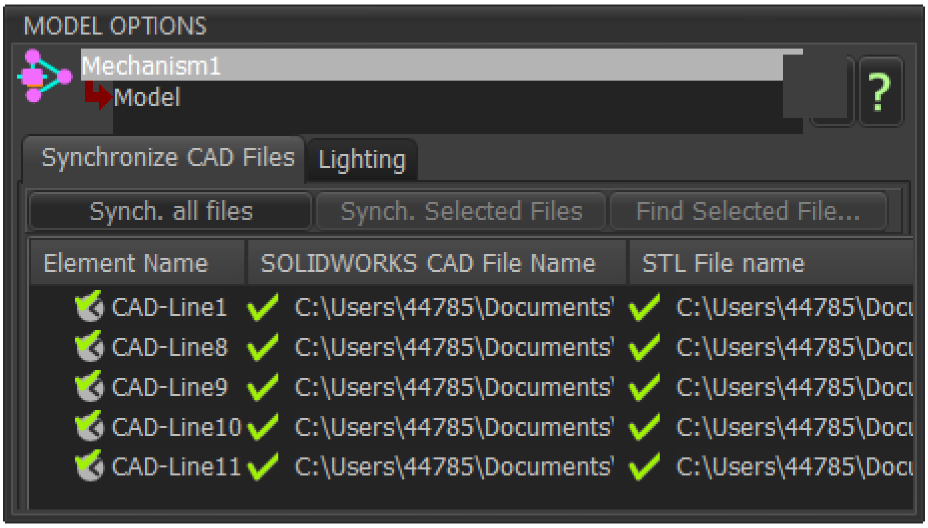
1. Double-click the **Model** or **Mechanism** element in the **ASSEMBLY-TREE**

OR

1. Right-click the **MODEL** or **MECHANISM** element at the top of the **ASSEMBLY-TREE**
2. Click **Edit element** in the shortcut menu

The **MODEL OPTIONS DIALOG** is now open.

Model Options dialog.



Model Options dialog

There are two tabs.

Synchronize CAD Files

There is a list of the **CAD-SOLIDS** that you have imported onto **CAD-LINES** with the CAD-Line dialog[364].

Background

CAD-SOLID: the term for a 3D CAD model that you have imported onto a **CAD-LINE**.

You can import **CAD-SOLIDS**:

- directly from **SOLIDWORKS** (see CAD-Line dialog > SOLIDWORKS tab[365]), or
- as an STL file (see CAD-Line dialog > STL Import tab[376]).

CAD files you save to disc have a **time-stamp**.

When you open the **Model Option dialog**, we compare for you:

- The **Time-stamp** at the time you linked it to the **CAD-LINE**
- The **Time-stamp** of the CAD file that is on disc.

CAD models:

If you have imported a **CAD-SOLID** onto a **CAD-LINE**, we list for you:

Element-Name

The **CAD-LINE** , with a status icon:

- the CAD file on your hard-drive is newer than SOLIDWORKS document on the **CAD-LINE**.

- the CAD file is not on your hard-drive in the place expected

- the time-stamp is the same as that of the CAD file on your hard-drive.

SOLIDWORKS CAD File name

The CAD file is either:

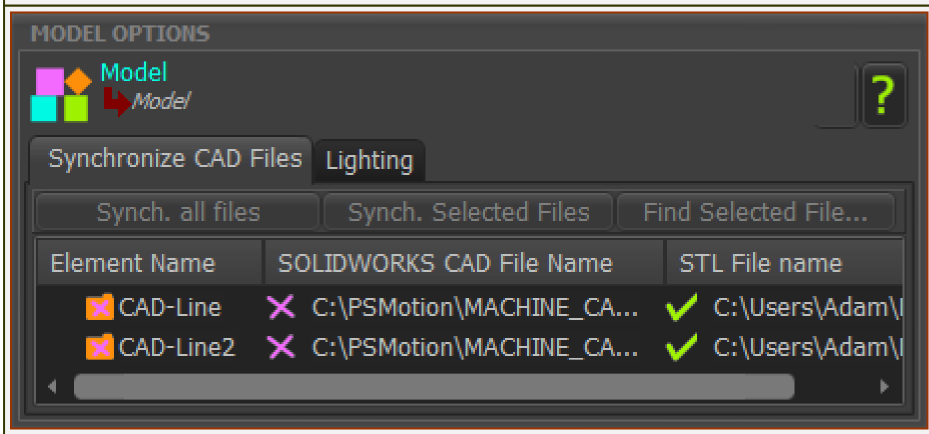
- Not found on your hard drive

- Found on your hard drive

STL File name

The STL file that has a link to the **CAD-LINE**.

We check for you that the STL file is in the path, as expected.



Model Option dialog

Control Buttons:

Use the control buttons to re-import or find SOLIDWORKS files if they are not up-to-date.

Synch. all files

1. Click **Synch. all files** button to check you have the most up-to-date SOLIDWORKS files.

The files import again, if needed.

Synchronize Selected Files

In the Element Name list:

1. CTRL + Click each of the **CAD-LINE** that you want to make sure has the latest **CAD-SOLID**
2. Click **Synch. Selected Files**

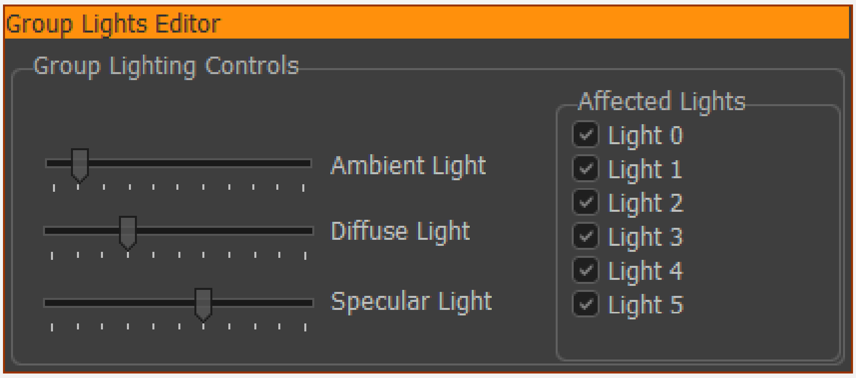
We re-import for you the files on each CAD-Line you select.

Find Selected File

1. Click a **CAD-LINE** in the list
2. Click **Find Selected File...** button
3. Browse to find a file that **MechDesigner** cannot find.

Lighting

GROUP LIGHTS EDITOR



Model Options > Lighting tab

The sliders control those **AFFECTED LIGHTS** that have a check in the check-box

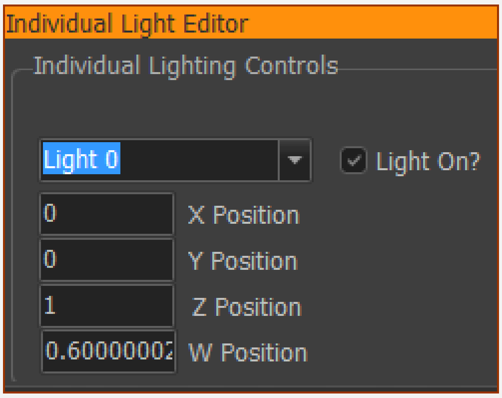
1. Click each **AFFECTED LIGHT** check-box to make lights active.
2. Use the sliders to change their:
   - **AMBIENT**, **DIFFUSE**, and **SPECULAR LIGHT** Levels
2. Move your mouse-pointer over the graphics-area to update the lighting

---

Note:

It is frequently better to decrease **Ambient Light Levels**, and increase **Diffuse** and **Specular Light Levels** to view **MD-SOLIDS** and **CAD-SOLIDS**.

INDIVIDUAL LIGHT EDITOR



To turn on or off each light and to control its source point:

1. Use the drop-down box to select a light (Light 1 to 6)
2. Click the check-box to turn the light that is in the drop-down list on or off.
3. Enter numbers into the X, Y, Z and W Position boxes to change the direction of the light in the drop-down box.
    - ±X, ±Y ±Z directions for each light
    - W - not sure how this works!
4. Move your mouse-pointer over the graphics-area to update the lighting

An External link to Light : Good Luck!

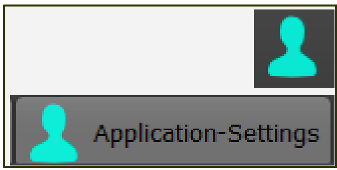
1.5.11.3 Dialog: Application-Settings

Application-Settings

Use **Application-Settings** to edit the working environment.

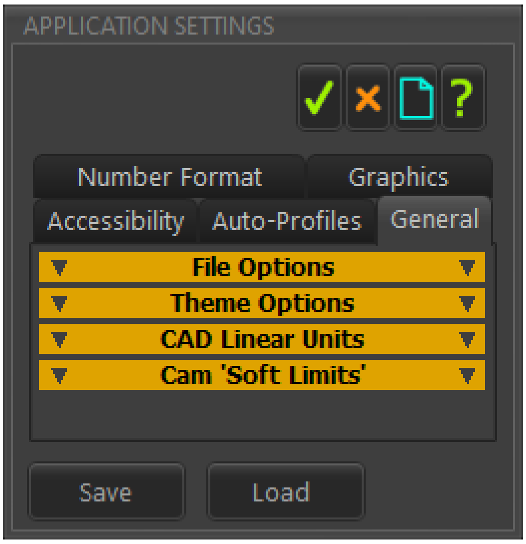
See also: Application-Settings, Themes, Styles, and the Save and Load buttons 624

How to open the Application-Settings dialog

	Click **Edit toolbar** > **Application-Settings** OR Click **Edit menu** > **Application-Settings**

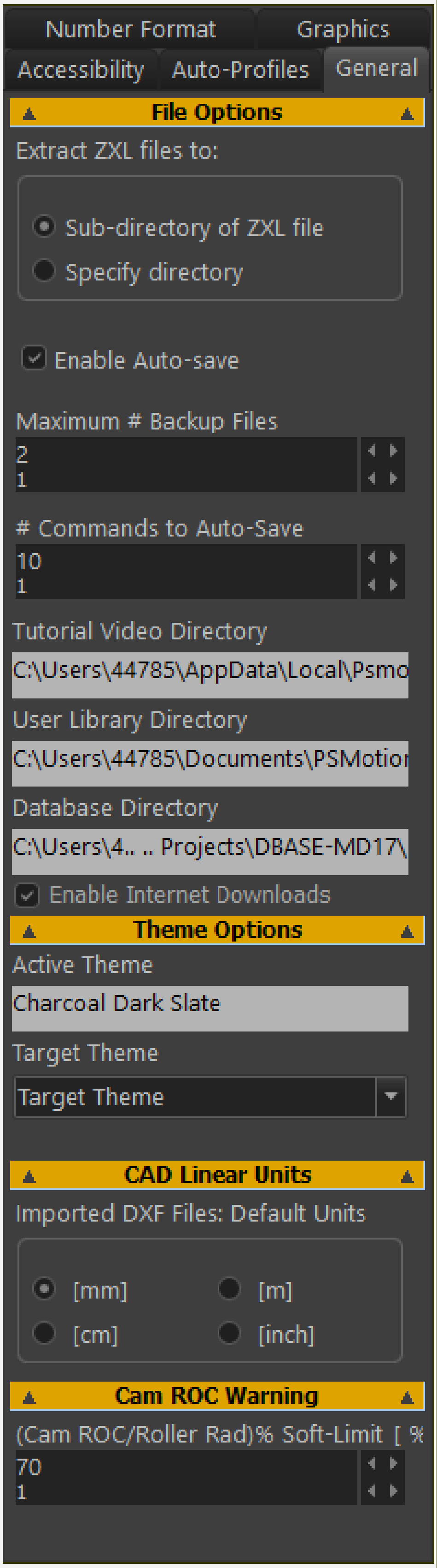
The **APPLICATION SETTINGS DIALOG** is now open.

Application-Settings dialog:



Application Settings dialog

General



FILE OPTIONS **See also: ZXL file-type.**

EXTRACT ZXL FILES TO:

- ⊙ **SUB-DIRECTORY OF ZXL FILE**: Automatically, we add for you a sub-directory to that of the ZXL file in which to extract files that are in the ZXL file.
- ⊙ **SPECIFY DIRECTORY**: You specify a path in which to extract files that are in the ZXL file.

☑ **ENABLE AUTO-SAVE**:

Enable to automatically save the active model, after **# COMMANDS TO AUTO-SAVE**, **AND** overwrite the active model in RAM.

Note: also, to enable **Auto-Save**, save a new model with a file-name.

MAXIMUM # OF BACKUP FILES

When you **ENABLE AUTO-SAVE**:

The total number of backups.
The names of backup files are: **CXL.1**, **MTD.1** ; **CXL.2**, **MTD.2** ; ... **CXL.#**, **MTD.#** ; ...

See: Why so many file-names?[638]

 # COMMANDS TO AUTO-SAVE

When you **ENABLE AUTO-SAVE**:

The number of commands between each Auto-Save. We:

1. Rename **file-name. CXL** and **file-name.MTD** to **file-name.~CXL** and **file-name.~MTD**
2. Save **file-name. CXL** and **file-name.MTD** to RAM.

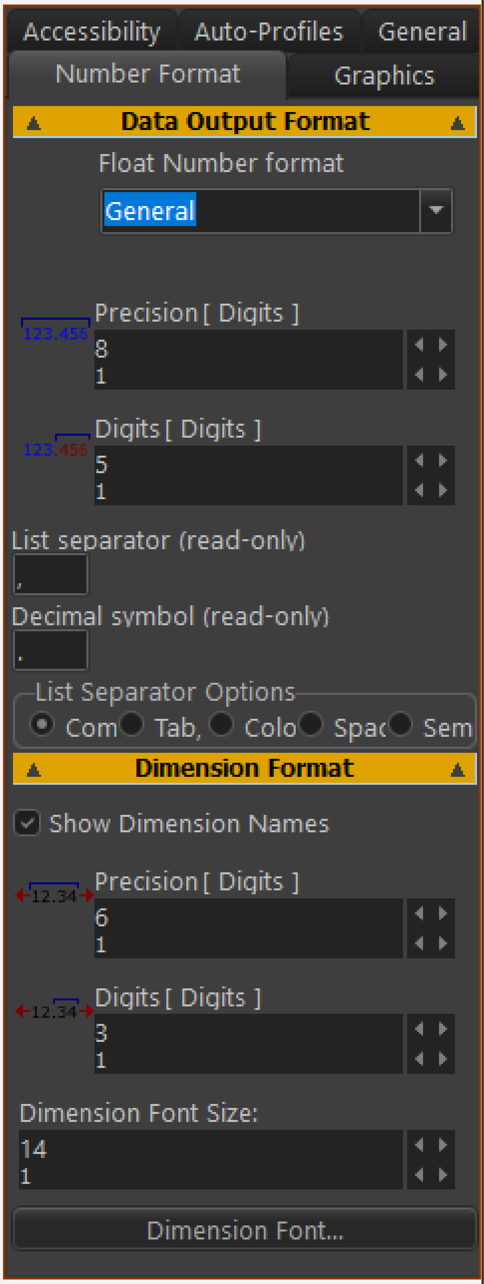
USER LIBRARY DIRECTORY - click the box to specify the path for your **USER LIBRARY DIRECTORY**

ALLOW INTERNET DOWNLOADS : Enable to allow downloads.

THEME OPTIONS

	ACTIVE THEME: After you select a **TARGET THEME**, the box shows the **Theme**. **TARGET THEME**: Select from: • CHARCOAL DARK STYLE, WINDOWS, AQUA LIGHT SLATE, WINDOWS10 DARK, TABLET DARK, SLATE CLASSICO, WINDOWS 10 SLATE GRAY, and WINDOWS 10. **Note**: In this help documentation, the **Theme** is CHARCOAL DARK SLATE. **CAD LINEAR UNITS** **IMPORTED DXF FILES: UNITS** We use these units to scale the **DXF-Drawing**. The scale is 1:1 when the units are equal to those of the original **DXF-Drawing** that you import. **See also: Open DXF File, Edit DXF-Element** 354 **CAM ROC WARNING** **If | Radius of the Cam-Profile | < % × Radius of Follower-Roller** • The Cam-Profile is more likely to be **Undercut** • The Cam-Profile is **red** in the graphics-area It is a **WARNING ONLY** - a soft-limit.

Number Format



Note: Precision of calculations do not change if you edit these parameters.

DATA OUTPUT FORMAT

Data-format of data you can calculate and save to your hard disk. E.g. Data from a GRAPH FB or a CAM-COORDINATES FB.

FLOAT NUMBER FORMAT: **See** **Internet Link here** **about number formats**

PRECISION and DIGITS - see below

LIST SEPARATOR (READ-ONLY) - the regional character that separates values.

For example, "," in a CSV file.

DECIMAL SEPARATOR (READ-ONLY) - the character that separates the integer and fractional parts of a number.

For example, "." in 12.3456

List Separator Options:

Select the separate you want to use for data in a file that you save to your hard disk.

DIMENSION FORMAT

☑ SHOW DIMENSION NAMES

Top-tip: Rename the DIMENSION if you add the DIMENSION to a DESIGN-SET[528] - **see** **Rename element**[335]

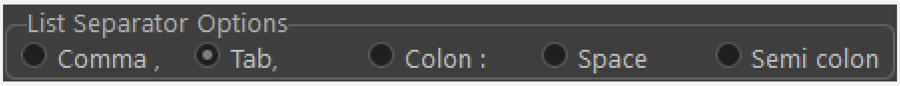
Data-format of dimensions, in the graphics-area:

- PRECISION and DIGITS - see below
- DIMENSION FONT SIZE - experiment (typically 14)
- DIMENSION FONT SIZE - the Windows font picker opens. Experiment with the font.

Notes:

	PRECISION: The total number-of 'useful' digits in the real number before and after the decimal mark. DIGITS: The number-of-digits after the decimal separator. Usually, set : PRECISION ≥ DIGITS +3, . However, it depends on your model requirements.

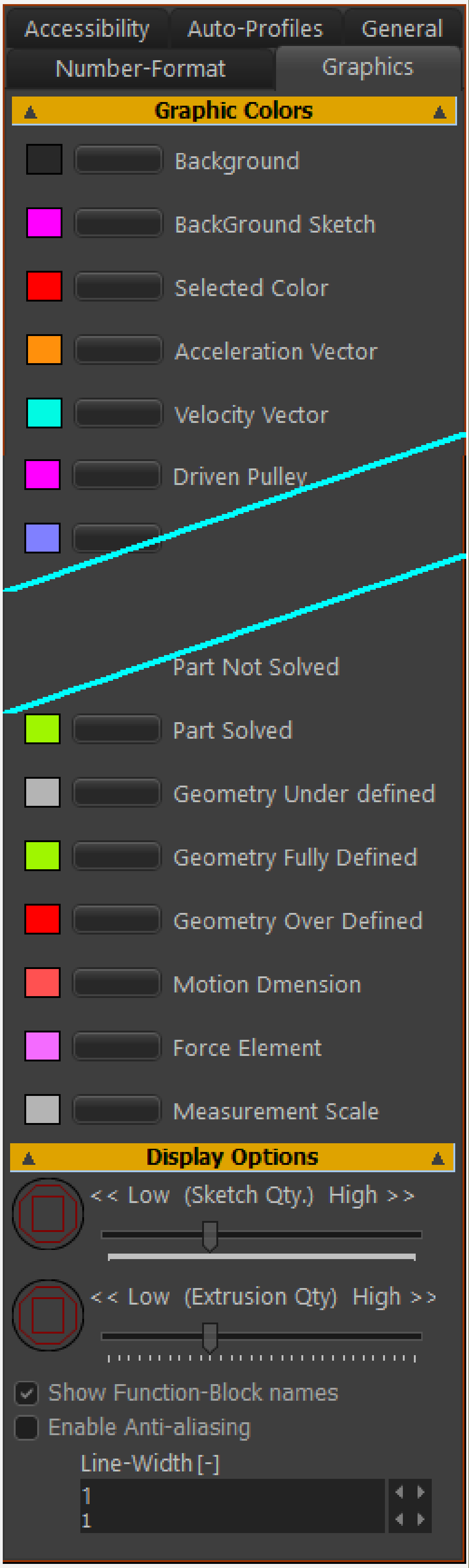
LIST SEPARATOR OPTIONS - read-only



PRECISION AND DIGITS

Example ~ 1234.56789		DIGITS 2	4	6	8
PRECISION	2	1.2E03	1.2E0003	1.2E3	1.2E3
	4	1,235.00	1,234.0000	1,234.000000	1,235.00000000
	6	1,234.57	1,234.5700	1,234.570000	1,234.57000000
	8	1,234.57	1,234.5679	1,234.567900	1,234.56790000

Graphics tab



DISPLAY COLORS

Edit the color of the symbols in the graphics-area.

Standard colors:

- **Part Not Solved** (equivalent term is : **not kinematically-defined**) is blue
- **Part Solved** (equivalent term is: **kinematically-defined**) is a green

XY-axes in the **MECHANISM-EDITOR** and **PART-EDITOR** are:

- Orange: X–axis
- Green: Y–axis

XYZ-axes (**RGB**) at the Origin in MODEL-EDITOR:

- Red: X–axis,
- Green: Y–axis,
- Blue: Z-Axis

DISPLAY OPTIONS

There are two sliders

<< LOW (SKETCH QUALITY) HIGH >>

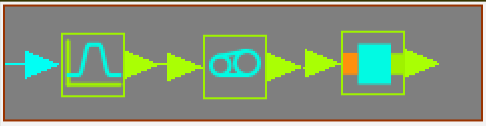
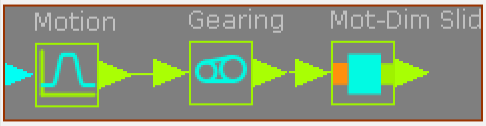
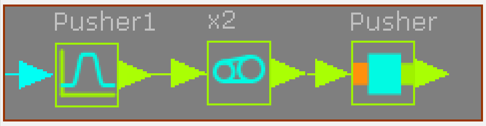
Slide the handle to the left to decrease, and to the right to increase, the number of facets around the CIRCLE and ARC sketch-elements.

<< LOW (EXTRUSION QUALITY) HIGH >>

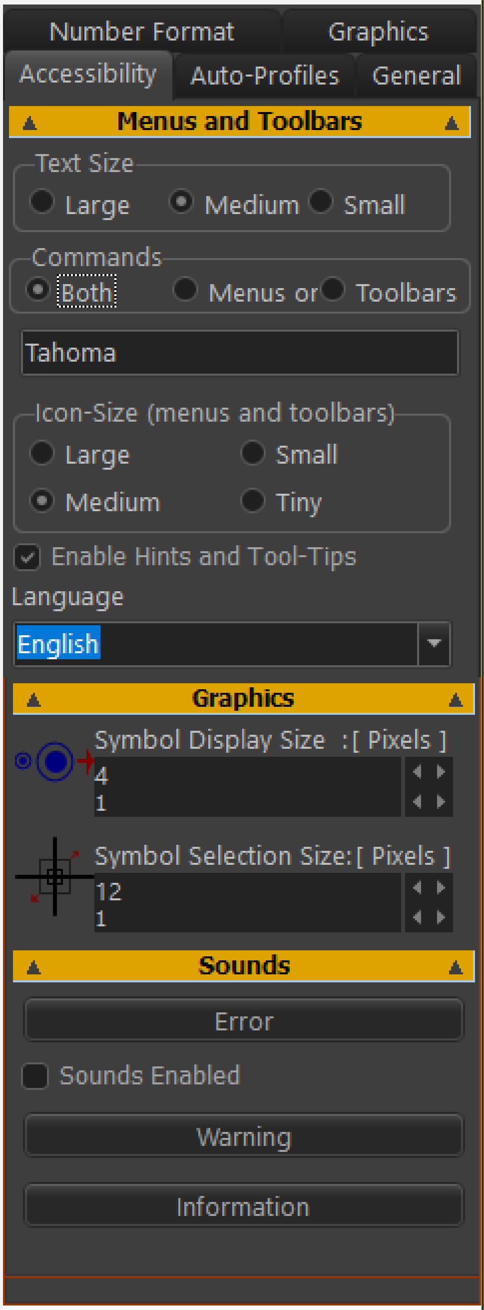
Slide the handle to the left to decrease, and to the right to increase, the number of facets around EXTRUSIONS

☑ SHOW FUNCTION-BLOCK NAMES (see images left)

Enable to show the names of each FUNCTION-BLOCKS above the FB in the graphics-area.

	This is more helpful if you rename FUNCTION-BLOCK - **see** Rename element 335 ☑ ENABLE ANTI-ALIASING* Enable to remove the jagged edges from the symbols of elements in the graphics-area. LINE-WIDTH Edit the LINE-WIDTH to increase or decrease the thickness of sketch-elements. * I find ANTI-ALIASING is good for LINES, **bad** for ARCS, CIRCLES, and **very bad** for GEARS. I do not ENABLE ANTI-ALIASING.
 Do not display Function-Block names  Display Function-Block names  Rename and Display Function-Blocks	

Accessibility tab



MENUS

TEXT SIZE

Text size in menus and dialogs.

Large - too big ? ; **Medium -** recommended ; **Small -** OK?

Each is relative to the **ICON SIZE** (see below)

Select a font for dialogs - for example, Tahoma

COMMANDS (NEW MD17)

Both (Menus and Toolbars) ; Menus only, Toolbars only.

ICON SIZE

Large - size is 48×48 pixels (too big?)

Medium - size is 32×32 pixels (OK, recommended)

Small - size is 24×24 pixels (OK, recommended)

Tiny - size is 16×16 pixels (too small?)

Note : If the icons in the toolbars do not show correctly after you change the **ICON SIZE**, then reset the **ICON-SIZE** to **Medium** and, if necessary, re-start **MechDesigner.**

LANGUAGE (An English Joke about language)

Languages: English, Italian, German, French, Spanish, Portuguese, Dutch, Polish, Russian, Japanese, Chinese.

Note: If you change languages, please wait ~10seconds.

ENABLE HINTS WITH TOOL TIPS

After a short pause, we show the Hint for a command as you move your mouse over the icon. However, the hints frequently get in the way of the command icon!

We also show the hints in the Feedback Area 326.

See also **Help menu** [72]

GRAPHICS

SYMBOL DISPLAY SIZE (PIXELS):

The size of symbols that represent the elements in the graphics-area.

SYMBOL SELECTION SIZE (PIXELS):

The size of the pointer **pin-head**. Increase to make it easier to select an element, but, at the same time, you may also select more than one element.

SOUNDS

☑ **SOUNDS ENABLED**

Enable the check-box to hear a different sound with each message in the Feedback-Area [326]. There are many messages!

Click the buttons to hear the sound for the three types of messages.

Auto-Profile tab

DEFAULT SIZES

DEFAULT PART-OFFSET (default = 0)

The default offset of all PROFILE/EXTRUSIONS you add to a PART.

DEFAULT BALL RADIUS

The default size of the BALL-JOINT symbol.

See also: **Add Ball-Joint** [114] ; **Ball-Joint dialog** [559]

DEFAULT BEARING DIA. (dia. = diameter)

DEFAULT GROUND BEARING DIA. (dia. = diameter)

The default dimension given to ARCS at moving and fixed (with BASE-PART) PIN-JOINTS when you do Add Auto-Profile(s).

See also: **Add Auto-Profiles** [244]

DEFAULT EXTRUSION DEPTH

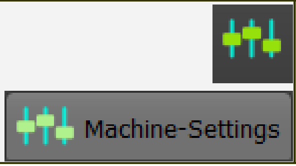
	The default EXTRUSION-DEPTH parameter in the EXTRUSION DIALOG. **See also:** **Add Auto-Profile** 242 ; **Add Auto-Profiles** 244 ; **Extrusion dialog** 360

1.5.11.4 Dialog: Machine-Settings

Machine-Settings

Use the **Machine-Settings dialog** to edit the MACHINE SPEED, NUMBER-OF-STEPS in a machine-cycle, and to edit the ENGINEERING UNITS.

How to open the Machine-Settings dialog



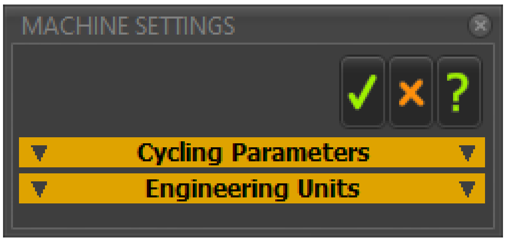
Click Edit toolbar > Machine-Settings

OR

Click Edit menu > Machine-Settings

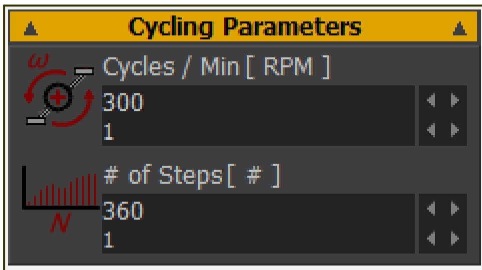
The **Machine-Settings dialog** is now open.

Machine Settings dialog



Machine Settings dialog

CYCLING PARAMETERS



Cycling Parameters

CYCLES / MIN: (RPM) (**See also Note 1** 353)

RPM - Revolutions per Minute.

It is the model's **Simulation-Speed**.

It is the rate-of-change of the MASTER-MACHINE-ANGLE.

MotionDesigner reads and uses this parameter. For example:

Degrees: A MOTION-WIDTH of 360º is one machine cycle in degrees

Seconds: A MOTION-WIDTH of (60/RPM) is one machine-cycle in seconds

---

NUMBER-OF-STEPS: (**See also Note 2** 353)

Number of calculation points in a machine-cycle.

Notes:

- NUMBER-OF-STEPS and Cam Accuracy - no relationship

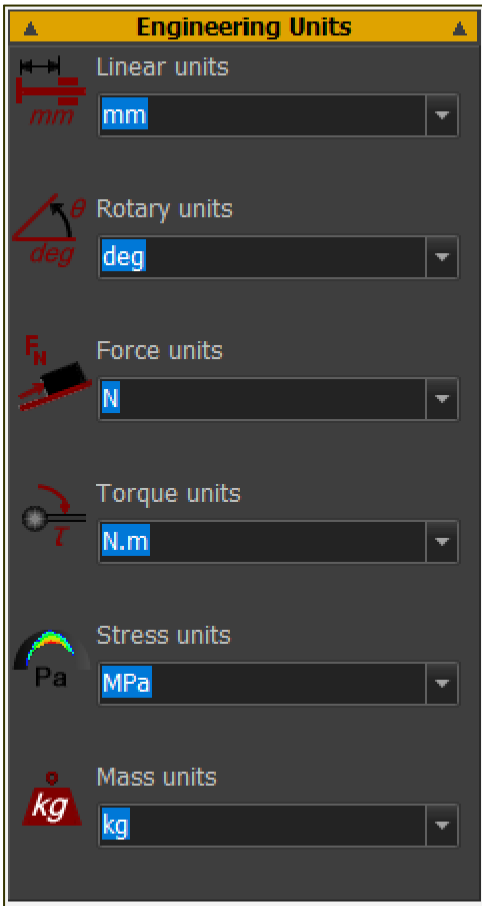
Do **not** increase the NUMBER-OF-STEPS to increase the accuracy of a Cam.

Use the **Cam-Coordinates dialog**[446] to calculate and save a Cam with any number of points and accuracy.

- NUMBER-OF-STEPS is the number of facets along a Cam in the graphics-area
- NUMBER-OF-STEPS is the number of data-points along a graph - **see Graph FB**[477]
- NUMBER-OF-STEPS is the number of facets along the curve of a Trace-Point - **see** Trace-Point
- NUMBER-OF-STEPS is the number of points/dots on the **Motor Torque and Speed Curves**
- Usually, 120 is good. More than 360 is not usually needed.

See also: Run menu > Step Forward / Step Backward[58]

ENGINEERING UNITS



Engineering Units

ENGINEERING UNITS : (**See also** Note 3[353])

LINEAR:	mm, cm, meters, inch.
ROTARY:	deg, radians, cycles
FORCE:	N, lbf (pound-force)
TORQUE:	N.m, N.mm, ft.lbf

STRESS:	Pa(N / m2), MPa(N / mm2), PSI(lbf / in2).
MASS:	kg, gms (grams), lb, oz

More about Machine Settings parameters.

Note 1:

CYCLES / MIN does **not** change the **animation-speed**.

Change the **animation-speed** with the Animation Speed Slider 328 .

Note 2:

Do NOT increase **Machine-Settings >Number-of-Steps** 351 to increase the accuracy of a **2D-CAM**! Use the **Cam-Coordinates dialog** 446 to increase the accuracy of a **2D-CAM** you export for manufacture.

Number-of-Steps = 120 is ideal. 360 should be the maximum, for nearly all models.

To move the model with small steps (increments), we recommend you use the Spin-Box 632 in the MASTER MACHINE ANGLE.

Note 3:

If you change the dimension units, you do **not** change the size of the model.

For example: **100 mm** is **3.94 inches** if you change dimension units from **mm** to **inches.**

For example: **100 degrees** is **1.75 radians** if you change dimension units from **degrees** to **radians.**

In all cases, we do **not** show you the units in the graphics-area.

1.5.11.5 Dialog: DXF-Element

DXF-Element

A **DXF-ELEMENT** is an element that you add to the **ASSEMBLY-TREE** when you do **File menu > Open > File of type : DXF** 36

One **DXF ELEMENT** in the **ASSEMBLY-TREE** is a container for one **DXF-Drawing**.

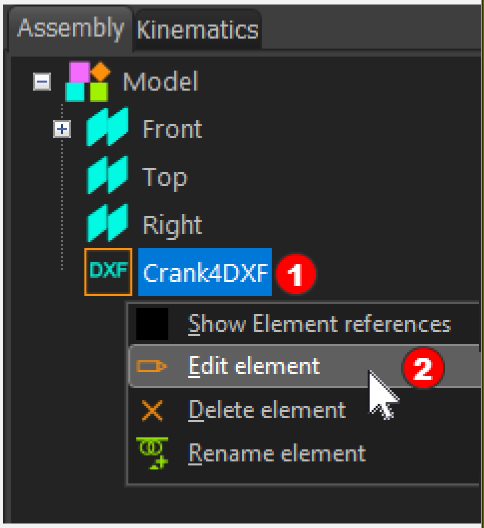
You can edit the **DXF-ELEMENT** in the **ASSEMBLY-TREE** to:

- Link the **DXF-ELEMENT** to a different **DXF-Drawing.**
- Apply different **LINEAR UNITS** to the **DXF-Drawing.**

Note:

To display a **DXF-Drawing** in the graphics-area, you must edit a **CAD-LINE**, and select the **DXF-ELEMENT** in the **CAD-Line dialog > DXF tab** 371 .

How to open the DXF-Element dialog



Editing the DXF-Element from the Assembly-Tree

Note: To add a **DXF-ELEMENT** to the **ASSEMBLY-TREE**, you must open a DXF file with **File > Open**.

To edit the DXF-Element

1. Find a **DXF-ELEMENT** ❶ in the **ASSEMBLY-TREE**
2. Right-click the **DXF-ELEMENT**

In the shortcut menu:

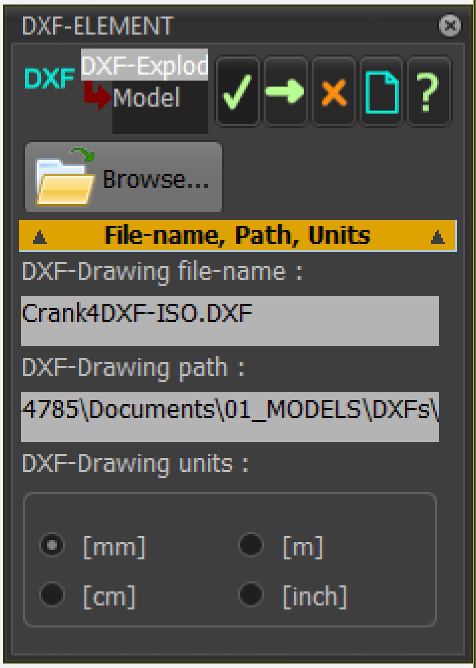
3. Click **Edit Element** ❷

OR

See **How to open a dialog** 627

The **DXF-Element dialog** is now open.

DXF-Element dialog



FILE NAME, PATH, AND UNITS

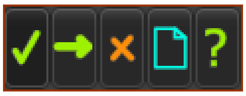
DXF-DRAWING FILE-NAME ; PATH

Click the BROWSE button to find and select a **DXF-Drawing**.

DXF-DRAWING UNITS

To show the **DXF-Drawing** to the correct scale, select the DXF UNITS of the **original DXF-Drawing**.

To apply the new **DXF-Drawing** and **Units** to the DXF-ELEMENT:



1. Click **APPLY** to link the **DXF-Drawing** with the DXF-ELEMENT.
2. Click to close the dialog.

1.5.11.6 Dialog: Plane

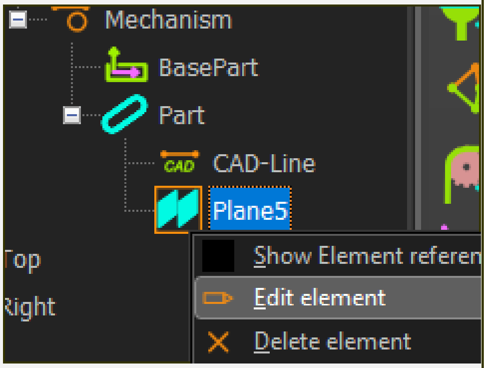
Plane

See also: **Model Editor > Add Plane** [82] **and** **Mechanism-Editor > Add Plane** [92]

PLANES define the layout of your machine.

You add other PLANES and MECHANISM-EDITORS to PLANES.

How to open the Plane dialog-box



Edit Plane

The PLANE DIALOG opens when you start the Add Plane command.

To open a PLANE DIALOG you add to the model at a different time:

1. Right-click a PLANE in the ASSEMBLY-TREE
2. Click **Edit-element** in the short-cut menu

OR

1. **See How to Open a dialog** [627]

Note:

You cannot edit the FRONT, TOP, or RIGHT planes.

The PLANE DIALOG is now open.

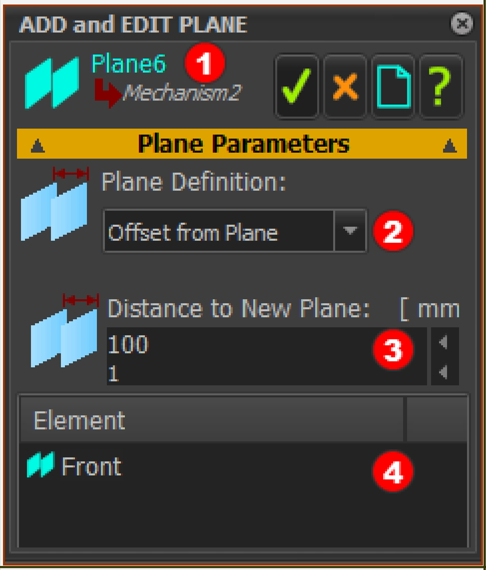
Plane dialog

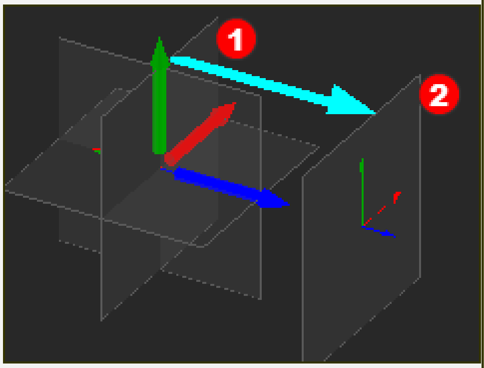
The PLANE DIALOG has two formats, which you can identify by the PLANE DEFINITION parameter.

The format is a function of the element you select to add the new PLANE.

FORMAT 1: Offset from Plane

When you select a PLANE, the PLANE DEFINITION is "OFFSET FROM PLANE".

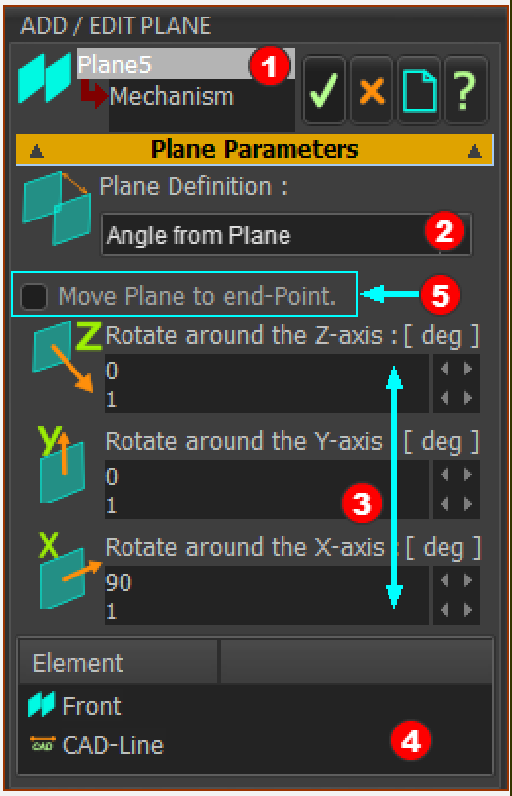
<table>
<tr>
<td>


</td>
<td>
❶ New Plane: PLANE6
PLANE PARAMETERS
❷ PLANE DEFINITION: OFFSET FROM PLANE
The new PLANE is offset along the Z-axis of the PLANE you select.
❹ Element box (bottom of dialog): the PLANE you select.
Parameter to edit:
❸ DISTANCE TO NEW PLANE
The distance from the PLANE you select (e.g. FRONT❹) to the new PLANE ❶.
</td>
</tr>
<tr>
<td>


New Plane in the Graphic-Area
</td>
<td>
Notes:
In the image, the new PLANE❷ is offset along the Z-axis of PLANE❶ by the linear distance equal to DISTANCE TO NEW PLANE.
</td>
</tr>
</table>

FORMAT 2: Angle from Line

When you select a LINE, the **X-axis**, or the **Y-axis** of a PART, the PLANE DEFINITION is "ANGLE FROM PLANE".



❶ **New Plane:** PLANE5

PLANE PARAMETERS

❷ PLANE DEFINITION: ANGLE FROM LINE

❹ **Element box** (bottom of dialog): the LINE you select, and the PLANE to which the LINE is a great, great, grand, ... child?

Parameters to edit:

❺ MOVE PLANE TO END-POINT

Enable o move the origin of the new PLANE from the **START-POINT** to the **END-POINT** of the LINE that is in **ELEMENT** box❹.

The **X-axis** of the new PLANE is now from the **END-POINT** to the **START-POINT** of the LINE.

Usually, do not enable. However, you must enable MOVE PLANE TO END-POINT to add a BEVEL GEAR-PAIR[146] .

---

❸ ROTATIONAL AXES

- ROTATE AROUND X-AXIS : Rotate the new PLANE around the **X-axis** direction of the LINE
- ROTATE AROUND Y-AXIS : Rotate the new PLANE around the **Y-axis** direction of the LINE
- ROTATE AROUND Z-AXIS : Rotate the new PLANE around the **Z-axis** direction of the LINE

Notes:

When you select a LINE (**Format 2**) :

The **ORIGIN** of the new PLANE is:

- at the **START-POINT** of the LINE, **OR**
- at the **END-POINT** of the LINE, if you enable MOVE PLANE TO END-POINT in the PLANE dialog.

The default **+ve X-AXIS** of the new PLANE is:

- from the **START-POINT** to the **END-POINT** of the LINE, **OR**

- from the **END-POINT** to the **START-POINT** of the **LINE**, if you enable **MOVE PLANE TO END-POINT**.

Related topics

Model toolbar > Add Plane 82 (in the **MODEL-EDITOR** tab)

Model toolbar > Add Plane 92 (in a **MECHANISM-EDITOR** tab)

How to open a dialog

How to edit a parameter 627

1.5.11.7 Dialog: Profile/Extrusion

Profile / Extrusion

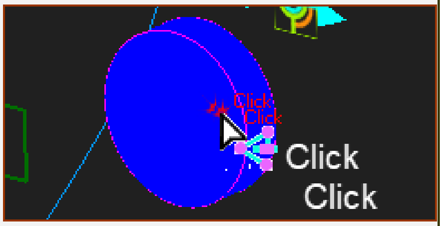
See Add Profile/Extrusion 253

Use the **EXTRUSION DIALOG** to edit the properties of an **EXTRUSION**.

Each **EXTRUSION** is a child to a **PROFILE**.

How to edit an Extrusion / How to open the Extrusion dialog

If you CAN see the Extrusion in the graphics-area



Double-click Extrusion

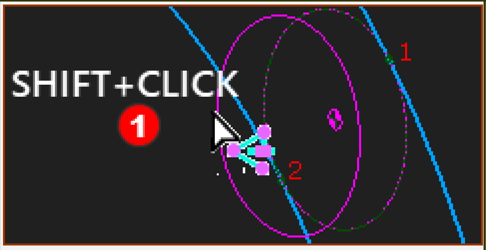
To open the **EXTRUSION DIALOG**

1. Double-click the **EXTRUSION** in the **GRAPHICS-AREA**

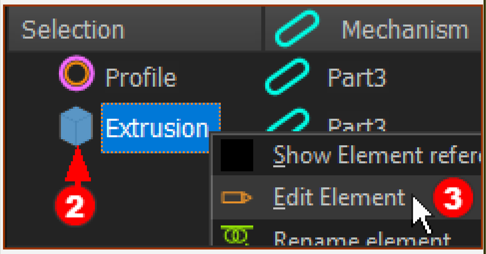
or

1. See How to open a dialog 627

If you CANNOT see the Extrusion in the graphics-area



SHIFT-CLICK Profile



Profile/Extrusion in Selection-Window

STEP 1: In the graphics-area

❶ **SHIFT + Click** the (**Pink**) **PROFILE**

STEP 2: In the Selection-Window

The **PROFILE** and **EXTRUSION** show in the **SELECTION-WINDOW**

❷ **SELECTION-WINDOW**: Right-click the **EXTRUSION** element

In the shortcut menu:

❸ Click **Edit Element.**

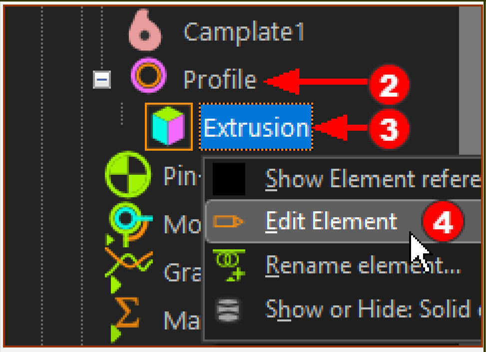
Alternatively, if you CANNOT see the Extrusion in the graphics-area

CLICK Profile

STEP 1: In the graphics-area

❶ **CLICK** a (**Pink**) **PROFILE**

The **ASSEMBLY-TREE** expands to identify the **PROFILE**❷ and **EXTRUSION**❸



Profile/Extrusion in Assembly-Tree

STEP 2: In the Assembly-Tree

1. ASSEMBLY-TREE: Click the EXTRUSION❸

The Element name is now blue, the ICON has an orange box❸

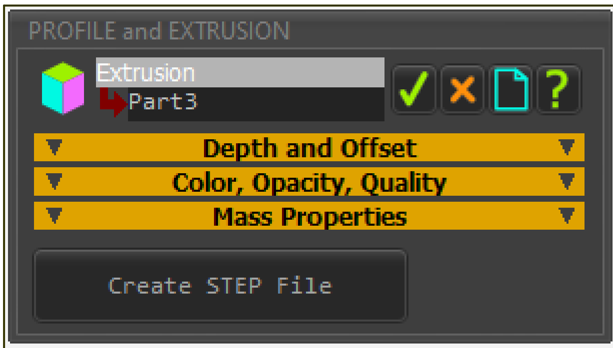
2. ASSEMBLY-TREE: Right-Click the EXTRUSION❸

A shortcut menu shows next to your pointer:

3. SHORTCUT MENU: Click **Edit Element**❹

The EXTRUSION DIALOG is now open.

The Extrusion dialog



Extrusion dialog

There are three separators in the EXTRUSION DIALOG.

DEPTH AND OFFSET

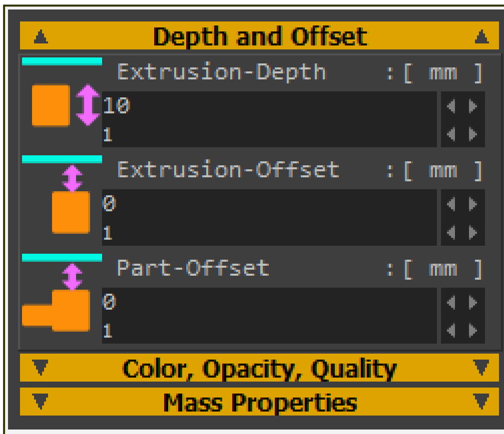
COLOR, OPACITY AND QUALITY

MASS PROPERTIES

Create STEP File

Click this button to save the EXTRUSION as a STEP file-type.

DEPTH AND OFFSET



Extrusion dialog | Depth and Offset

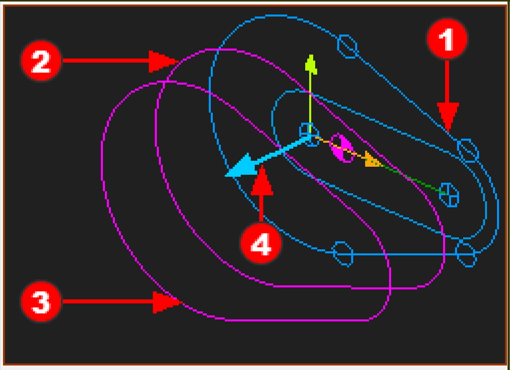
EXTRUSION-DEPTH (default = see Application-Settings> Auto-Profile tab 349)

The distance to the **Secondary** contour❸ from the **Primary** contour❷, along the +Z-axis❹ of the PART.

EXTRUSION-DEPTH must be positive. **Minimum value = 0.001mm**

EXTRUSION-OFFSET (default = 0)

The distance to the PRIMARY CONTOUR from the dimension that is specified by PART-OFFSET.



Sketch-Loop and Profile contours

EXTRUSION-OFFSET can be negative or positive.

PART-OFFSET (default = 0)

Applies to ALL EXTRUSIONS in a PART.

The distance to the PRIMARY CONTOUR from the Mechanism-Plane to which we add the distance specified by the EXTRUSION-OFFSET parameter.

PART-OFFSET can be negative or positive.

Note: Distance to **Primary** contour❷ from MECHANISM-PLANE = PART OFFSET + EXTRUSION OFFSET

The Primary and Secondary Contours of the PROFILE:

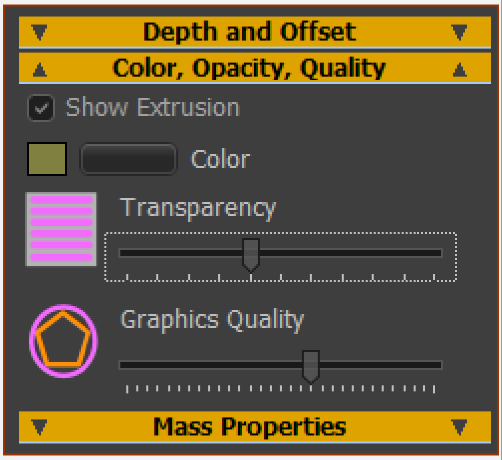
❶ Sketch-Loop

❷ Primary-Contour

❸ Secondary-Contour

❹ Z-axis is perpendicular(⊥) to the Mechanism-Plane

COLOR, OPACITY, QUALITY



SHOW EXTRUSION

To show or hide the EXTRUSION

Note: To hide PROFILE contours, see **Display toolbars > Show/Hide Profiles**

COLOR

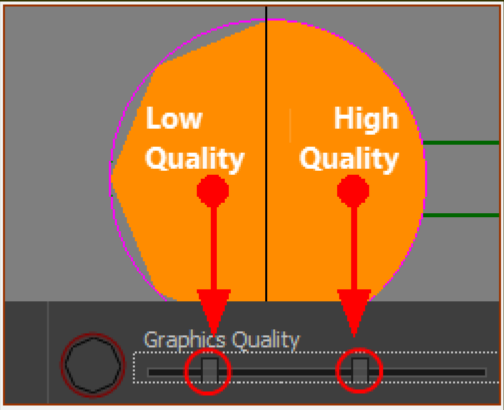
Button to select the color of the EXTRUSION with the Windows® Color-Picker

TRANSPARENCY (slider)

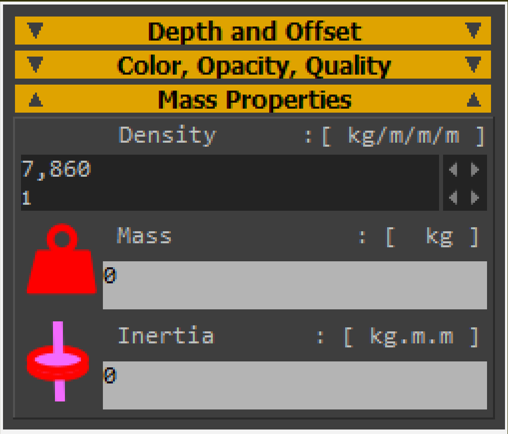
Slider to change the TRANSPARENCY (1/Opacity) of the EXTRUSION in the graphics-area

GRAPHICS QUALITY (slider)

Slider to change the GRAPHICS QUALITY of the EXTRUSION

 Low Quality High Quality	**Note:** To update to a different GRAPHICS QUALITY, you may need to edit the PART in the PART-EDITOR and then close the PART-EDITOR immediately. **See also:** Application Settings | Graphics 345

MASS PROPERTIES

	DENSITY $[kg/m^3]$ The MASS and INERTIA properties (below) change as you edit the DENSITY. MASS (read-only) $[kg]$ MASS = DENSITY × area of **sketch-loop** × EXTRUSION DEPTH. The mass is uniformly distributed. The center-of-mass is on the MECHANISM-PLANE. The position of the center-of-mass is a function of the shape of the **sketch-loop** you select to add the PROFILE. INERTIA (read-only) $[kg.m^2]$ INERTIA (**Mass Moment of Inertia**) is calculated with respect to the center-of-mass. **See also** CAD-Line dialog > Mass Properties tab 367

1.5.11.8 Dialog: CAD-Line >

CAD-Line

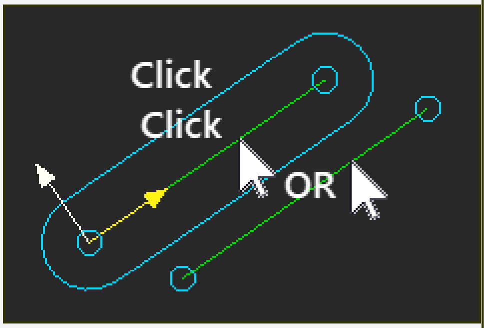
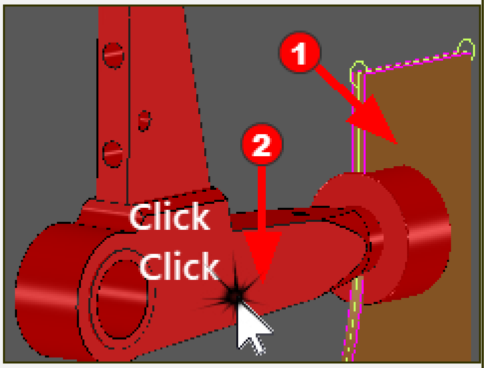
A **CAD-LINE** is a child to a **PART**.

- Each **PART** you add to the model has a **CAD-LINE** from the **START-POINT** to the **END-POINT** of the **PART**.
- You can also add **CAD-LINES** to **PARTS** and the **BASE-PART** - see Add CAD-Line[279]

Use the **CAD-LINE DIALOG** to:

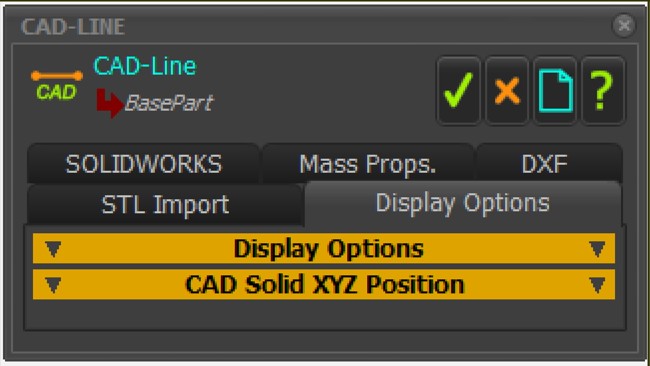
- Import a **CAD-SOLID** from SOLIDWORKS, OR import an STL file from other CAD.
- **IMPORT MASS-PROPERTIES** from SOLIDWORKS, AND enter **USER MASS-PROPERTIES**
- Display a **DXF-Drawing**, and edit its color.(**Note**: You must first import the **DXF-Drawing** with **File menu > Open DXF**[36])
- Change how to display a **CAD-SOLID** - Color, Transparency, Edge, ...

How to open the CAD-Line dialog

 Double-Click a CAD-Line to open the CAD-Line dialog	To open the **CAD-LINE DIALOG** 1. Double-click a **CAD-LINE** in the graphics-area of the **MECHANISM-EDITOR**, **PART-EDITOR**, or the **ASSEMBLY-TREE**. OR 1. **See How to Open a dialog**[627]
 Double-Click a CAD-Solid to open the CAD-Line dialog	OR 1. Double-click a **CAD-SOLID** in the **MODEL-EDITOR**, **MECHANISM-EDITOR**, or **PART-EDITOR**. OR 1. **See How to Open a dialog**[627]

The **CAD-LINE DIALOG** is now open.

CAD-Line dialog



CAD-Line dialog

CAD-Line dialog tabs:

- SOLIDWORKS[365]
- Mass Properties[367]
- DXF[371]
- STL Import[376]
- Display Options[376]

1.5.11.9 -> SOLIDWORKS tab

CAD-Line > SOLIDWORKS tab

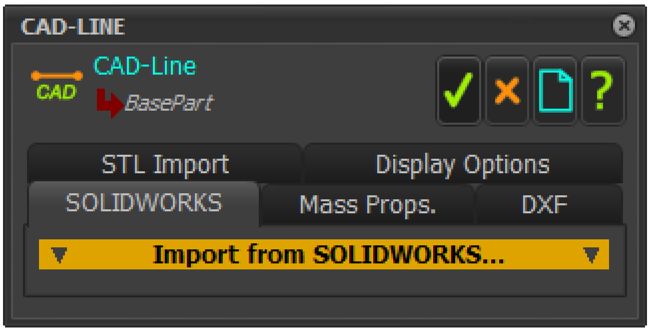
See also: Mass-Properties tab[367], DXF tab[371], STL Import tab[376], Display Options tab[381].

Use the CAD-Line > **SOLIDWORKS** tab to:

- Import a SOLIDWORKS Part/Assembly document (SOLIDWORKS refers to their CAD files as "documents"). onto a CAD-LINE as a **CAD-SOLID**.
- Control the surface accuracy of the **CAD-SOLID** when you import it from SOLIDWORKS.
- Remove a SOLIDWORKS Part/Assembly document from a CAD-LINE.
- Reopen a SOLIDWORKS Part/Assembly document in SOLIDWORKS that has been (previously) imported onto a CAD-LINE.
- Rename the CAD-LINE to the name of the active SOLIDWORKS Part/Assembly document.

CAD-Line dialog

SOLIDWORKS tab



CAD-Line dialog> SOLIDWORKS tab

Before you import a document from **SOLIDWORKS**:

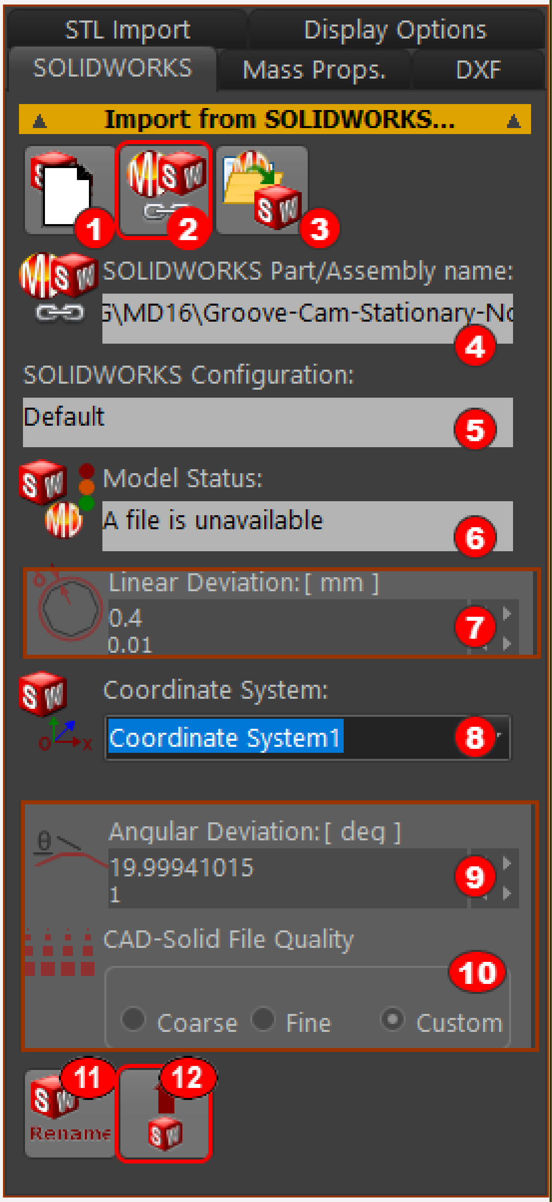
- Make sure the SOLIDWORKS Part/Assembly document you want to import is open in SOLIDWORKS and it is the active document.
- Make sure the SOLIDWORKS Part/Assembly document has a file-name.

- Usually, add a Coordinate-System feature to the SOLIDWORKS Part/Assembly document to align with the **CAD-LINE**.
- Usually, simplify the SOLIDWORKS document to reduce the complexity of the model.

Warning: The SOLIDWORKS Part/Assembly document does not import into **MechDesigner** if, in SOLIDWORKS, you use a Chinese Traditional font to name a Configuration.

Rename the **Configuration feature** with a **Western font**.

IMPORT FROM SOLIDWORKS



CAD-Line dialog > SOLIDWORKS tab

STEP 1: Click the READ ❷ button

WAIT until the:

- **SOLIDWORKS® PART/ASSEMBLY NAME** (read-only) shows in box ❹
- **SOLIDWORKS CONFIGURATION** (read-only) shows in box ❺
- **MODEL STATUS** (read-only) shows in box ❻

> **Model Status:**
> **Unavailable** - before you import SolidWorks® document the first time.
> **Out of Date** - the file in box❹ is older than the current date/time.
> **Up to Date** - the date/time of file in box❹ is the equal to the date/time when imported.

STEP 2: If there is more than one Coordinate-System, select a COORDINATE-SYSTEM ❽.

STEP 3: Click the IMPORT ⓬ Button

WAIT - a large model can take time to import.

OPTIONAL BUTTONS(❶❸)

> **Button❶** : **REMOVE** the SOLIDWORKS® document in box ❹ from the **CAD-LINE**
>
> **Button❸** : **OPEN** the SOLIDWORKS® document in box ❹ (that you have previ-

	ously imported) in SOLIDWORKS® **Button**⓫ : RENAME CAD-LINE to the file-name of the SOLIDWORKS document in box ❹. CAD-SOLID FILE QUALITY ❿ ⦿ **Fine**: more vertices ⦿ **Coarse**: fewer vertices ⦿ **Custom** : you can edit: • LINEAR DEVIATION❼: Maximum =0.5mm; Minimum =0.014mm - see Warning • ANGULAR DEVIATION❾: Maximum =30º; Minimum =0.4º - see Warning Warning : The Number-of-Vertices 381 increase rapidly as you reduce the LINEAR/ANGULAR DEVIATION to give a large STL file. A large STL file slows down **MechDesigner**. Also, the display of the **CAD-SOLID** in **MechDesigner** may not always improve as you reduce the LINEAR/ANGULAR DEVIATION. Experiment! **See: Edge Angle Limit** 379 .

1.5.11.10 -> Mass Properties tab

CAD-Line > Mass Properties tab

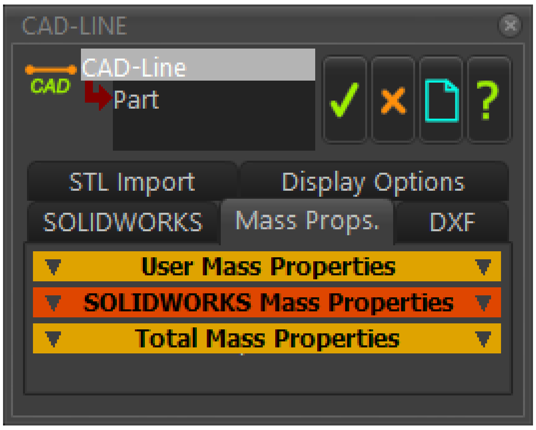
See also : CAD-Line dialog 364

Use the **CAD-Line > Mass-Properties** tab to:

- Enter user-defined mass properties
- Import the mass-properties of a SOLIDWORKS document
- Review the total mass-properties of a PART

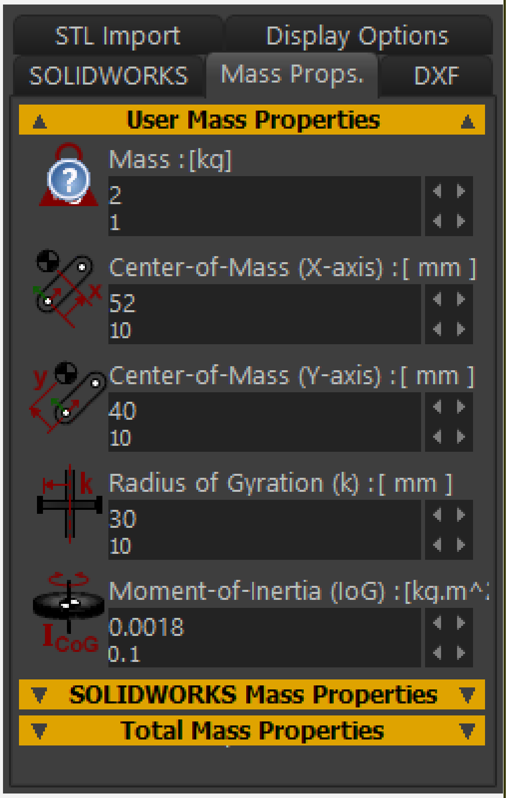
CAD-Line dialog

Mass Properties tab



CAD-Line dialog > Mass- Properties tab

USER MASS PROPERTIES



MASS (Units: kg)

CENTER-OF-MASS: X–AXIS (mm)

CENTER-OF-MASS: Y–AXIS (mm)

MOMENT OF INERTIA (I_g) - ($kg.m^2$ NOT $kg.mm^2$)

The Mass Moment of Inertia about the Center-of-Mass.

You can enter the:

RADIUS-OF-GYRATION (mm),

OR

MOMENT-OF-INERTIA $(kg.m^2)$

Note:

MOMENT OF INERTIA is should always read as MASS MOMENT OF INERTIA

The X-axis is the CAD-LINE, the Y-axis is at +90º on the Mechanism-Plane.

The 0,0 is at the START-POINT of the CAD-LINE.

Moment-of-Inertia: Radius-of-Gyration, and Point-Mass.

CASE 1:

If you enter a MASS but do NOT enter a RADIUS-OF-GYRATION or MOMENT-OF-INERTIA, the MASS is termed a "**Point Mass**".

The x,y position of the MASS relative to the CAD-LINE is at CENTER-OF-MASS: X–AXIS, and CENTER-OF-MASS: Y–AXIS.

CASE 2:

If you enter a MASS and a MOMENT-OF-INERTIA, then the RADIUS-OF-GYRATION, k_g :

$$k_g = \sqrt{\frac{I_g}{m}}$$

CASE 3:

If you enter a MASS and a RADIUS-OF-GYRATION, then the MOMENT-OF-INERTIA, I_g is:

$$I_g = m.k_g^2$$

PARALLEL AXIS THEOREM

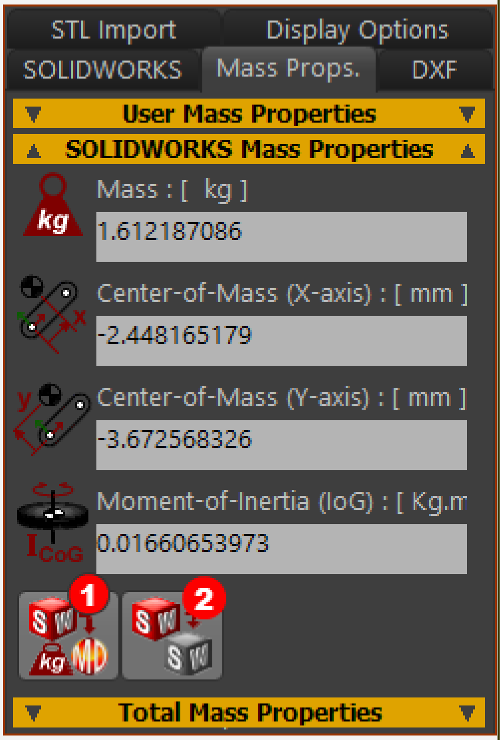
We use for you the **Parallel Axis Theorem** to calculate the **Mass Moment-of-Inertia** about the PART'S instantaneous center-of-rotation.

$$I_o = I_g + M.h^2$$

h = distance to the Center-of-Mass from the center-of-rotation.

SOLIDWORKS MASS PROPERTIES

When you import a **SOLIDWORKS** document onto a CAD-LINE, you can also import its **Mass-Properties.**



Button ❶ IMPORT / UPDATE SOLIDWORKS MASS PROPERTIES

Note: Before you click button ❶, make sure the active **SOLIDWORKS** document is on the CAD-LINE.

MASS **(kg)**

MASS of the active SOLIDWORKS document.

CENTER-OF-MASS - X-AXIS **(mm)**

The distance to the CENTER-OF-MASS along the **X-axis** from the START-POINT of the CAD-LINE.

CENTER-OF-MASS - Y-AXIS **(mm)**

The distance to the CENTER-OF-MASS along the **Y-axis** from the START-POINT of the CAD-LINE.

MOMENT-OF-INERTIA $(kg.m^2)$

The MASS MOMENT OF INERTIA with respect to the CENTER-OF-MASS

Button ❷ REMOVE SOLIDWORKS MASS PROPERTIES

TOTAL MASS PROPERTIES

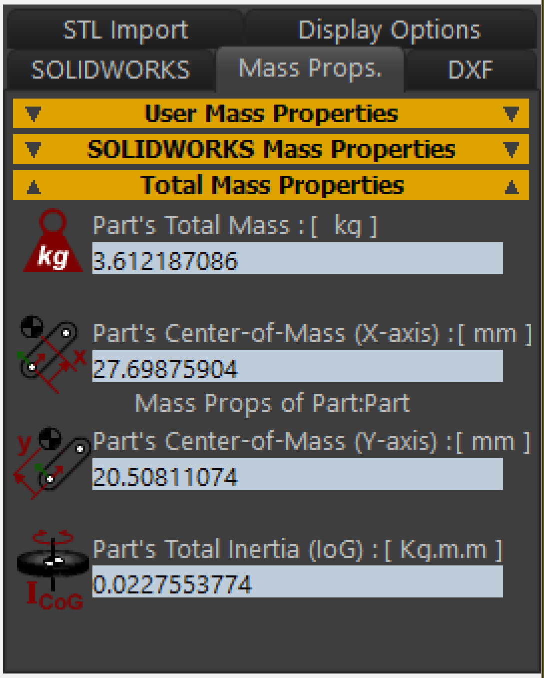
Note:

You can add many CAD-LINES to a PART. If you import SOLIDWORKS documents onto more than one CAD-LINE in a PART, we recommend that the START-POINT and X-axis of all CAD-LINE'S are coincident and collinear, respectively.

Total Mass Properties:

The **Total Mass Properties** include, for each PART, ALL of those:

- **Mass** and **Mass-Properties** that we calculate for you for ALL PROFILE/EXTRUSIONS in the PART
- **User Mass-Properties** as you define for ALL CAD-LINES in the PART
- **SOLIDWORKS Mass-Properties** that you import for ALL CAD-LINES in the PART



NOTES:

Parallel-Axis Theorem

Mass Moment of Inertia about Part's Rotational-Axis =

Total Mass Moment of Inertia about center-of-Mass

+ Total Mass × (Distance to Part's Rotational-Axis)^2

Relationship between Mass Moment-of-Inertia and Radius of Gyration

Total Mass Moment of Inertia (about center-of-Mass) =

Total Mass × (Radius-of-Gyration)^2

Total Mass of Part =

Mass of all Extrusions 363

+ Total mass of all CAD-Lines in the same Part

	Total Mass Moment of Inertia about the Part's center-of-Gravity = Mass Moment of Inertia of all Extrusions + **Total Mass Moment of Inertia of all CAD-Lines in the same Part**

1.5.11.11 -> DXF tab >

CAD-Line > DXF tab

See also: Open DXF-File 36 , DXF-Element 354

Use the **DXF** tab to:

- Display* a **DXF-Drawing**
- Align the **DXF-Drawing** with the **CAD-LINE**
- Edit the color of the **DXF-Drawing**
- Convert **DXF Entities** in the **DXF-Drawing** to **MechDesigner** sketch-elements
- Remove the **DXF-Drawing** from the **CAD-LINE**

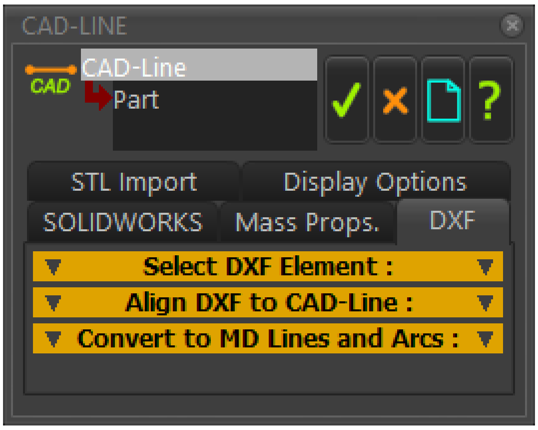
* **Before** you can display a **DXF-Drawing**, you must use File menu > Open DXF file 34 to import a minimum of one **DXF-ELEMENT**. The container for the **DXF-Drawing** is the **DXF-ELEMENT** in the **ASSEMBLY-TREE**.

DXF Terminology

Term :	Definition
DXF :	Drawing eXchange Format. DXF is a CAD data file format designed for sharing drawing data universally across CAD applications.
DXF-Drawing :	The drawing that you want to import from your CAD and to display in the graphics-area in **MechDesigner**.
DXF-ELEMENT :	The **DXF-ELEMENT** is the **container** for the **DXF-Drawing** that you import when you do **File menu > Open | *.DXF file-type** When you open a DXF file, we add a **DXF-ELEMENT** to the **ASSEMBLY-TREE**.
CAD-LINE :	The element you edit to select a **DXF-ELEMENT** to display a **DXF-Drawing**.
DXF-Outline :	The efficient sketch that we use to display a **DXF-Drawing**. You cannot edit a **DXF-Outline**.
DXF-Entity :	Points, Arcs, and Lines are DXF-Entities in the sketch of the **DXF-Outline**. You can use the **CAD-LINE DIALOG** to convert Arc and Line DXF-Entities to regular **MechDesigner** **ARC** and **LINE** sketch-elements.

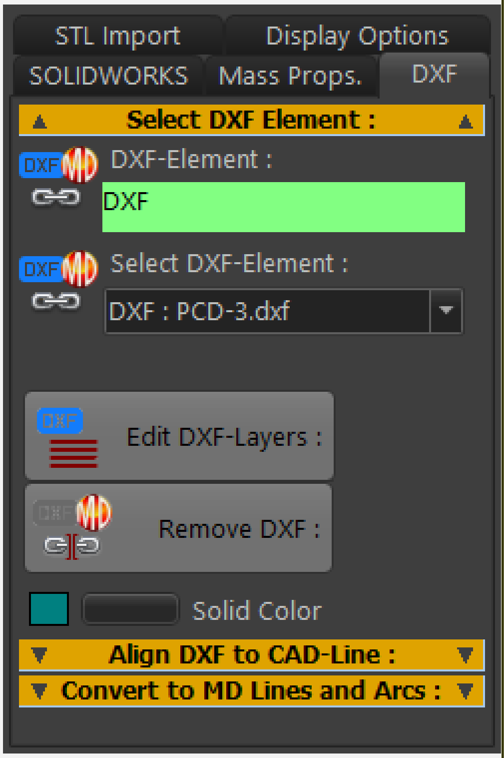
CAD-Line dialog

DXF tab



CAD-Line dialog > DXF tab

SELECT DXF-ELEMENT



SELECT DXF-ELEMENT: drop-down list-box

1. Click the drop-down arrow to select a DXF-ELEMENT

The **DXF-Drawing** is now in the graphics-area immediately.

Notes:

- We show **DXF-Points** ONLY when the **CAD-LINE** DIALOG is open.
- See here373 if you cannot see the **DXF-Drawing** in the graphics-area.
- See **File > Open > DXF file-type**, if you cannot see a DXF-ELEMENT in the drop-down.

Optional buttons:

EDIT DXF LAYERS :

To open the DXF LAYERS DIALOG376 to show or hide different LAYERS in the **DXF-Drawing**.

See SOLID COLOR (below) to change the color of the **DXF-Drawing**.

REMOVE DXF :

To remove the **DXF-Drawing** from the CAD-LINE.

SOLID COLOR:

To edit the color of the **DXF-Drawing**.

DXF-ELEMENT

For example: DXF : PCD-3.DXF

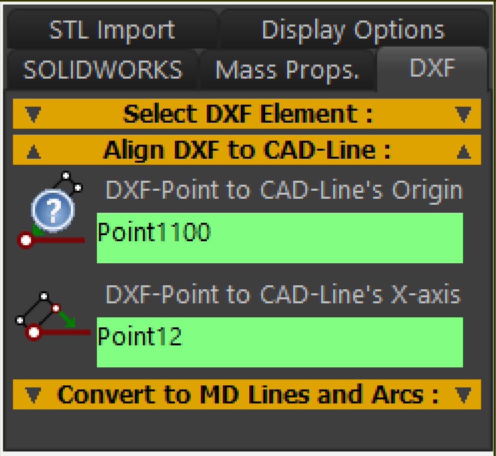
DXF is the name of the DXF-ELEMENT that you add to the ASSEMBLY-TREE when you do File menu > Open DXF file-type[34]. It is the container for the **DXF-Drawing**.

PCD-3.DXF is the name of the **DXF-Drawing** that is "in" the DXF-ELEMENT.

If you cannot see the **DXF-Drawing**:

- Change the background color of the graphics-area.
  See Application Settings | color tab[345]
- The size of the **DXF-Drawing** may be very large/small relative to the graphics-area.
  See View menu > Zoom-Out[70] (or use the wheel button on you mouse)
- The scale of the DXF-Drawing may not be correct.
  Check the LINEAR UNITS of the **DXF-Drawing**. It is normal to use the same LINEAR UNITS as the original **DXF-Drawing**.
  See Edit DXF-Element dialog[355] > DXF-DRAWING UNITS

ALIGN DXF TO CAD-LINE



Align the DXF-Drawing with the CAD-Line, select two(2) DXF-Points.

DXF POINT TO CAD-LINE'S ORIGIN

1. Click in the box to make the box ORANGE - **see Note #1**
2. Click the **DXF-Point** in the **DXF-Drawing** that you want to move to the START-POINT of the CAD-LINE - **see Note #2**

   The DXF-POINT shows in the box and the box is Green

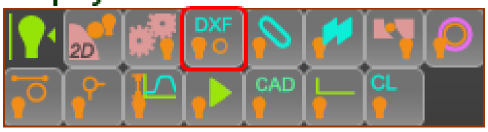
DXF POINT TO CAD-LINE

3. Click in the box to make the box ORANGE
4. Click a **DXF-Point** in the **DXF-Drawing** that you want to move to

	the X-axis of CAD-LINE - see **Note #2** The **DXF-Drawing** moves to align with the CAD-LINE.

Notes:

Display toolbar > DXF-Points



#1 - If you can see the **DXF-Drawing** but cannot see **DXF-Points**, then make sure **Display DXF-Points** in the **Display Filter toolbar** is enabled.

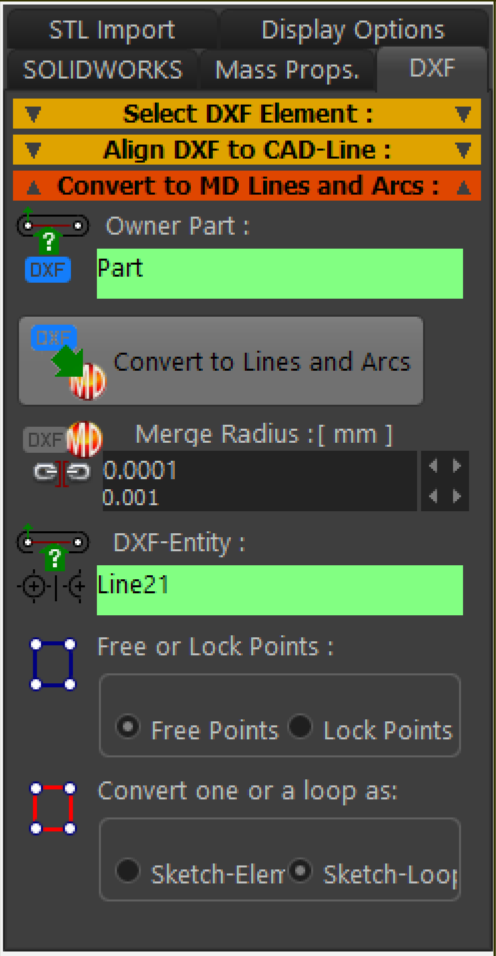
#2 - **DXF-Points** do not show as “selected” when you mouse-over them, but do click it!

CONVERT DXF ENTITIES TO MD LINES AND ARCS

You **cannot** edit the **DXF entities** (**DXF Line**, **DXF Arc**, and **DXF Point)** - they are **dumb**.

You can use this separator to copy the shape of **DXF entities** to **MechDesigner** LINE, ARC, and POINT sketch-elements.

After you convert them to **MechDesigner** sketch-elements, you can optionally remove the original **DXF entities**.



OWNER PART

This box controls the **PART** onto which to copy **DXF entities** as sketch-elements.

Default the **OWNER PART** is the same **PART** as that of the **CAD-LINE**. To change the **OWNER PART**:

1. Click the **OWNER PART** box to make it **ORANGE**
2. Click a **PART** in the graphics-area or the **ASSEMBLY-TREE**.

   The **PART** should now be in the **OWNER PART** box. The box should be **GREEN**

DXF ENTITY

This box controls the **DXF-ENTITY** you convert to a sketch-element.

3. Click the **DXF ENTITY** box to make it **ORANGE**

   You may want also want to:

   - Click the **SELECT-LOOP** radio-button so that, if possible, you convert a number of DXF-Entities to a sketch-loop
   - Click the **LOCK POINTS** radio-button to lock/fix the **POINTS** in the sketch-elements to the **PART**, after you convert the DXF entities to sketch-elements
   - Optionally, edit the **MERGE RADIUS** value to help make a sketch-loop with those DXF entities inside the **MERGE-RADIUS'** value - I have never found a reason to edit **MERGE RADIUS**.

4. Click a **DXF ENTITY** (a **DXF LINE** or **DXF ARC**) in the graphics-area

   The **DXF-ENTITY** box should now be **GREEN**

5. Click the **CONVERT TO MD ENTITIES** button

Repeat **1** to 5 again to convert other DXF Entities to MD sketch-elements.

TOP-TIPS:

After you CONVERT DXF TO MD LINES AND ARC, you can click the REMOVE DXF button in SELECT DXF ELEMENTS.

You can double-click a DXF ENTITY to open the CAD-LINE DIALOG.

1.5.11.12 -> -> DXF Layers

CAD-Line > DXF tab > DXF Layers

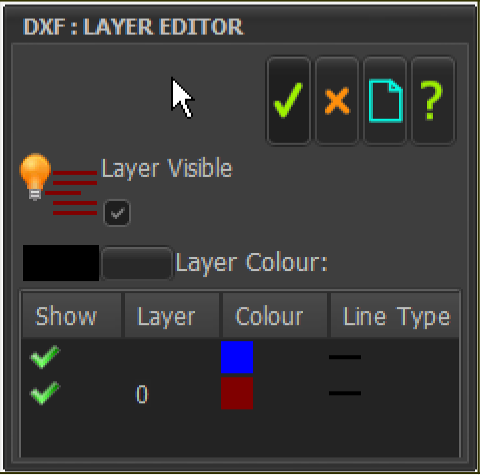
DXF-Drawings frequently use **Layers** for different drawing information.

Use the DXF LAYERS DIALOG to show or hide each Layer in a **DXF-Drawing**.

To open the DXF LAYERS DIALOG:

1. Click the EDIT LAYERS button in the CAD-Line dialog > DXF tab[371]

DXF Layers dialog



To Show or Hide a Layer:

1. Click a ✓ (or ✗) in the **Show** column
2. Click the **Layer Visible** (or **Layer Hidden**) check-box

To change the color of a Layer:

This option does not work!

See **Solid Color** in the DXF tab[371]

1.5.11.13 -> STL Import tab

CAD-Line > STL Import tab

See also : CAD-Line dialog[364]

Use the **CAD-Line dialog > STL Import** tab to:

- Import an **STL** file - to import 3D CAD models as a **CAD-SOLID** when you do not have SOLIDWORKS.
- Edit the STL FILE UNITS to be equal to those of the linear units of the original STL file.
- Edit the EDGE ANGLE LIMIT to remove "ghost" lines in **MechDesigner** on the **CAD-SOLID** that represents the original STL file.

See more : STL Files[379]

Prepare and save the STL file in your CAD software:

Before you save the STL file in your CAD software:

Rotate the model to align its XY-Plane with the **XY-Plane** of the MECHANISM-EDITOR.

In the Save as... dialog in your CAD software:

Select **Binary** as the STL file-type.

Edit, and remember, the **Linear units** of the STL file.

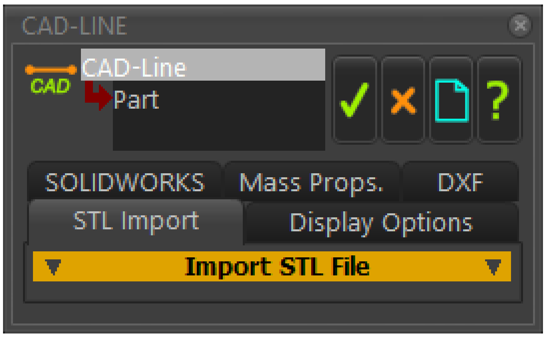
If you cannot edit the **Linear units** of the STL file, they are usually SI units - meters (m).

After you import an STL file:

See CAD-Line Display Options tab 383 to move the STL file in the X, Y, Z-axis directions.

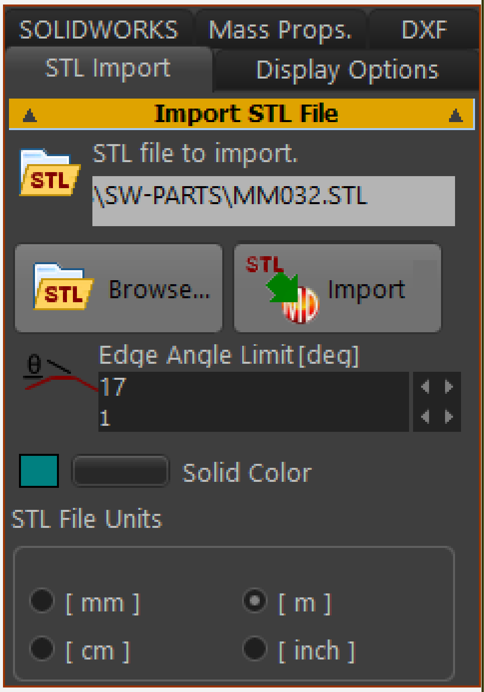
CAD-Line dialog

STL Import tab



CAD-Line dialog > STL Import tab

IMPORT STL FILE



To import an STL file:

1. Click the **BROWSE** button
2. Explore and select an **STL** file
3. Select the Linear Units (to equal those of the **STL** file)
4. Click the **IMPORT** button, or edit the EDGE ANGLE LIMIT - see below
5. Close the dialog

Note: To see the **CAD-SOLID**, enable Visibility toolbar > Show Solids in Mechanisms 66

EDGE ANGLE LIMIT

1. Enter a Value in the EDGE-ANGLE LIMIT box

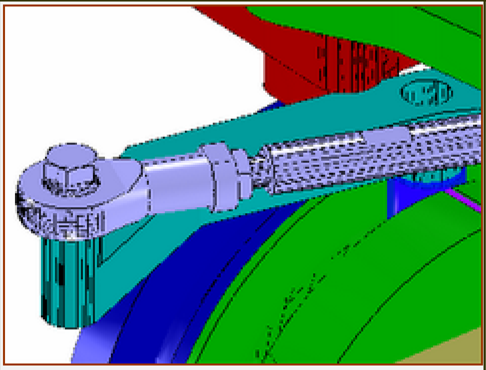


Image with too many Facet-Edges

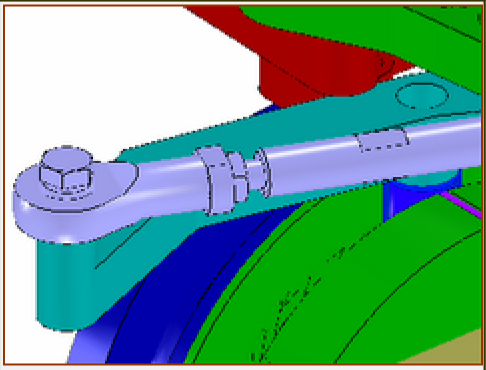


Image with Facet-Edges OK

This parameter can change the **apparent** quality of the STL file in the graphics-area.

EDGE ANGLE LIMIT analyzes the acute angle between two adjacent facets of the tessellated CAD-Solid that represents the STL file of the original CAD model.

- If the acute angle between two adjacent facets is **less than(<)** the EDGE ANGLE LIMIT, we **do not** show a line at the edge of the two facets.
- If the acute angle between two adjacent facets is **greater than (>)** the EDGE ANGLE LIMIT, we **do** show a line at the edge of the two facets.

SOLID COLOR button - to edit the color of the STL file:

1. Click the SOLID COLOR button
2. Select a color in the Windows Color Picker®
3. Click OK in the Windows Color Picker®

STL FILE UNITS

1. Select the units of the **original STL file.**

   Try meters, [m], if you are not sure.

Top-Tip

I find these options are a good compromise of display quality, display accuracy, and STL file-size.

EDGE ANGLE LIMIT =80 **(STL Import tab)**

LINEAR DEVIATION = 0.14 **(SOLIDWORKS tab)**

ANGULAR DEVIATION =30 **(SOLIDWORKS tab)**

STL Files

FILE-SIZE

The **STL** file **tessellates** to approximate the surfaces of the original CAD model as a mesh of triangles. Each triangle is a small face, also called a **facet**. The number of facets is a function of:

- the complexity of the original CAD model, and
- how accurately you want the STL file to tessellate the original CAD model.

If you want to import many STL files, you also want a:

SMALL file-size for each STL file,

... AND each STL file to appear to be equal to the original CAD model,

... AND to see only those facets that are real edges in the CAD model.

Strategies to reduce the STL file-size.

STRATEGY 1: Reduce the complexity of the original CAD Model to reduce the STL file-size

Add a new configuration for the CAD model. In the new configuration:

- Do a geometry check to find if it has any small gaps or whiskers
- Suspend external fillets and internal fillets, especially if they do not have a function
- Replace fillets with chamfers if functional
- Suspend all fasteners
- Suspend fastener holes and hole features
- Suspend all cosmetic details
- Replace complex models you may have downloaded from the internet with simplified models, e.g. bearings.

STRATEGY 2: Reduce the accuracy of the STL file

There parameters are in the **CAD-Line** > SOLIDWORKS tab.

LINEAR DEVIATION :

The maximum LINEAR DEVIATION (distance) between the surface of the original CAD model and the tessellated surface of the STL file.

ANGULAR DEVIATION :

The maximum ANGULAR DEVIATION between adjacent facets of the tessellated surface of the STL file.

If you do not have SOLIDWORKS, find these parameters in your 3D-CAD before you save your model as the STL file. It is possible LINEAR and ANGULAR DEVIATION are options in the **Save as** > **STL file-type** dialog.

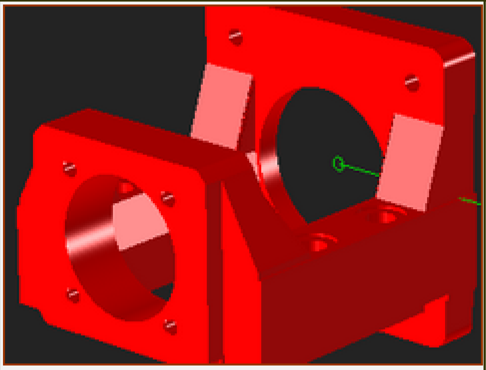
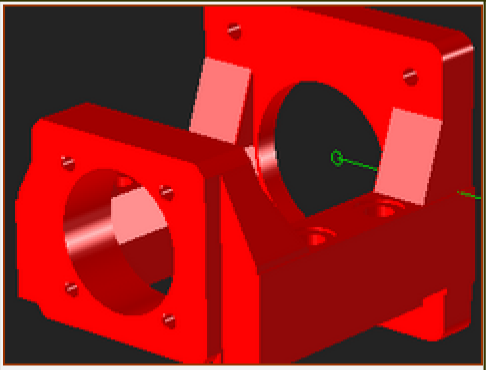
STRATEGY 3: Use the EDGE ANGLE LIMIT parameter - see **IMPORT STL FILE above**

STL files will show their facets if the angle in EDGE ANGLE LIMIT is less than the facet of the **CAD**-SOLID. Experiment. Import the model again each time you edit EDGE ANGLE LIMIT (try 80 degrees).

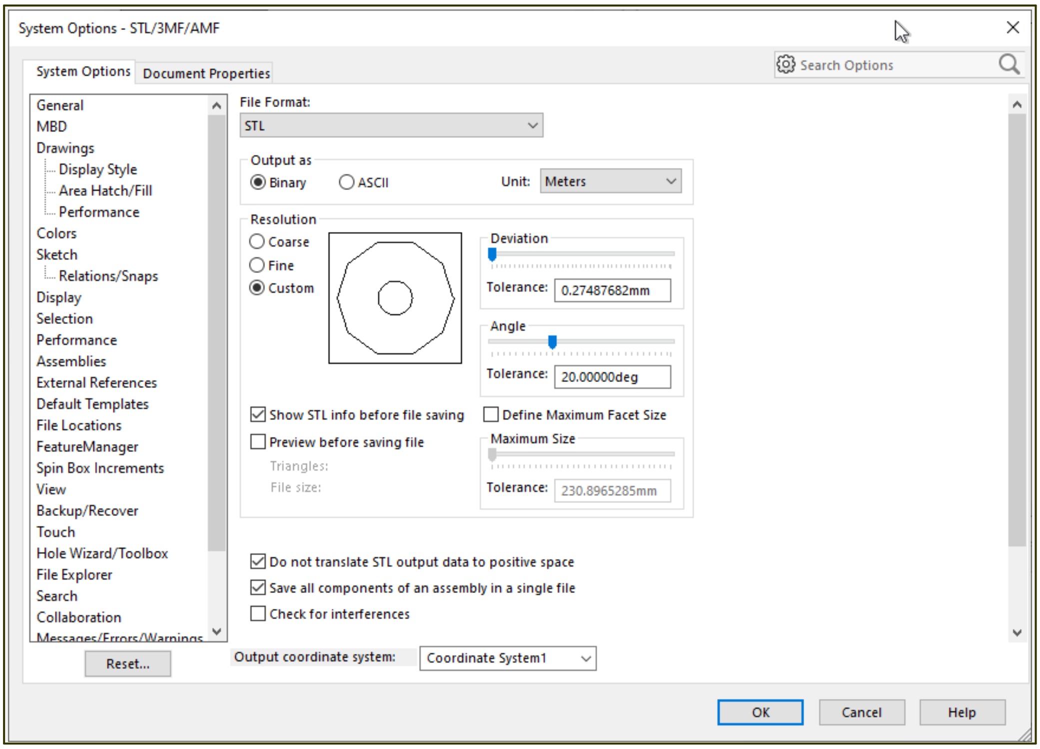
EXAMPLES

Below, the two images are of the same SOLIDWORKS part.

They appear to be identical. However, there is a large difference in the number of facets and vertices.

 STL: Large number of Vertices	**BAD - many facets** • Linear Deviation = 0.014mm and • Angular Deviation = 0.4º There are • 119132 vertices • ~40000 triangles • The STL file size is 3.5 Mega Bytes
 STL: Few number of Vertices	**GOOD - few facets** • Linear Deviation = 0.5mm and • Angular Deviation = 5º There are: • 7533 vertices • ~2500 triangles • The STL file size is 0.365 Mega Bytes

Save as STL file-type : Options in SolidWorks



1.5.11.14 -> Display Options tab

CAD-Line > Display Options tab

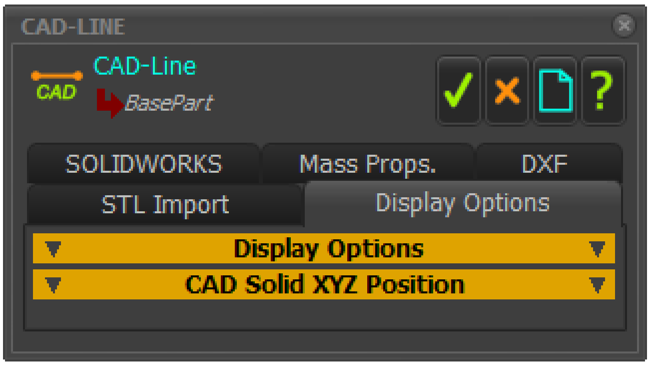
Use **Display-Options** tab to:

- Edit the color and transparency of a **CAD-SOLID**.
- Toggle the Show or Hide a **CAD-SOLID** .
- Move a **CAD-SOLID** in the X, Y, Z-axis directions.

CAD-SOLIDS are those CAD models you import onto a **CAD-LINE** with the **CAD-Line dialog** 364

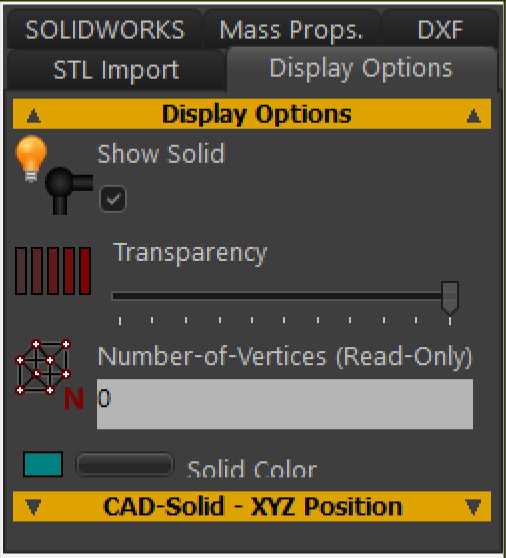
CAD-Line dialog

Display Options tab



CAD-Line dialog > Display Options tab

DISPLAY OPTIONS



SHOW SOLID (check-box)

Click the **SHOW SOLID** check-box to show or hide the **CAD-SOLID** that is on the **CAD-LINE**.

Note: Enable Visibility toolbar > Show Solids in Mechanisms[66] to show **CAD-SOLIDS** in **MECHANISM-EDITORS**.

TRANSPARENCY:

Drag the **TRANSPARENCY** slider-bar to change the transparency of the **CAD-SOLID** on the **CAD-LINE**. Experiment!

SOLID COLOR:

Click the **SOLID COLOR** button to open and edit the color of the **CAD-SOLID** with the Windows® color picker,

NUMBER OF VERTICES: (**read-only**)

Complex files have more vertices. **MechDesigner** may be slow to respond to new commands when there are **many CAD-SOLIDS**, each with many **NUMBER-OF-VERTICES**.

How many is too many? Try to make **NUMBER-OF-VERTICES** **<** 10,000.

Experiment with the **FINE**, **COARSE** and **CUSTOM** radio-buttons in the SOLIDWORKS tab[365].

TOP TIPS:

Make the model is as simple as possible. E.g. remove screws, screw holes, cosmetic threads, ...

Make a new SOLIDWORKS Configuration, and in the new configuration:

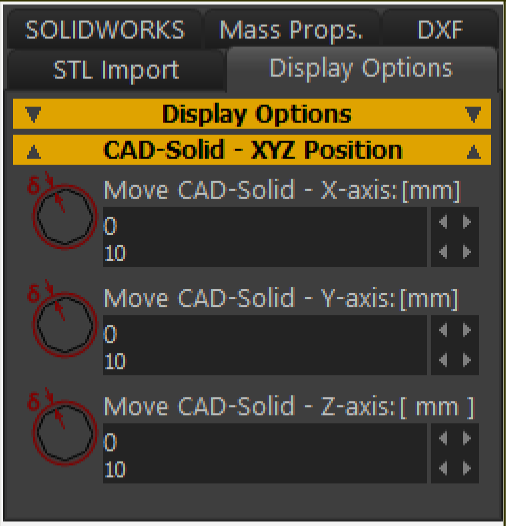
- Remove cosmetic fillets
- Remove non-functional internal or external fillets (rounds)
- Optionally, replace fillets with chamfers

Simplify CAD files and models you download from OEMs or CAD file services (e.g. Trace-Parts), For example:

- Bearings: remove or suppress balls, rollers, seals, shields, cage, and replace with a simplified solid section.
- Motors: replace with a simplified solid section.

- Aluminum extrusions: replace with a simplified section.

CAD SOLID XYZ POSITION



MOVE CAD-SOLID - X (or **Y**, or **Z**)- **AXIS**

If your **CAD-SOLID** is not in the correct place use the **MOVE CAD-SOLID - X** (or **Y**, or **Z**) to translate the **CAD-SOLID**.

You cannot rotate the **CAD-SOLID**.

Notes:

Before you import a **CAD-SOLID**:

If you use the **STL Import tab** to import your CAD model, rotate your mode in your CAD software

If you use the SOLIDWORKS **tab** to import your CAD model, add a **Coordinate System** feature such that the X-axis aligns with the **CAD-LINE** and the Origin is coincident with the start-Point of the **CAD-LINE** **before** you import it.

1.5.11.15 Dialog: 3D-Cam

3D-Cam

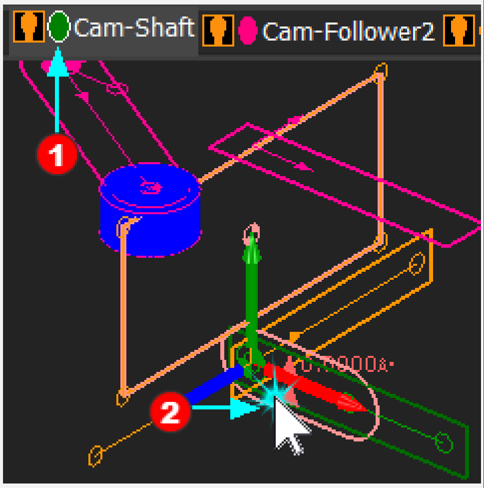
See Add 3D Cam 133

Note:

We do **NOT** immediately calculate the surfaces of **3D-CAMS** when you open a model that has **3D-CAMS**. To see the **3D-CAM** surfaces, you must edit and rebuild the **3D-CAMS** with the **3D-CAM DIALOG**.

You must find the **3D-CAM** in the **ASSEMBLY-TREE**, as a child to the **MECHANISM-EDITOR** that includes the **Cam-Part** - e.g. a Cam-Shaft.

How to open the 3D-Cam dialog-box ...



If you cannot see the **3D-CAM** in the graphics-area.

STEP 1: Find the Cam-Part

The **3D-CAM** is a child to the **Cam-Part**.

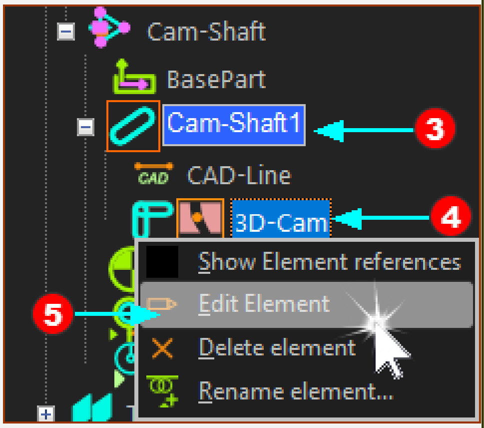
1. Click the **Mechanism-name-tab** ❶ that has the **Cam-Part** ❷ as a child.

In the graphics-area:

2. Click the **PART-OUTLINE** ❷ of the **Cam-Part** that has the **3D-CAM** as a child.

Or, in the **ASSEMBLY-TREE**

2. Click the **Cam-Part** that has the **3D-CAM** as a child.



To the left, in the **ASSEMBLY-TREE**, the **Cam-Part** (Cam-Shaft1 ❸) is selected.

STEP 2: In the Assembly-Tree

1. Explore the **Cam-Part**(Cam-Shaft1 ❸) in the **ASSEMBLY-TREE** to show its child elements

The **3D-CAM** is a child to the **Cam-Part**.

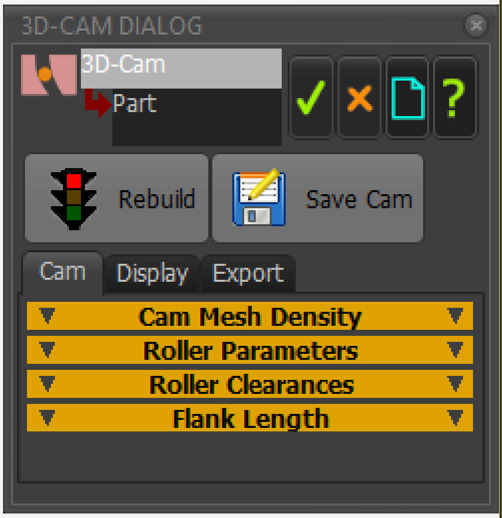
2. Right-click the **3D-CAM** element ❹

In the shortcut menu:

3. Click **Edit Element** ❺

The **3D-CAM DIALOG** is now open.

3D-Cam dialog



3D-Cam dialog

There are two buttons at the top of the **3D-CAM DIALOG**:

Rebuild   Save Cam

Click the Rebuild button to, show, and/or re-build the **3D-CAM** after you edit any of the parameters in the **3D-CAM DIALOG**, or after you open a model with **3D-CAMS**.

See more below 394 .

There are three tabs:

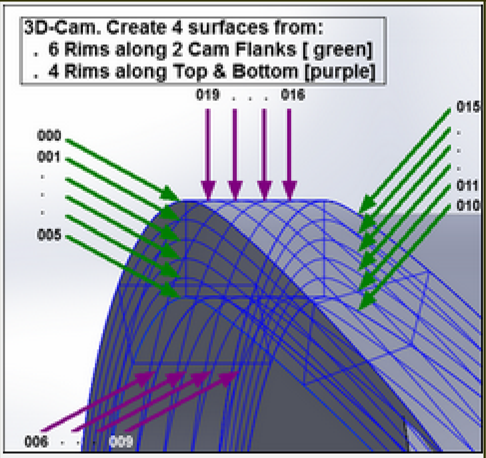
Cam 385

Display 391

Export 384

CAM tab

CAM SURFACE MESH DENSITY



Rims along the Cam-Flanks (Purple), the Top and Bottom (Orange), and Points along each Rim.

PREAMBLE:

Four(4) Cam Surfaces

A **3D-CAM** has four(4) surfaces. The four(4) surfaces are the:

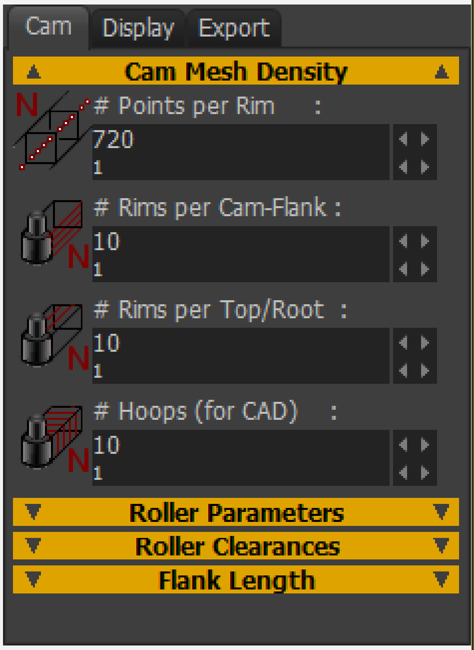
- **2 × Working Surfaces**: these are the Cam-Flanks that are in contact with the **Follower-Roller**
- **Root Surface**: the floor is deeper in the cam to be clear of the end of the **Follower-Roller**
- **Top**: you do not need this surface in the actual cam. We add it to close the **3D-CAM**.

Rims and Points

Rims: are along the length of each surface. We distribute **Rims** equally across each surface so that are approximately parallel with each other.

Points: are along the length of each **Rim**. We distribute **Points** equally along each **Rim**.

You control the number of **Rims** and the number of **Points** along the Rims in the CAM MESH DENSITY separator.



POINTS PER RIMS:

The number of **Points** along each **Rim**

RIMS PER FLANKS:

The number of **Rims** across each **Cam-Flank** (working surface) of the 3D-CAM.

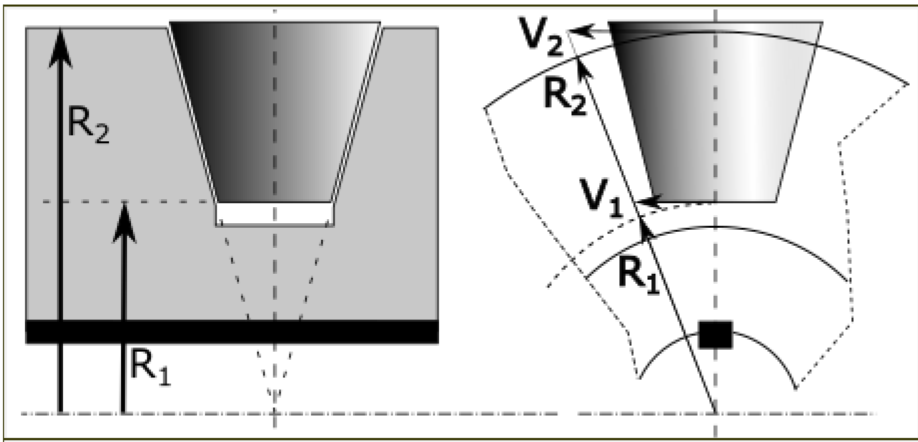
RIMS PER TOP / ROOT:

The number of **Rims** across the **Root** and **Top** surfaces (non-working surface) of the 3D-CAM.

HOOPS (FOR CAD)

Hoops wrap around the 3D-CAM . They connect each **Rims** at the same **Point #**. We use **Hoops** to help SOLIDWORKS model the surfaces.

ROLLER PARAMETERS



PREAMBLE:

These parameters are for **Tapered Follower-Rollers**.

$V = r.\omega$ [Linear Velocity (V) = Radius(r) × Angular Velocity (ω)]

Cam Flank Velocity: different points on the cam-flank surface are at different radii from the cam's rotational axis.

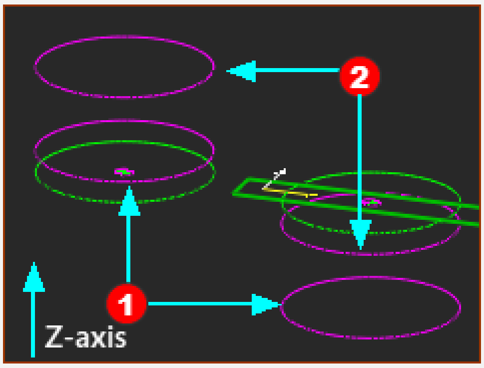
Therefore, a point that is at a large radius from the Cam's rotational-axis has a greater velocity than a point that is at a small radius.

Cylindrical Follower-Roller Velocity: all points on the surface of a cylindrical follower bearing are at equal radii from its rotational-axis. Therefore, the tangential velocities of all points on the surface of a cylindrical roller are identical.

The velocity of the cam's surface and the follower's surface can only be equal to each other at one radius from the center of the Cam. The follower-roller must be skidding at all other points!

Tapered Follower Velocity: the surface velocity of a tapered-roller increases as its radius increases. If its apex is coincident with the rotational-axis of the cam, it can have a surface speed that is equal to the surface speed of the cam. Thus, it can roll on the cam surface as the cam rotates. This is possible during the dwell periods.

Nevertheless, cylindrical or barrel rollers are usually used as they are readily available, cheap, and they can withstand high loads.



Two Extrusions - different Extrusion-Offset

The Roller Diameter of a Tapered Roller?

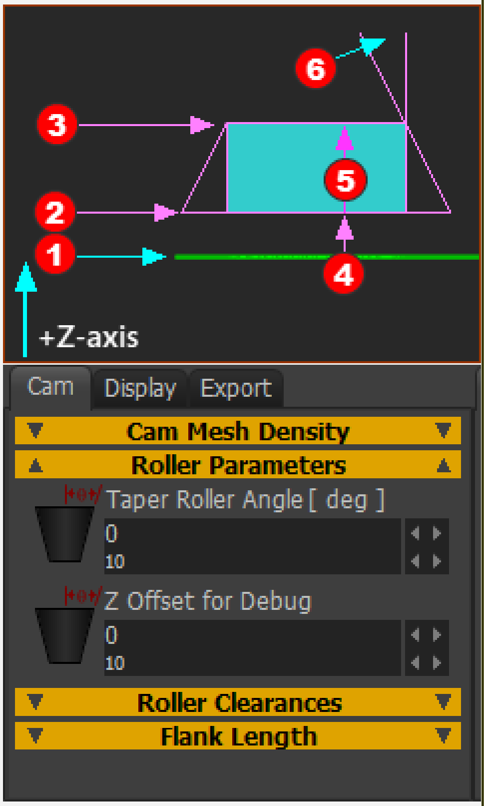
First, review the EXTRUSION-OFFSET and EXTRUSION-DEPTH parameters that define the PROFILE EXTRUSION of the **Follower-Roller**.

Use the EXTRUSION DIALOG 360 to make the EXTRUSION-DEPTH parameter equal to the actual Width (or Length) of the **Follower-Roller** (frequently, the '**B**' parameter in bearing catalogs).

Extrusion dialog: (Note: PART-OFFSET parameter = 0 mm).

EXTRUSION-OFFSET (mm): Position (Z-axis) to the Primary-Contour❶ from the Mechanism-Plane.

EXTRUSION-DEPTH (mm): = Dimension between the Primary❶ and Secondary❷ -Contours. Positive value ONLY



TAPER-ANGLE of the Follower-Roller.

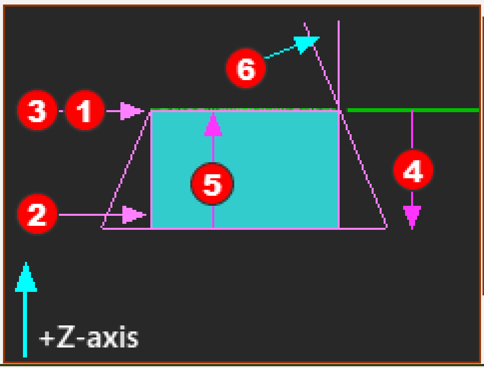
Taper-Angle (degrees) inclines the Flanks of the 3D-CAM. The taper angle pivots about the Secondary-Contour❸.

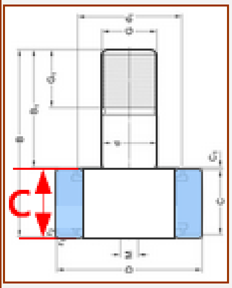
This is not as convenient as the Primary-Contour❷, for which we apologize.

With reference to the image to the left, you can see that a **Negative** TAPER ANGLE❻ **decreases** the diameter of the Roller in the +Z-axis direction.

Whereas, a **Positive** TAPER ANGLE, increases the diameter of the Roller in the +Z-axis direction.

Z OFFSET FOR DEBUG - ignore.





C = Actual Roller Width

Recommendation , if you want to use the TAPER-ROLLER parameter:

Edit the parameters so that Secondary-Contour of the Profile for the Follower-Roller is on the Mechanism-Plane.

STEP 1

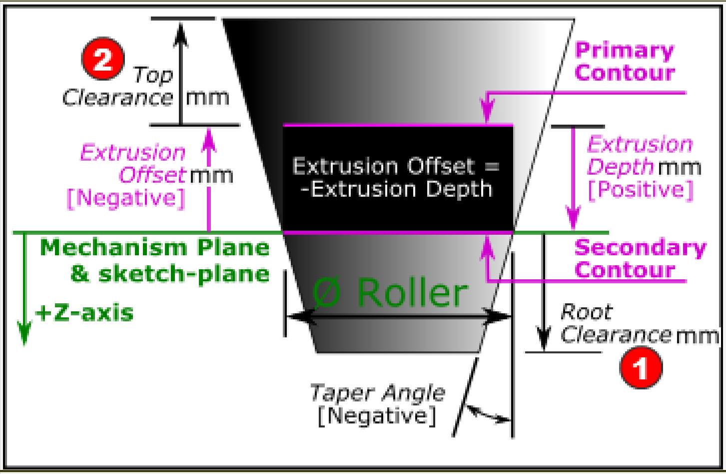
Edit the Follower-Profile (Extrusion) with the EXTRUSION DIALOG

The EXTRUSION-OFFSET❹ should be the **negative of the** EXTRUSION-DEPTH ❺.

EXTRUSION-DEPTH(mm) = ACTUAL ROLLER WIDTH(mm) (Equal to dimension C in SKF catalog

EXTRUSION-OFFSET (mm) = **–** EXTRUSION-DEPTH(mm) (Equal to negative of dimension C in SKF catalog.

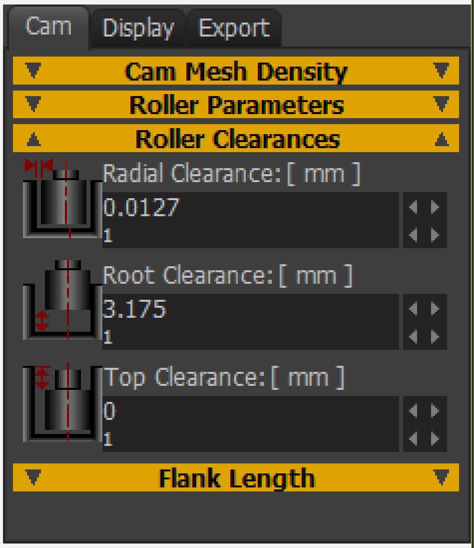
The Secondary Profile❸ is now **on** the MECHANISM-PLANE❶. The TAPER-ANGLE❻ parameter rotates and pivots on the MECHANISM-PLANE.



STEP 2:

Use the ROLLER CLEARANCES separator (see below 389) to edit the ROOT-CLEARANCE and TOP-CLEARANCE to extend the flanks as you need for the actual roller and 3D-CAM

ROLLER CLEARANCES



PREAMBLE:

There must be a small clearance for a **Follower-Roller** to roll between the Cam's flanks.

Also, you must make sure the Follower-Roller does not touch the Root/Floor of the Cam-Blank.

Thus, CLEARANCES are practical considerations.

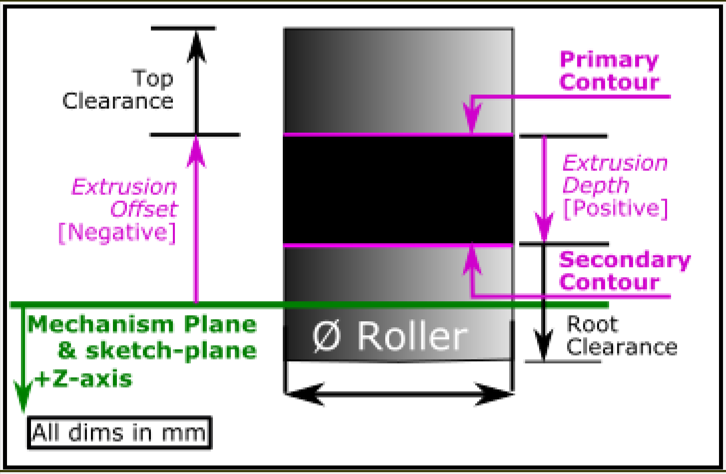
To calculate the basic 3D-CAM (without Roller Clearances), we use for you the:

- **Radial** dimension of the CIRCLE that represents the Follower-Roller.
- EXTRUSION-DEPTH of the CIRCLE as the depth of the Cam-Flanks
- PART-OFFSET + EXTRUSION-OFFSET of the EXTRUSION from the MECHANISM-PLANE to locate the **Cam-Flanks**.

You should use the actual dimensions of the Follower-Roller, and use ROLLER CLEARANCES to give the clearances you need.

RADIAL-CLEARANCE (mm)

	IMPORTANT: Total Clearance = 2 × RADIAL CLEARANCE. A positive RADIAL CLEARANCE moves the cam-flanks **out**, from the **Follower-Roller**. A negative RADIAL CLEARANCE moves the cam-flanks **in**, towards the **Follower-Roller**.



ROOT-CLEARANCE (see also Note)

A positive value moves the Root-Face towards the center of the Cam - see **Note**.

Add ROOT-CLEARANCE to make sure the **Follower-Roller** does not touch the actual **Root** (the **floor**) of the cam-groove/track.

Note:

Stud Crowned/Barrel Follower-Roller bearings have a zero to quite a large negative tolerance (e.g. 0 to –0.05mm)

Stud Cylindrical Follower-Roller bearings have a small tolerance, (e.g. h5 fit)

TOP-CLEARANCE (see also Note)

A positive value moves the Top-Face away from the center of the Cam - see **Note**.

Add TOP-CLEARANCE to make sure the top-face of the model is outside the Cam-Blank

Note:

The **Top-Face** may be the **Root-Face** of the Cam - vice-versa!

To find which is which, Experiment! Enter a value for the ROOT-CLEARANCE and click the **REBUILD** button. Observer in the model which face moves.

FLANK LENGTH

PREAMBLE:

FLANK LENGTH parameters apply to **Indexing Cams**.

When you add a 3D-CAM, we calculate for you the cam over a complete machine-cycle, 0 – 360. However, **Follower-Rollers** of indexing cams are not in contact with the cam for a complete machine-cycle, 0 – 360. The **Follower-Rollers** progressively engage, then disengage with the cam, in a similar way to gear teeth.

You use the parameters in the FLANK-LENGTH separator to calculate the cam for the period in which the Follower-Roller is engaged with the cam.

FLANK-LENGTH:

START-ANGLE

END-ANGLE

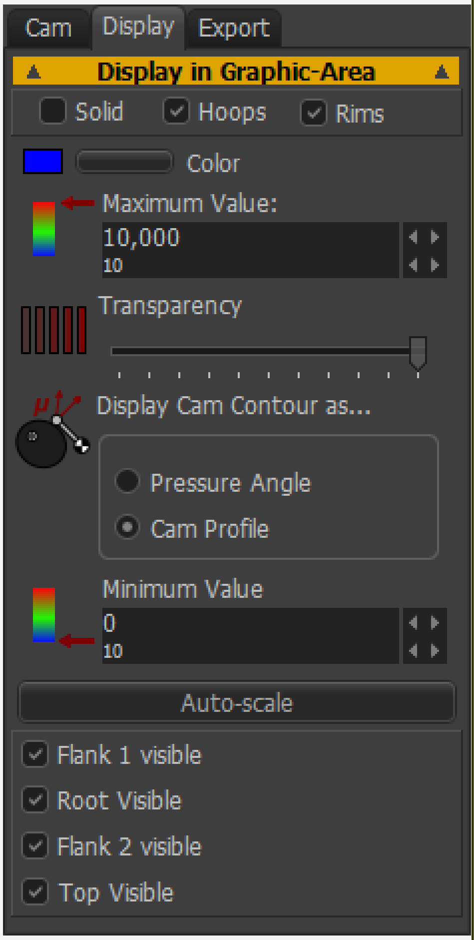
These angles are with respect to the **Master-Machine-Angle**.

When you edit the START-ANGLE and END ANGLE, we re-calculate for you the Cam from the START-ANGLE to the END-ANGLE.

The number-of-points along the cam do not change. Thus, the points along each **rim** are nearer to each other.

DISPLAY tab

DISPLAY IN GRAPHIC-AREA



PREAMBLE:

The Display tab controls how you show the **3D-CAM** in the graphics-area.

SOLIDS* | HOOPS | RIMS.

☑ **SOLIDS***: show or hide, **3D-CAM** as an **MD-SOLID**

☑ **HOOPS**: show or hide a hoop at each Point - see [# Points] 385

☑ **RIMS**: show or hide the **Rims** along the 3D-Cam

* You **must** enable the **SOLIDS** check-box to see the **3D-CAM** in other **MECHANISM-EDITORS** and the **MODEL-EDITOR**

COLOR

- Use the Windows® color-picker to select a color of the **3D-CAM**

TRANSPARENCY

- Use the slider to change the **TRANSPARENCY** of the **3D-CAM**.

DISPLAY CAM CONTOUR AS...

- **PRESSURE-ANGLE**
- **CAM-PROFILE**

When you show the **3D-CAM** as **PRESSURE ANGLE**, the faces have a color-code.

- Red identifies a high **PRESSURE-ANGLE**
- Blue identifies a low **PRESSURE-ANGLE**

MINIMUM / MAXIMUM

By default, the color-code scales to the maximum and minimum values of the **PRESSURE-ANGLE**

If you want to change the scale, use the Maximum Value and Minimum Value boxes.

AUTO-SCALE button

Click the **AUTO-SCALE** button to reset to the maximum and minimum values again.

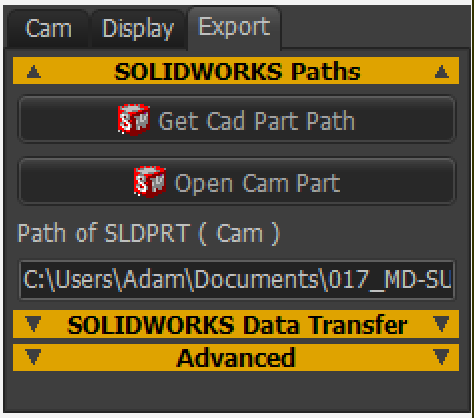
FLANK 1 VISIBLE, ROOT VISIBLE, FLANK 2 VISIBLE, TOP VISIBLE

	Show or hide each surface.

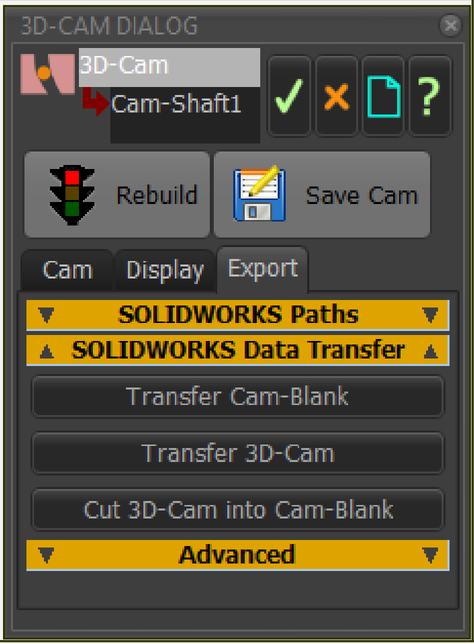
EXPORT tab

NOTE: From **MD13.2**, it is easier to save the **3D-CAM** as a **STEP** file with the Save button394.

SOLIDWORKS PATHS

<table>
<tr>
<td>
</td>
<td> PREAMBLE:
After you export a 3D-CAM to SOLIDWORKS, copy the path and file-name of the SOLIDWORKS document into this dialog. Then, later, you can use this dialog to open the CAD model of the 3D-CAM again.
GET CAD PART PATH button
If the SOLIDWORKS document has a Part name, click the button to copy the path and file-name into the PATH OF SLDPRT (CAM) box.
OPEN CAM PART button
In the future, click the button to open in SOLIDWORKS the SOLIDWORKS document that is in the PATH OF SLDPRT (CAM) box. </td>
</tr>
</table>

SOLIDWORKS DATA TRANSFER

<table>
<tr>
<td>
</td>
<td> PREAMBLE:
We recommend you use the Save button to save the 3D-CAM as a STEP file - See Rebuild and Save buttons394
Alternatively, you can use these buttons to transfer the Cam-Blank, and the 3D-CAM to SOLIDWORKS.
Before you click these buttons:

Open SOLIDWORKS
Start and save a new SOLIDWORKS part document (.SLDPRT) and make sure it is the active document.
</td>
</tr>
<tr>
<td colspan="2"> TRANSFER CAM BLANK button

We export for you the sketch of the Cam-Blank and its Axis-of-Rotation to SOLIDWORKS.
</td>
</tr>
</table>

- We instruct SOLIDWORKS to use the **Cam-Blank** and **Axis-of-Rotation** to add a revolved feature.

TRANSFER 3D-CAM **button**

- We export for you the points along each Rim and Hoop
- We instruct SOLIDWORKS to:
  - use the points along the Rims to create an XYZ Curve features
  - create surfaces from the Curve features for each Cam-Flank, and the Top, and the Bottom faces.
  - Knit the four surfaces together with the Knit surface feature.

CUT 3D-CAM INTO CAM-BLANK **button**

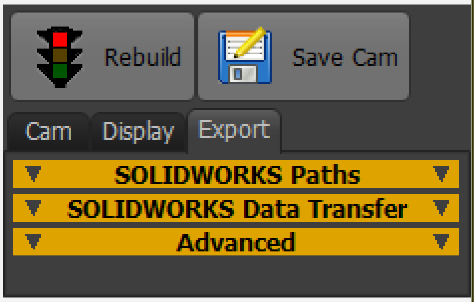
- We instruct SOLIDWORKS to:
  - Cut the Knit the surfaces feature from the Cam Blank revolved feature.
  - Hide the Knit-surfaces feature.

You may need to edit the Surface Cut feature to reverse the direction of the cut

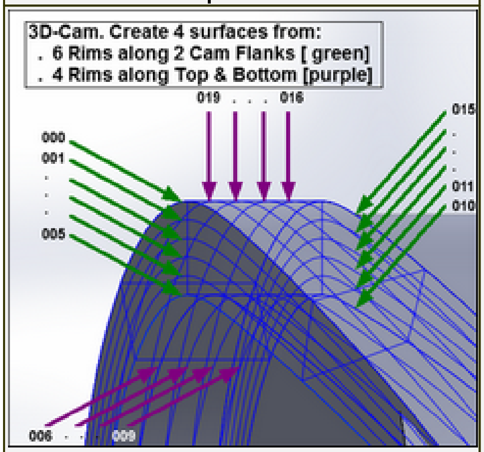
---

REBUILD and SAVE buttons

Rebuild and Save Cam buttons



Export tab



Rims along the Cam-Flanks (Purple), the Top and Bottom (Orange), and Points along each Rim.

Rebuild

Click the Rebuild button:

- to recalculate the 3D-CAM with updated parameters
- before you transfer the 3D-CAM to SOLIDWORKS
- before you save the 3D-CAM

Save Cam

Click the Save Cam button:

- to save the cam as a STEP, TXT, or a SLDCRV file-type.

Note*:*

STP file-type is the **STEP file-type** and recommended ...

... you can open a STEP file-type in most 3D-CAD programs.

.... see **METHOD 1 below Export the 3D-Cam as a STEP file**, below.

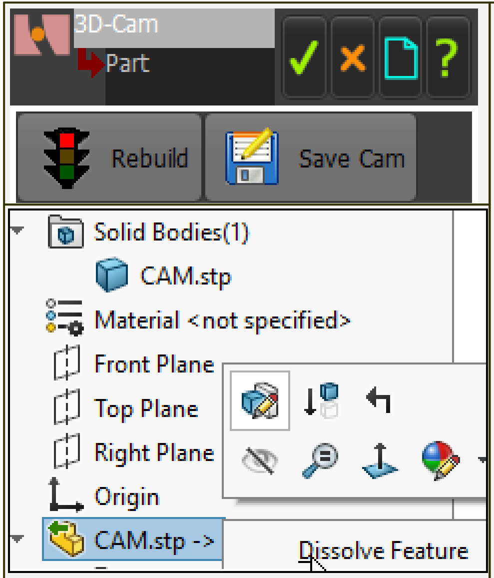
TXT and SLDCRV file-types

We save for you the XYZ coordinates of each **Rim** to a different file.

In the image, left, there **20 Rims.** We save for you 20 files, one file for each **Rim**.

Export 3D-CAM

METHOD 1: Export the 3D-Cam as a STEP file (RECOMMENDED)



"Dissolve Feature"

IN MECHDESIGNER:

In the **3D-CAM DIALOG:**

1. Click the Rebuild button
2. Click the Save Cam button
3. Select **.stp** as the file-type, and save the cam - for example, **CAM.STP**

SOLIDWORKS

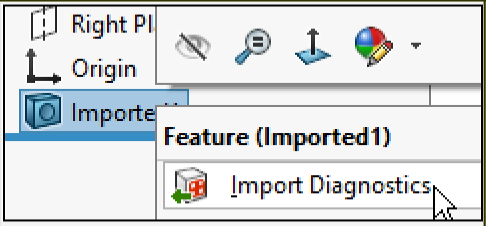
STEP 1: Create a Solid from the 3D-Cam surfaces.

1. Open **Cam.STP** file in SOLIDWORKS®
2. If you are prompted, do not do "**Import Diagnostics**"
3. If "**Import Diagnostics**" starts automatically, do NOT "**Attempt to Heal** "
4. Save **Cam.STP** as a SOLIDWORKS® Part (.SLDPRT) file-type. E.g. **Cam.SLDPRT**

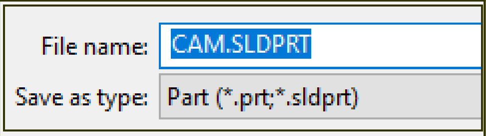
In SOLIDWORKS® you may also need to:

1. Right-Click **Cam.STP** in the **Feature Manager**
2. In the shortcut menu: Click **Dissolve Feature** or **Break Link** and click **Yes, break the link**

AND:



"Import Diagnostics"



"Save the Cam"

1. Right-Click - again - the **CAM.STP** in the **Feature-Manager**
2. In the shortcut menu: Click **Import Diagnostics**

In the **Import Diagnostics dialog:**

3. Disable **Attempt to Heal All** button, and then close the **Import Diagnostics** command.

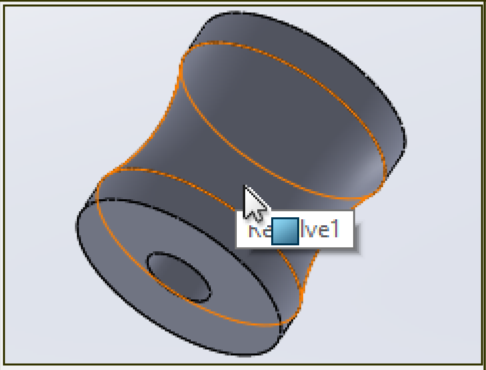
AND:

1. Add end-caps to the four surfaces of the **3D-Cam** - see **Insert menu > Surface > Boundary Surface**
2. Knit the 6 surfaces together - see **Insert menu > Surfaces > Knit**.

   Select the check-box "**Create-Solid**", and the OK button.

AND:

1. Save **Cam.STP** as a SOLIDWORKS® file-type. E.g. **Cam.SLDPRT.**


SOLIDWORKS: Cam-Blank

SOLIDWORKS

STEP 2: Open the Cam-Blank:

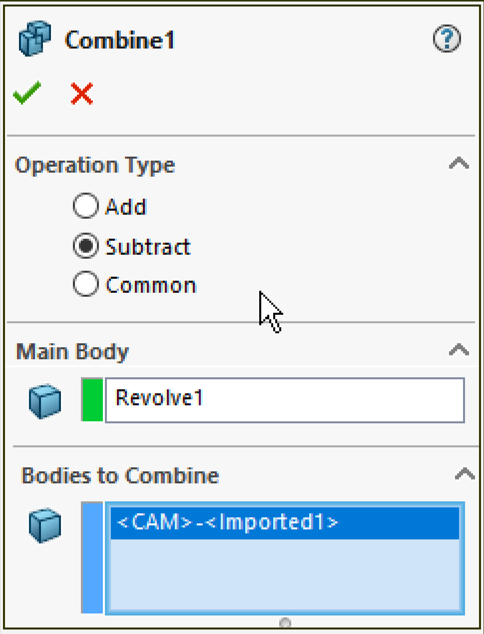
1. Open a prepared SOLIDWORKS® part **Cam-Blank.SLDPRT**.

SOLIDWORKS: Insert Part

SOLIDWORKS

STEP 3: Add the 3D-Cam (Cam.SLDPRT)...

2. **Insert menu > Part ...** ; select "**CAM.SLDPRT**"
3. Click the **TICK** at the top of the SOLIDWORKS feature manager.



SOLIDWORKS: Combine > Subtract

Cam.SLDPRT is now a feature and a **Solid Body (Cam<imported)**

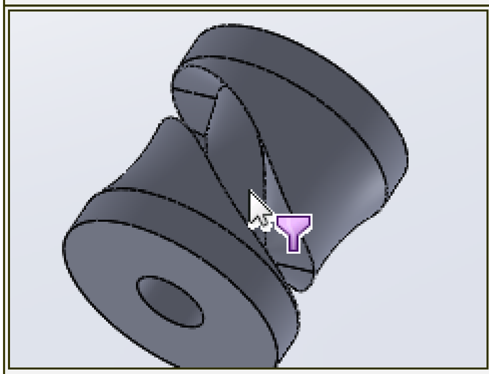
If the **Cam-Part** is on the **Front Plane** (in **MechDesigner)** the **Cam.SLDPRT** ((3D-Cam) is usually in the correct orientation relative to the **Cam-Blank.SLDPRT**.

If it is not, you must move the sketch (in SOLIDWORKS®) of the **Cam-Blank** to the correct Plane.

SOLIDWORKS

STEP 4: Cut the 3D-Cam from the Cam-Blank...

4. **Insert menu > Feature > Combine:**
    a. Select **Subtract** as the **Operation Type** and,
    b. In the **Bodies to Combine** box, select
        i. **Cam-Blank** as the **Main-Body** and
        ii. **Cam<imported>** as the **Body to Subtract**.


SOLIDWORKS: Result

RESULT:

You should see the **Cam-Track** in the **Cam-Blank**.

Note: It is possible that the Solid Body "**Cam<imported>**" and **Cam-Blank.SLDPRT** are not defined on the correct Planes.

In this case, redefine the sketch-planes of "**Cam.Blank**" (easiest method) or move "**Cam<imported>**" (more difficult to do)

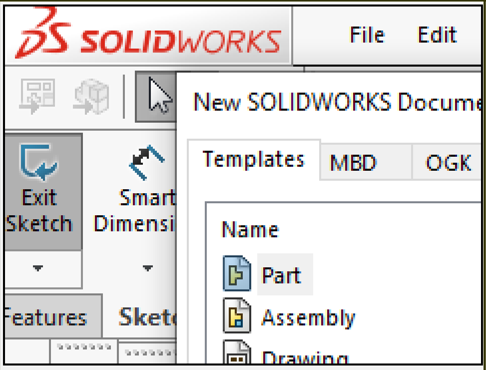
To move the sketch, you can

1. Select the sketch, CTRL+C, then pre-select a Plane or flat surface, then CTRL V.

To move **Cam<imported>**, do:

1. Insert menu > Feature > Move/Copy... and select Cam.SLDPRT as the body to move.

METHOD 2: Transfer the data directly to SOLIDWORKS



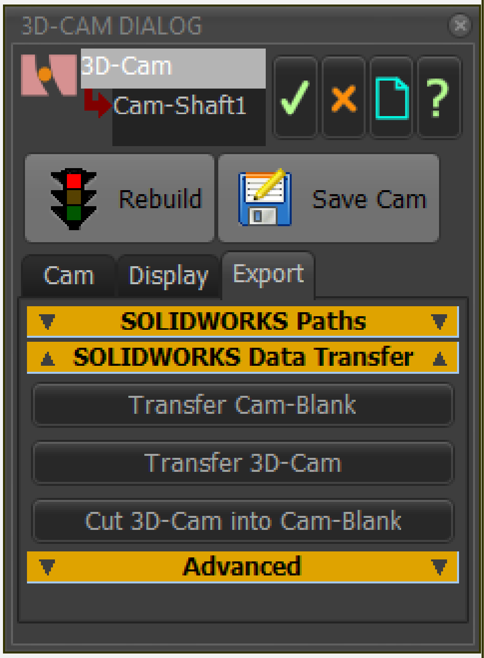
We do not usually recommend Method 2.

We recommend that you save the Cam as a STEP file - see METHOD 1 - above.

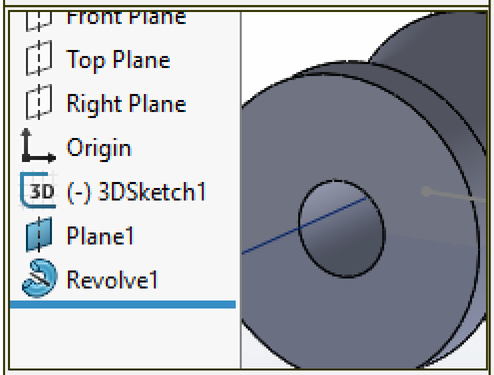
STEP 1: In SOLIDWORKS®,

Make sure the active document is a Part document:

1. Open SOLIDWORKS®
2. Add a new Part
3. Save the new Part



Click "Transfer Cam Blank"



Cam-Blank in SOLIDWORKS

STEP 2: In MechDesigner - Transfer the Blank

In **Export tab** > SOLIDWORKS DATA TRANSFER

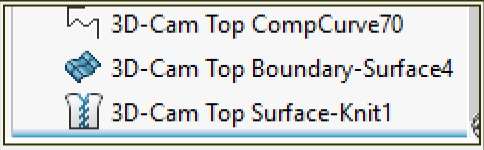
1. Click the TRANSFER CAM BLANK button

We send for you the sketch-loop and rotational-axis in the Cam-Blank tab to SOLIDWORKS.

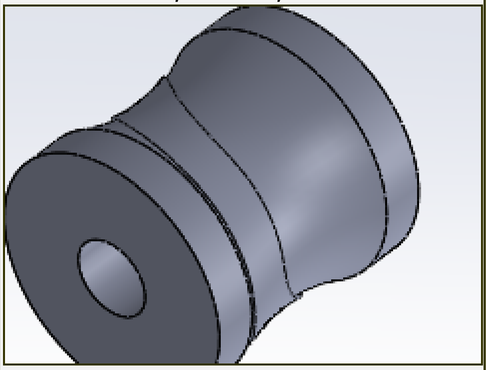
In the image to the left, you can see in SOLIDWORKS:

- **3DSketch1** which is the rotational-axis
- **Revolve1** which is the feature that revolves the sketch-loop around the rotational-axis, into the Solid.

See **Getting Started Tutorials 6C** for more information.



XYZ Curves, Surface, Knit features



Cam-Blank and 3D-Cam

STEP 3: In MechDesigner - Transfer the 3D-Cam

1. Click the **TRANSFER 3D-CAM** button

To make the transfer quicker, hover to show a drop-down menu in SOLIDWORKS®.

For example, show the help menu drop-down.

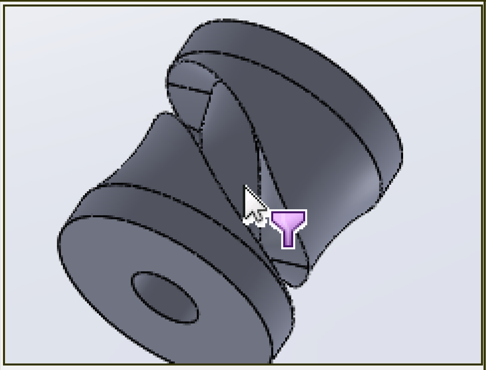
We do not know why this makes the transfer faster, but it works!

We control SOLIDWORKS to use the data to:

1. Add the Points in each **Rims** to create **XYZ Curve** entities.
2. Add four Surfaces features
   a. two **Cam Flanks**; one **Floor**, and one **Top** Surface

Note: You may need to add 'End-Caps' to the Cams if the cam is an indexing Cam.

3. Add the Knit-feature to knit the Surfaces



3D-Cam cut into Cam-Blank

STEP 4: Click Remove Surfaces from Blank button

1. Click the **REMOVE SURFACES FROM BLANK** button

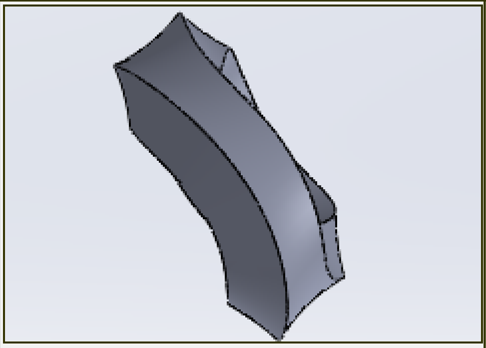
   The **3D-Cam Surfaces** Cut into the **Cam-Blank**.

Wait! - you should now see the image to the left

If you see ONLY the CAM TRACK and not the Finished Cam **(see image below)**

STEP 5: Save the Part In SOLIDWORKS®

1. **Insert > Cut > With Surface**
2. Select the **Knitted 3D-Cam Surface** - the last feature in the **Feature Manager**.



3D-Cam without Cam-Blank

3. Edit the **Surface Cut** feature in SOLIDWORKS® and click the Change Direction button.
4. Hide the **Knitted Surface** feature of the **3D-Cam.**

1.5.11.16 Dialog: 2D-Cam >

2D-Cam

2D-Cam - typical work-flow

Cam Work-flow

Action	Help Topic
1. Add a 2D-Cam	see Add 2D-Cam [128]
If the new 2D-CAM is one of a pair of **Conjugate-Cams**, or it is one flank of a **Groove-Cam**:	
1.a. Add a CONJUGATE-CAM FB	see Add Conjugate Cam FB [165]
1.b. Edit the CONJUGATE-CAM FB to select the two 2D-CAMS.	see Conjugate-Cam dialog [436]
2. Select a 2D-CAM or a CONJUGATE-CAM FB as the Power Source for the kinematic-chain that includes the Follower	see Configure-Power Source [589]
3. Review the 2D-CAM : **Display, Properties, Roller-Life, Cam-Life, ...**	see 2D-Cam dialog [401]
4. Add a Cam-Data FB	see Add Cam-Data FB [199]
5. Edit the CAM-DATA FB to link it to a 2D-CAM - close the dialog	see Cam-Data dialog [440]
6. Connect wires from the output-connectors of the CAM-DATA FB to a GRAPH FB	
7. Analyze the 2D-CAM	see Cam-Data dialog : Cam Analysis [440]
8. Edit the CAM-DATA FB again to calculate the Cam's Coordinates	see Cam-Data dialog : Cam-Coordinates [446]

How to open the 2D-Cam dialog

To open the 2D-CAM DIALOG:

1. Double-click a 2D-CAM in the graphics-area or ASSEMBLY-TREE.

OR

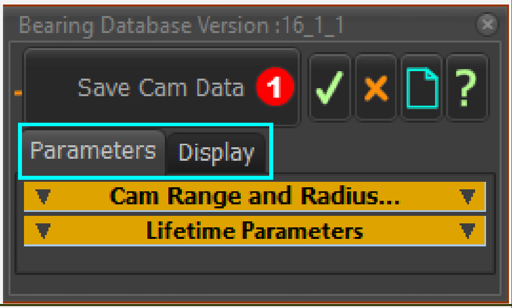
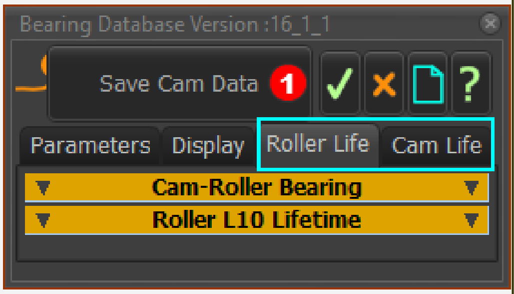
1. **See How to Open a dialog** [627] **.**

The 2D-CAM DIALOG is now open.

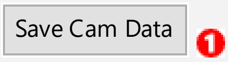
2D-Cam dialog

The 2D-CAM DIALOG has two formats:

SHORT format	EXTENDED format

	
The two tabs are: **Parameters** 403 **Display** 407	The two NEW tabs are: **Roller Life** 411 **Cam Life** 428

Save Cam Data button



Click **Save Cam Data** at the top of the dialog to save the data to a CSV file-type. The CSV file saves the parameters and the data at each step in the machine cycle. The CSV saves the Roller-Life and the Cam-Life details when you enable Roller and Cam Lifetime.

Time	X-Coordinates	Y-Coordinates	Contact Force	Contact Shear Stress	Radius of Curvature	Pressure Angle	Sliding Velocity	Cam Angular Velocity	Interferes?
s	mm	mm	N	MPa	mm	degree	mm/s	rad/s	Y/N

IMPORTANT: Do NOT use the X-Y coordinates that you can save with this dialog to manufacture the cam. Use a CAM-DATA FB to calculate and save the Cam-Profile as XY-Point, BiArcs, and STEP file-type.

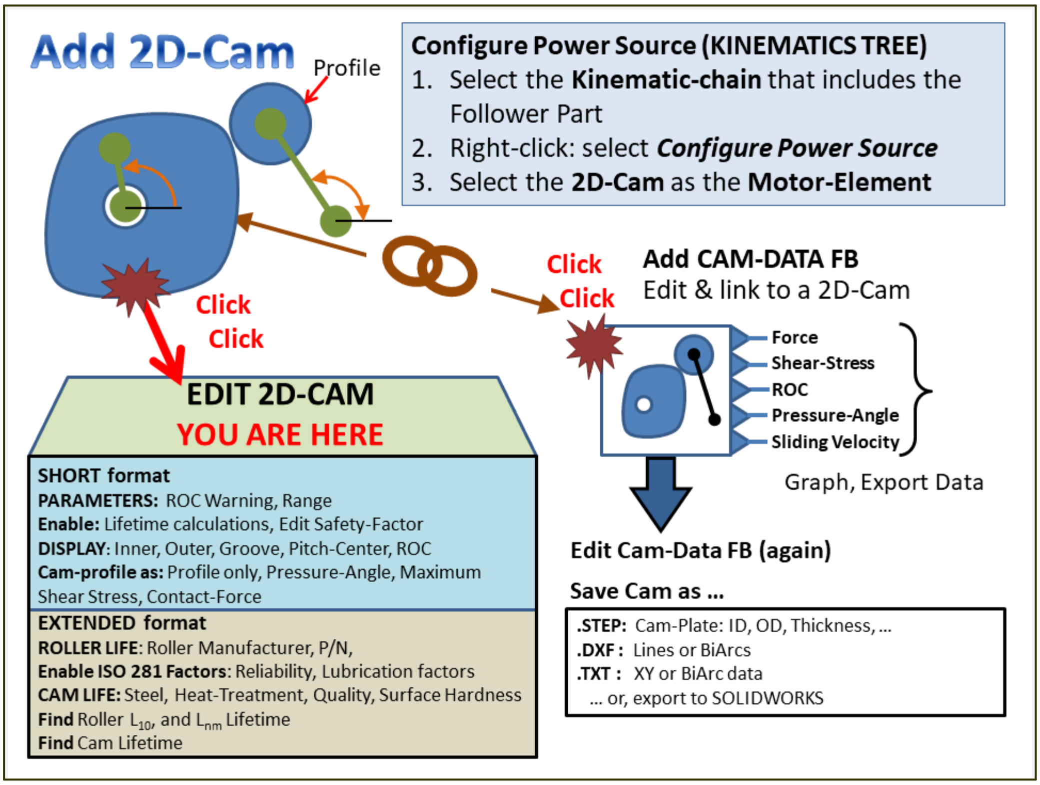
Note:

If you open the file in Excel > Data tab > Data and Transform data group > From Text/CSV file, use Unicode UTF-8 (65001) as the File Origin.

See also:

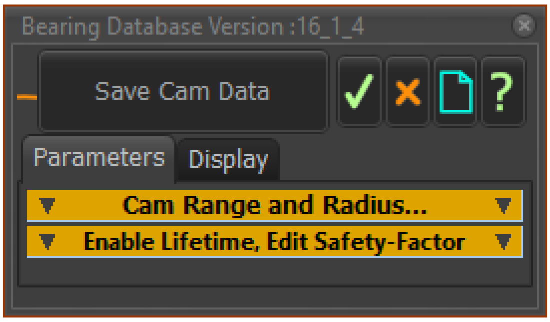
The output connectors of the CAM-DATA FB 440 for other analysis of the 2D-CAM.

2D-Cam - work-flow as a diagram



1.5.11.17 -> Parameters tab

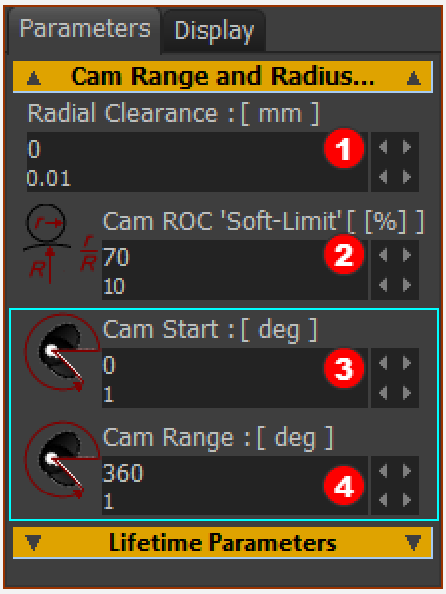
2D-Cam > Parameters tab



2D-Cam dialog > Parameters tab

Parameters tab

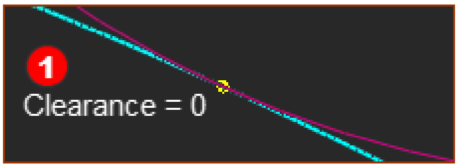
CAM RANGE AND RADIUS...



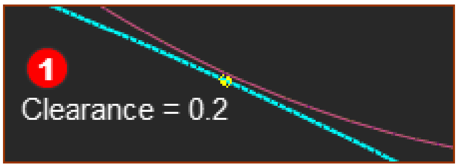
Cam Range and Radius tab

❶ **RADIAL CLEARANCE** (MM) Default = 0

When **RADIAL CLEARANCE ≠ 0**, we calculate for you a **Cam-Profile** that is offset from the true **Cam-Profile**.



Cam without Radial Clearance



Cam with 0.2mm Radial Clearance

Application:

- **Groove-Cam**: Clearance to fit a Follower-Roller bearing in the track of a Groove-Cam between the Cam-Flanks,
- **Conjugate-Cam**: Clearance to compensate for assembly tolerances with a Conjugate Cam assembly - or you can use one bearing with an eccentric.
- **Rough-Cut**: "Negative Clearance" to export cam coordinates for a rough-cut of a cam, before its final cut.

Notes:

a) You can also edit this parameter in the Cam-Coordinates dialog[446].

b) Barrel Follower-Roller bearings (typically a 500mm radius across the width of the bearing) frequently have a relatively large negative tolerance bias (e.g.: $0 \Longrightarrow -50\mu m$). Even cutting a cam to size may leave too much clearance.

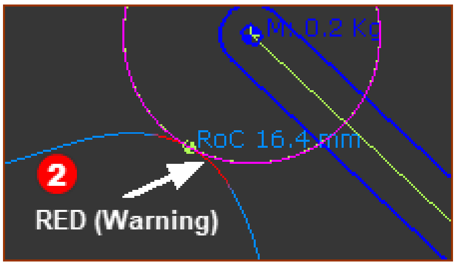
❷ **CAM R.o.C. 'SOFT-LIMIT' (%)**

Note: default global setting: **Application Settings** [341] > **General tab** > **Cam Radius Soft-Limits.**

This parameter compares the **absolute value** of the 2D-CAM'S radius of curvature (R.o.C.) with the radius of the Follower-Roller, at each point along the 2D-CAM.

IF $\left|\frac{RoC_{cam}}{R_{foll}}\right| \times 100\% < (Soft - Limit)\%$

THEN the **Cam-Profile** is RED in the graphics-area.



Cam-Profile RED = Warning

Example:

CAM R.O.C. 'SOFT-LIMIT' (%) = 100%

The **Cam-Profile** is RED where the **Radius-of-Curvature** is less than the **Roller's Radius.**

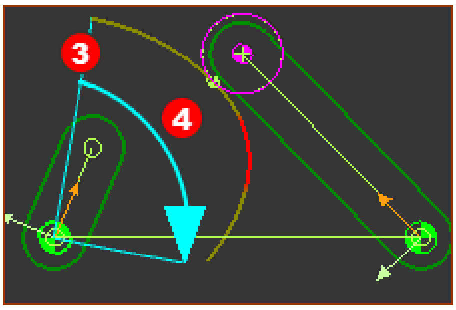
YOU must make sure the 2D-CAM does not have an under-cutting problem.

❸ CAM START (default = 0) ; ❹ CAM RANGE (default = 360)

By default, we calculate **AND** display **2D-CAMS** from 0 to 360 of the **Master Machine Angle** (**MMA**).

Edit these parameters to calculate and display the 2D-CAM over a different range of the **MMA**:

- CAM-START - the first point
- CAM-START + CAM-RANGE - the last point



Cam Start <> 0; & Cam Range < 360

Examples:

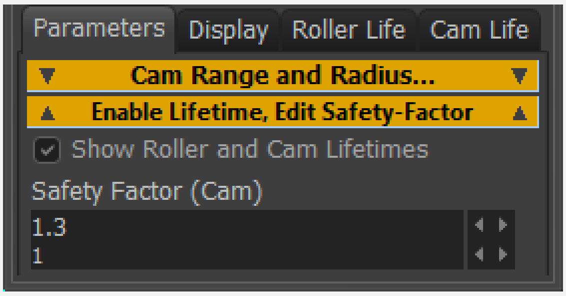
- When a Cam rotates 2 × in a machine-cycle:

CAM START= 0 ; CAM RANGE = 180

- To calculate and display a **Slot-Cam** from one end to the other end, and only in one direction

CAM START $= x$; CAM RANGE $= y$

ENABLE LIFETIME, EDIT SAFETY-FACTOR



Enable Show Roller and Cam Lifetimes

☑ SHOW ROLLER AND CAM LIFETIMES

If you enable **SHOW ROLLER AND CAM LIFETIMES**, we add two new tabs to this dialog:

- **ROLLER LIFE** tab - **see** Roller Life 411
- **CAM LIFE** tab - **see** Cam Life 428

Also,

In the **Display tab** - **see** Display tab > CAM DISPLAY OPTIONS 407 - we remove **GROOVE** and **NEGATIVE GROOVE**, as it possible to calculate the Life of the Inner or the Outer Flank.

Use these tabs:

- to select a Roller calculate the life of the **OUTER OR** the **INNER** cam-profile.
- to
- We display **Force-Vectors**.

To hide **Force-Vectors**, see Forces toolbar > Force-Vectors - Display 237

SAFETY-FACTOR (CAM)

We apply for you the **SAFETY-FACTOR (CAM)** to the **Cam's Contact-Stress** and the **Roller's Equivalent Contact-Load**

Cam Life tab

Dynamic Maximum Contact Stress (N/m^2) = **Max Contact-Stress** × **SAFETY-FACTOR (CAM)**

Roller Life tab

SAFETY-FACTOR (Roller) = **Safety Factor (Cam)**^{2}

∴ **Roller's Dynamic Equivalent Load** (N) = **Equivalent Load** × **SAFETY FACTOR (CAM)** ✕ **SAFETY FACTOR (CAM)**

E.g.: If SAFETY-FACTOR (CAM) = 1.1 ; SAFETY-FACTOR (ROLLER) = 1.21

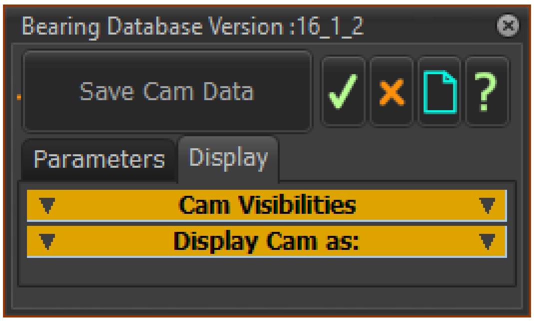
The **SAFETY FACTOR**

The **SAFETY-FACTOR** should consider at least the following:

- What drives the Cam-Shaft? Is it a constant speed servomotor or a single-cylinder diesel engine?
- What does the Follower drive? Is it a paper-tucker, or a forging, stamping press?
- What is the stiffness, rigidity, inertia, natural-frequency, of the load - is the load at the end of a long, thin shaft, or a short, stub spindle?
- What is the severity of the motion - does it have jerk continuity, or acceleration discontinuity?
- How much backlash is there in the Cam and Follower mechanical systems - does it use a precision Planetary gear-box with helical gears, or forged spur gears?

1.5.11.18 -> Display tab

2D-Cam > Display tab



2D-Cam dialog > Display tab

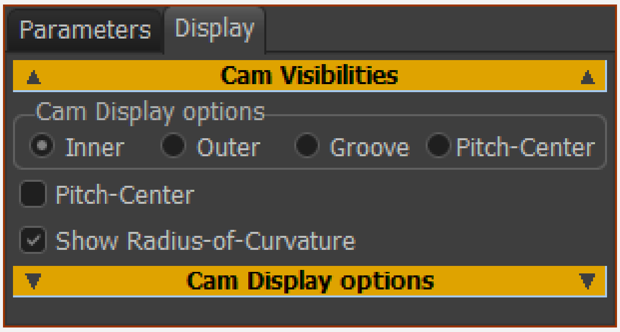
Display tab

CAM VISIBILITIES

There are two formats: **SHORT** and **EXTENDED**.

SHORT format

We show this format of CAM-VISIBILITIES when you do NOT enable SHOW ROLLER AND CAM LIFETIMES in the **Parameters** tab.



Cam Visibilities when Show Roller and Cam Lifetimes is NOT enabled

CAM DISPLAY OPTIONS :

⦿ **INNER** - show the inside (internal or smaller) Cam-Profile only

⦿ **OUTER** - show the outside (external or larger) Cam-Profile only

⦿ **GROOVE** - show the **INNER** and **OUTER** Cam-Profiles

⦿ **PITCH-CENTER** - show ONLY the **PITCH-CENTER** path - **see** Note[408]

You can enable also:

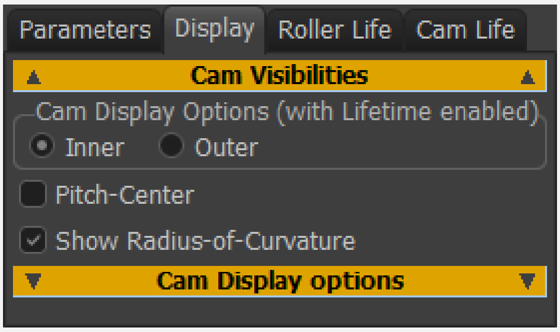
❑ **PITCH-CENTER** - show the **INNER**, or **OUTER**, or **GROOVE**, **AND** the **PITCH-CENTER** path **- see** Note[408]

❑ **SHOW RADIUS-OF-CURVATURE** - show the **RADIUS-OF-CURVATURE** at the contact-point of the **Follower-Roller** on the **Cam-Profile**.

EXTENDED format

We show this format of **CAM-VISIBILITIES** when you do enable **SHOW ROLLER AND CAM LIFETIMES** in the **Parameters** tab.

We calculate the lifetime the **INNER** or the **OUTER** Cam-Profile.



Cam Visibilities when Show Roller and Cam Lifetimes is enabled

CAM DISPLAY OPTIONS (WITH LIFETIME ENABLED)

⦿ **INNER** - show the inside (internal or smaller) Cam-Profile only

⦿ **OUTER** - show the outside (external or larger) Cam-Profile only

You can enable also:

❑ **PITCH-CENTER** - show the **INNER**, or **OUTER**, **AND** the **PITCH-CENTER** path **- see** Note[408]

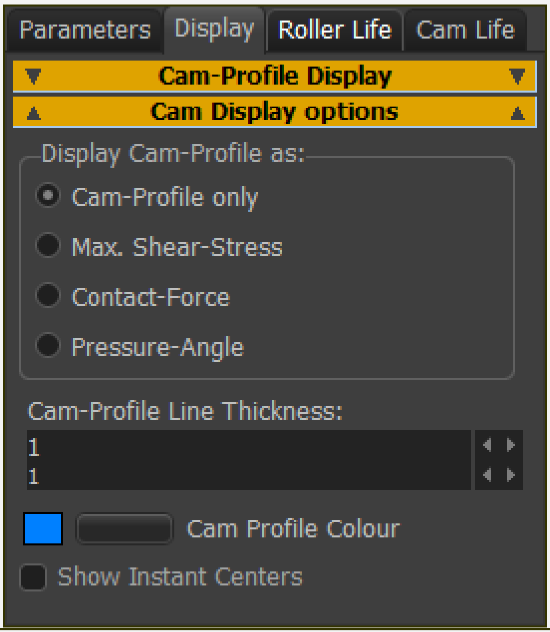
❑ **SHOW RADIUS-OF-CURVATURE** - show the **RADIUS-OF-CURVATURE** at the contact-point of the **Follower-Roller** on the **Cam-Profile**.

Note:

The **PITCH-CENTER** is the path of the center-point of a **Follower-Roller** bearing relative to the **Cam-Part**.

The **PITCH-CENTER** path is meaningful only when the **Follower-Profile** is a roller bearing.

CAM DISPLAY OPTIONS



Display Cam-Profile as:

- ⦿ CAM-PROFILE ONLY (default)
- ⦿ MAXIMUM SHEAR-STRESS*
- ⦿ CONTACT FORCE*
- ⦿ PRESSURE-ANGLE

* Configure the Power Source 589 to calculate correctly.

CAM-PROFILE LINE THICKNESS: (default =1)

Edit the thickness of the **Cam-Profile.**

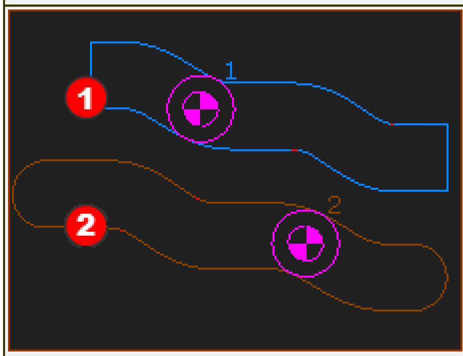
CAM-PROFILE COLOUR button

Edit the color of the **Cam-Profile** in the graphics-area.

Different colors are useful when there are many **Cam-Profiles** in your model.

TOP-TIP - rename the 2D-CAM element to the color you select for the **Cam-Profile**.

SHOW INSTANT CENTERS : For the kinemagicians!



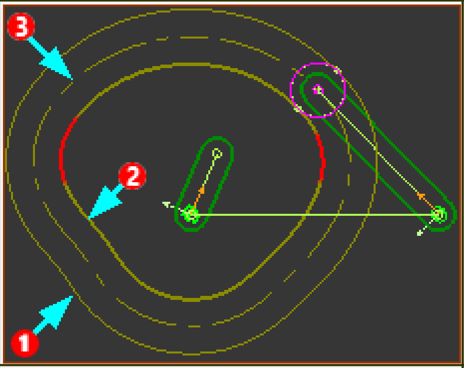
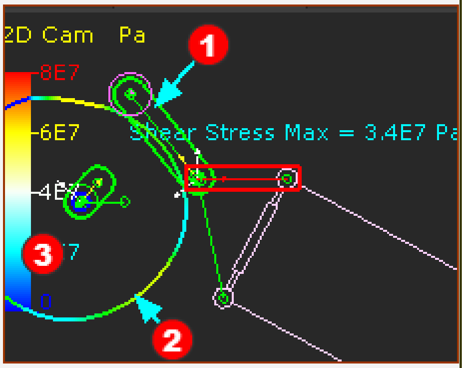
Without and With End-Caps

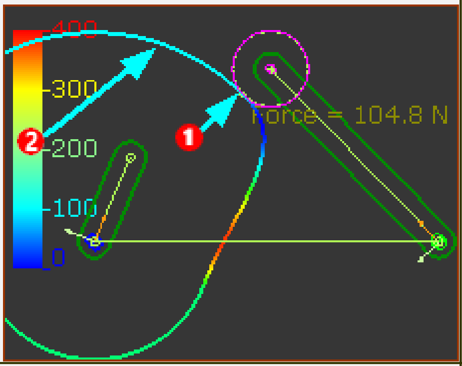
1 Without End-Caps

2 With End-Caps

Enable **SHOW END-CAPS** check-box. This check-box shows **only** when **MechDesigner** detects that the Cam-Profile is "open". A Cam-Profile is open if its start and end are not in the same place. With Slot-Cam types, it is frequently possible to close the **Cam-Profile** with **End-Caps** - see ❷ image above. **Note**: Slot-Cams can have "complications" that you must resolve before you can export its Coordinates to SOLIDWORKS or other CAD.

Example Display Options:

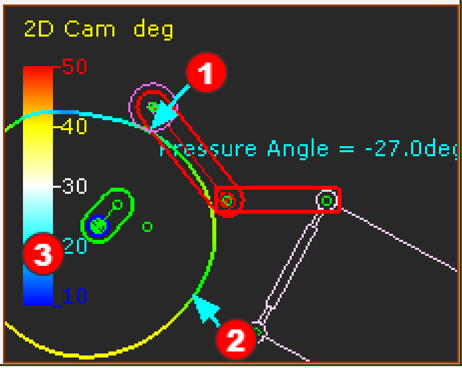
	⦿ **CAM PROFILE** **Outer**❶ and **Inner**❷ cams are continuous lines. **Pitch-Center Path**❸ is a dashed line.
	⦿ **MAXIMUM SHEAR-STRESS** ❶ **MAXIMUM SHEAR STRESS** value is near to the contact point ❷ Color of the cam agrees with the color-bar❸ ❸ Color-bar shows the range of the **MAXIMUM SHEAR-STRESS** **Notes**: **MAXIMUM SHEAR-STRESS** is below the surface, at: • ≈ 0.78 × Contact-Width for Line contact • ≈ 0.48 × Contact-Width for Elliptical contact **MAXIMUM SHEAR-STRESS** is: • ≈ 0.3 × Contact Stress for Line and Elliptical contact



⦿ CONTACT FORCE

❶ CONTACT FORCE value is near to the contact point.

❷ Color of the Cam and Color-Bar agree with the CONTACT FORCE



⦿ PRESSURE ANGLE

❶ PRESSURE ANGLE is near to the contact point.

❷ Color of the cam agrees with the color-bar❸

❸ Color-bar is the scale of the PRESSURE ANGLE

See also **Pressure Angle**

1.5.11.19 -> Roller Life tab

2D-Cam > Roller Life tab

Notes:

> Make sure the **2D-CAM** or a **CONJUGATE CAM FB** is the power-source for the **Follower-Part** - **see** **Configure Power Source** 589
>
> The **Follower-Roller bearing** you select in this tab, controls the diameter of the **Follower-Roller** in the model.
>
> Other names for a **Follower-Roller** bearing are: **Track-Roller**, **Track-Follower**, **Cam-Follower**, and others.

To Calculate the Roller Life, you must:

PARAMETERS tab

STEP 1: Enable SHOW ROLLER AND CAM LIFE

STEP 2: Enter a SAFETY FACTOR (CAM)

(Parameters tab > 405 ENABLE LIFETIMES, EDIT SAFETY-FACTOR 403)

Note: The SAFETY-FACTOR we apply to the **Follower-Roller** is equal to the square of the SAFETY-FACTOR (CAM).

E.g: If SAFETY FACTOR (CAM) = 1.1, then the SAFETY-FACTOR (FOLLOWER-ROLLER) = 1.21.

Top-Tip - Enter SAFETY-FACTOR = 1 to help you understand the results of the **Cam-Life** and **Roller Life**.

ROLLER LIFE tab

STEP 1: **Select a Roller bearing manufacturer** and **Roller bearing**

If you **ENABLE ISO 281 MODIFICATION FACTORS**:

STEP 2: Select a **RELIABILITY FACTOR**

STEP 3: Enter the **OIL OPERATING TEMPERATURE**

So that we can calculate the Operating Viscosity, you must also enter these four parameters for the oil:

STEP 4: Enter **OIL TEMPERATURE T1** and **VISCOSITY AT T1**

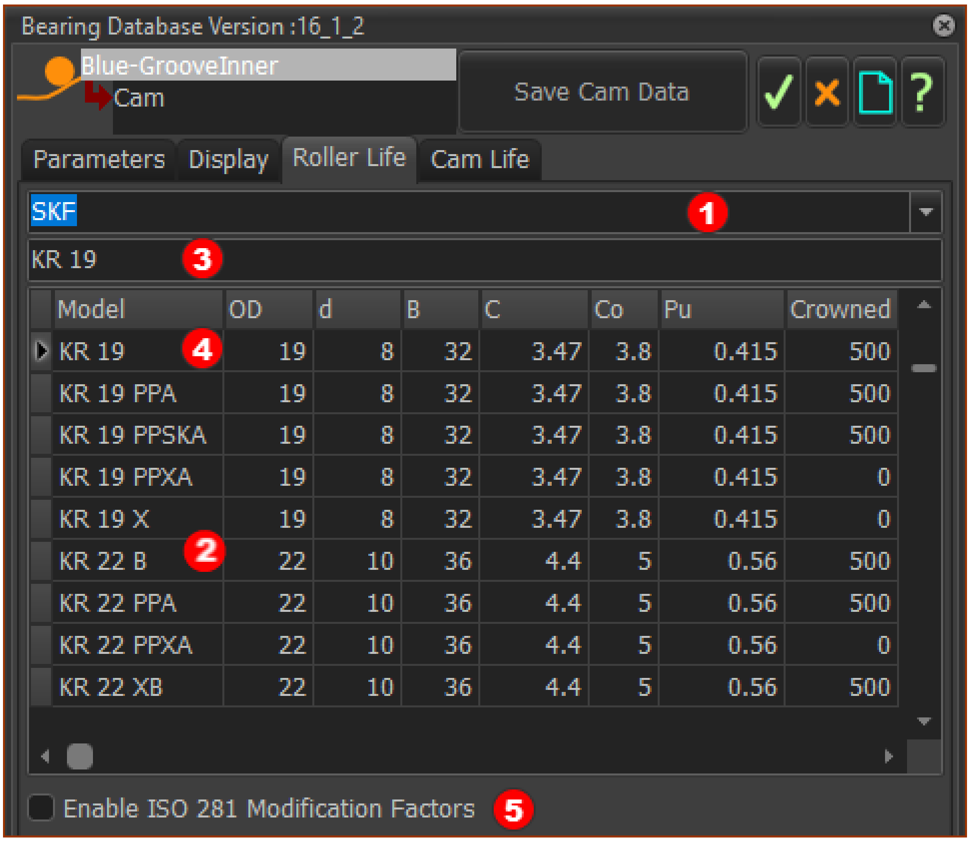
STEP 5: Enter **OIL TEMPERATURE T2** and **VISCOSITY AT T2**

(**Note, VISCOSITY AT T1 and VISCOSITY AT T2** are usually on the Oil's Data-sheet.

STEP 6: Select the **LUBRICATION TYPE**

STEP 7: Select the **CONTAMINATION LEVEL**

Review the Roller's Lifetime



2D-Cam dialog > Roller Life tab
Select a Manufacturer and Bearing Part-Number of Parameter

Roller Life tab

Select a Roller bearing.

STEP 1: **Select a Follower-Roller bearing Manufacturer** ❶

1. Click the drop-down list box to select a Follower-Roller Bearing Manufacturer

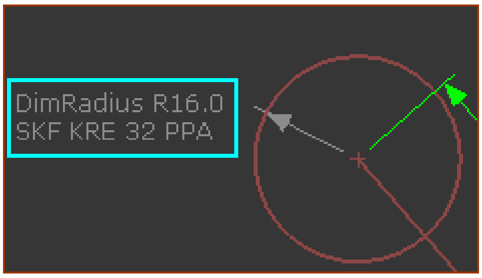
Available Manufacturers: **SKF, INA/FAG, KOYO, NSK, THK**

When you select a manufacturer, the bearing **Part-Numbers** and their parameters show in the table ❷.

STEP 2: Select a Roller Bearing from the table ❷

Note: Click a **Header** to sort by that **Header**. For example, click **OD** to sort by **Outside-Diameter.**

1. Click a **Part-Number from the table** ❷



Cam-Follower Radius
& Follower-Roller Part- Number

IMPORTANT NOTES

A. Before you select a Roller in the list of bearings, you **must** use the **PART-EDITOR** to add a **CIRCLE** and add a **Radius** for the **CIRCLE.**

B. When you select a Roller in the list of bearings, the **Radius dimension** of the **CIRCLE** changes **IMMEDIATELY** to the **OD/2** of the bearing you select (± **Radial Clearance** 403).

C. The **Part-Number** of the **Roller** is in the graphics-area under the Radius dimension - see image above

D. The **Radius dimension** of the **CIRCLE** sketch-element that represents the **Roller** is now read-only.

To change the Radius of the **Roller**:

- Select a different **Part-Number** for the **Roller** bearing

or

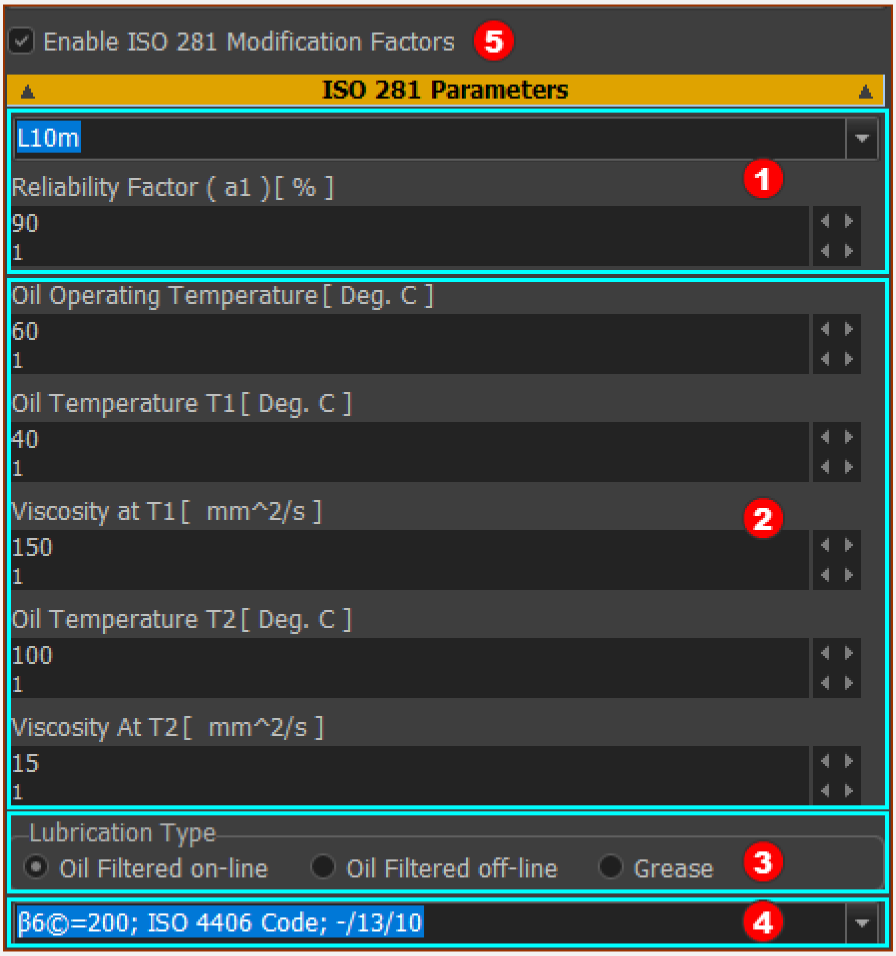
- Disable Show Roller and Cam Lifetimes check-box 405 , and then edit the Radius dimension with the **PART-EDITOR**.

You can see immediately the **Basic Rating Life,** L_{10} in the **L10 FOR ROLLER: PART NUMBER** separator.

ISO 281 PARAMETERS

To see these factors, select "**Enable the ISO 281 Modification Factors**"❺

We calculate for you the a_1 and a_{iso} modification factors as you enter the parameters below.



ISO 281 Modification Factors

Reliability Factor (a1)

- **Reliability Factor**: Use the drop-down to select a percentage for the bearing reliability.

  The **Reliability Factors** in the drop-down list (90 to 99.95%) are those recommended in ISO 281.

or

- **Reliability Factor:** as a percentage.

  In this case, we find for you the Reliability Factor nearest to a **Reliability Factor** as recommended in ISO 281.

Operating Viscosity

The viscosity of the oil's (or base-oil in a grease) at the operating temperature is function of its Viscosity Grade and Viscosity Index.

We calculate for you the viscosity at the operating temperature when you enter these five parameters:

- Operating Temperature, ℃
- Temperature T_1
- Viscosity ν_1 at Temperature T_1

- Temperature T_2
- Viscosity ν_2 at Temperature T_2

Rules:

- $T_1 < T_2$ and $\nu_1 > \nu_2$

Notes:

If you know the ISO VG of the oil, you can enter: $T_1 = 40°\text{C}$ and $\nu_1 = ISO\ VG$

Lubricating Oil and Grease datasheets usually provide the Viscosity at $40°\text{C}$ and at $100°\text{C}$.

❸ Lubrication Type

Select one of these lubrication methods:

- ⦿ **OIL FILTERED ON-LINE**: Circulating oil lubrication with the oil filtered on-line before being supplied to the bearings
- ⦿ **OIL FILTERED OFF-LINE**: Oil bath lubrication, or circulating oil lubrication with off-line filters (or without filtration)
- ⦿ **GREASE**.

ISO 281 does not consider Oil-Mist Lubrication.

❹ Contamination Factors for each Lubrication-Type

OIL FILTERED ON-LINE

Select the **Filtration Ratio**, $\beta_{x(c)}$, from the drop-down list box,

The operating, or actual, Filtration-Ratio of the oil should be as high, and if not higher, than the Filtration-Ratio you select.

- x - the particle size of the contamination, calibrated to ISO 11171 $[\mu m]$
- $\beta_{x(c)}$ - filtration ratio at contamination particle size x

The designation (c) signifies that the particle counters — of particles of size $x\ \mu m$ — shall be APC (automatic optical single-particle counter) calibrated to ISO 11171.

Also, the oil system shall have cleanliness within the range indicated by the cleanliness code according to ISO 4406.

Filtration Ratio and Filtration Code
$\beta_{6(c)} = 200$; **ISO 4406 Code; -/13/10**
$\beta_{12(c)} = 200$; **ISO 4406 Code; -/15/12**
$\beta_{25(c)} = 75$; **ISO 4406 Code; -/17/14**
$\beta_{40(c)} = 75$; **ISO 4406 Code; -/19/16**

OIL FILTERED OFF-LINE

Select the **Cleanliness Codes** from the drop-down list box that represents the anticipated operating conditions, according to ISO 4406.

Filtration Code
ISO 4406 Code; -/13/10
ISO 4406 Code; -/15/12
ISO 4406 Code; -/17/14
ISO 4406 Code; -/19/16
ISO 4406 Code; -/21/18

GREASE

Select the **Level of Contamination** from the drop-down list box that best represents the operating conditions.

Level of contamination	Operating Conditions
High cleanliness	Clean assembly with careful flushing; good sealing in relation to operating conditions; re-greasing carried out continuously or at short intervals Bearings, greased for life with effective sealing capacity in relation to operating conditions - for example, sealed bearings
Normal cleanliness	Clean assembly with flushing; good sealing in relation to operating conditions; re-greasing according to manufacturer's specification Bearings, greased for life with proper sealing capacity in relation to the operating conditions - for example, shielded bearings
Slight to typical contamination	Clean assembly; moderate sealing capacity in relation to operating conditions; re-greasing according to manufacturer's specifications
Severe contamination	Assembly in workshop; bearing and application not adequately washed after mounting; poor sealing capacity in relation to operating conditions; re-greasing intervals longer than recommended by manufacturer
Very severe contamination	Assembly in contaminated environment; inadequate sealing; long re-greasing intervals

ROLLER LIFE : BEARING P/N

We calculate these parameters for you when you select a Roller, and/or enable ISO 281 factors.

Lifetime for Roller : SKF KR 19		
Result	Valid Data	Units
Equiv Load	258.29763	[N]
Roller rev Count	4.0248855	#
L10m N	5765.3793	[Rev x 1million]
L10m Hrs	91822.636	[Hour]
L10m Yrs	10.482036	[Year]

Life for the seleced Roller(Cam-Follower Bearing)

Basic Rating Life, L_{10}

This states that if the bearing load, P, is equal to the **Basic Dynamic Load Rating**, C, then there is a 90% reliability that the bearing survives 1 million rotations, if manufactured with commonly used high quality material, of good manufacturing quality, and operating under conventional operating conditions.

Basic Rating Life (millions of rotations)

$$L_{10} = \left(\frac{C}{P}\right)^{p}$$

Operation in Hours

We also calculate the Roller life as operating hours.

Basic Rating Life (hours)

$$L_{10}\,hrs = \frac{10^6}{60.n}.L_{10}$$

Operation in Years

We also calculate the Cam-Life as operating years. One year is 8760 hours (24hours, 365 days).

Basic Rating Life (Years)

$$L_{10}\,years = \frac{L_{10h}}{8760}$$

L_{10}	Basic Load Rating (at 90% reliability) (millions of revolutions)
L_{10hrs}	Basic Load Rating (at 90% reliability) (operating hours)
$L_{10\,yrs}$	Basic Load Rating (at 90% reliability) (operating years)
C	Basic dynamic load rating (kN) of the Roller bearing
P	Equivalent dynamic bearing load (kN) (See image above : **Equiv Load**)

	The load continuously changes as the Cam rotates. Thus, we calculate for you an equivalent load.
n	Roller rotating speed (RPM) The speed continuously changes as the Cam rotates. Thus, we calculate for you an equivalent speed.
p	Exponent of the life equation = 3 for ball bearings =10/3 for roller bearings

Modified Rating Life, L_{nm}

Modified Rating Life - as per ISO 281

We must calculate for you:

- a_1 - a factor for Reliability - see below 419
- a_{iso} - a factor calculated with a System Approach - see below 419

$$L_{nm} = a_1.a_{iso}.L_{10}$$

see above for L_{10}

see below for a_1 and a_{iso} factors.

Operation in Hours

We also calculate the Roller life as operating hours.

Modified Rating Life (Hours)

$$L_{nm}hrs = \frac{10^6}{60.n} L_{nm}$$

Operation in Years

We also calculate the Roller-Life as operating years.

One operating year is 8760 hours (24hours, 365 days).

Modified Rating Life (Years)

$$L_{nm}\ years = \frac{L_{nmh}}{8760}$$

L_{10}	Basic Life Rating (at 90% reliability) (millions of revolutions)
L_{nm}	Modified Life Rating (at $100 - n\%$ reliability) (millions of revolutions)
$L_{nm}\ hr$	Modified Life Rating (at $100 - n\%$ reliability) (operating hours)
$L_{nm}\ yr$	Basic Load Rating (at 90% reliability (operating years))

a_1	Life modification factor for Reliability - see below 419
a_{iso}	Life modification factor for Systems Approach - see below 419
C	Basic dynamic load rating (kN) of the Roller bearing
P	Equivalent dynamic load (kN) The load usually continuously changes as the Cam rotates. Thus, we calculate for you an equivalent load.
n	Mean roller rotating speed The speed of a Follower-Roller continuously changes as the Cam rotates. Thus, we calculate for you its mean speed.
p	Exponent of the life equation = 3 for ball bearings =10/3 for roller bearings

Operating Life

The actual operating life is the life achieved by the bearing. It may differ significantly from the life we calculate.

It is not possible to calculate the actual operating life, as there is a range of possible installation and operating conditions. One method to estimate the operating life is to compare the installation and operating conditions with similar applications.

Possible factors that influence the Operating Life

- deviating operating data
- misalignment between the shaft and housing
- insufficient or excessive operating clearance
- contamination
- insufficient lubrication
- excessive operating temperature
- oscillating bearing movement with small swivel angles
- high vibration and false brinelling
- high shock loads (static overloading)
- damage to the bearing when it is installed

Bearing Life Modification Factors

Life Modification Factors for Reliability, a_1

The **Reliability Factor** is constant for all application conditions.

The drop-down list has the standard **Reliability Factor** percentages (90 to 99.95%), as given in ISO 281.

Modified Life Rating (at $100 - n\%$ reliability) (millions of revolutions)

Reliability	Failure Probability	L_{nm}	a_1 Factor
%	%	-	-
90	10	L_{10m}	1
95	5	L_{5m}	0,64
96	4	L_{4m}	0,55
97	3	L_{3m}	0,47
98	2	L_{2m}	0,37
99	1	L_{1m}	0,25
99,2	0.8	$L_{0.8m}$	0,22
99,4	0.6	$L_{0.6m}$	0,19
99,6	0.4	$L_{0.4m}$	0,16
99,8	0.2	$L_{0.2m}$	0,12
99,9	0.1	$L_{0.1m}$	0,093
99,92	0.08	$L_{0.08m}$	0,087
99,94	0.06	$L_{0.06m}$	0,080
99,95	0.05	$L_{0.05m}$	0,077

Life Modification Factor: a System Approach, a_{iso}

The **Life Modification factor**, a_{iso}, is a complex interaction between Oil or Grease Viscosity Grade, Filtration, Contamination, Oil Operating Temperature, the Fatigue load capacity of the Roller, the rotational-speed of the Roller, and the diameter of the Roller.

The equations given in ISO 281 to calculate these factors are empirical, complex, and interrelated. All of the factors, except C_u, are a function of the bearing speed and bearing load. In a cam mechanism, the speed and load on the roller continually change. Therefore, we calculate for you the factors at each step and integrate them to find their equivalent values.

$$a_{iso} = f\left(\frac{e_c.C_u}{P}, \kappa\right)$$

a_{iso}	Life modification factor, using a systems approach
C_u	Fatigue Limit of Bearing (N)
P	Dynamic Load (N)
κ	Viscosity Ratio (-)
e_C	Contamination Factor (-)

Fatigue Limit of Bearing, C_u (N)

ISO 281 defines the fatigue load, C_u, for a bearing as the load below which metal fatigue does not occur.

With poor lubrication, or contamination of the lubricant, the bearing can fatigue at loads which are significantly below the fatigue limit, C_u.

For the fatigue limit to be a valid value, the lubricant film must fully separate the rolling elements from the raceways and that dents from contaminants from handling do not exist on the rolling surfaces.

The contamination factor, e_c takes into account how the level of solid particle contamination of the lubricant influences the calculated bearing fatigue life. The particles cause indentations in the rolling surfaces of the bearing, and these indentations increase the local contact stress, which reduces the expected fatigue life.

- $e_c = 1$ means perfectly clean conditions without any indentations.
- $e_c \to 0$ means severely contaminated conditions resulting in pronounced indentations.

In the **SKF** rating life model, contamination, designated by the contamination factor, e_c, acts as a stress raiser, thereby reducing the fatigue load limit to $e_c.C_u$.

We then compare the reduced fatigue load limit, $e_c.C_u$, to the actual bearing load, P, to give a **fatigue resistance value** of $(e_c.C_u/P)$

- Conditions that are clean and a load that is less than the fatigue load limit give a high fatigue resistance value.
- Conditions that are contaminated and a load that is more than the fatigue load limit give a low fatigue resistance value.

The stress-raising influence of contamination on fatigue depends on a number of parameters, including: bearing size, relative lubricant condition, size and distribution of solid contaminant particles, and types of contaminants (soft, hard, etc.). Therefore, it is not meaningful to enter a value for the contamination factor e_c that has general validity.

If a catalog does not list the **Fatigue Load Limit**, and the mean bearing diameter is less than $\emptyset 100mm$. (nearly all Follower-Roller Bearings are less than $\emptyset 100mm$), then we use this approximation:

$\cong {}^{C_0}/_{8.2}$	**Roller and needle bearings, with a Mean Diameter < 100mm.**
$\cong = {}^{C_0}/_{22}$	**Ball bearings, with a Mean Diameter < 100mm**
Mean Diameter = (Outside Diameter + Inside Diameter) / 2	

Viscosity Ratio, κ

The **Viscosity Ratio,** κ, indicates the quality of the lubricant film formation.

The lubricant-film separates the raceway and rolling-elements. It is expressed as:

$$\kappa = \frac{\nu}{\nu_1}$$

ν_1	mm^2/s	**Reference Kinematic Viscosity** - a function of the bearing's diameter and its rotating speed.
ν	mm^2/s	**Kinematic Viscosity at operating temperature** - function of oil viscosity grade and temperature.

Note 1: Viscosity Ratio, κ , assumes that surface finish is for good quality Follower-Roller bearings.

Note 2: An approximate relationship between **Film Thickness Ratio** λ and **Viscosity Ratio,** κ, is:

$$\kappa = \lambda^{1.3}$$

$$\lambda = \frac{h_{min}}{\left(R_{q1}^2 + R_{q2}^2\right)^{0.5}}$$

λ	**Film Thickness Ratio** - the ratio of the actual film thickness to the composite roughness of the rolling elements and raceway surfaces*. This ratio must assume a "standard" surface finish the raceways and rolling elements.
h_{min}	**Minimum film thickness**
R_q	**RMS Roughness of the Rolling-Elements, or Rolling-Raceways**.

Notes:

A **Viscosity-Ratio** < 0.1 is outside of the limits of **ISO 281**. It is near to metal-to-metal contact.

A **Viscosity-Ratio** > 4 is the maximum that can be used by **ISO 281**.

ISO 281 states that a **Viscosity-Ratio** = 4 if it is actually you calculate it to be greater than 4.

A **Viscosity-Ratio** > 4 is getting too high for bearings. The needles or balls may slide and refuse to roll in the 'thick-oil', or the shearing of the oil may churn and increase the oil and bearing temperatures.

A **Viscosity-Ratio** in the range of $1.5 \leq \kappa \leq 4$ is approximately ideal.

Reference Kinematic Viscosity, ν_1

The Reference Kinematic-Viscosity, ν_1 (sometimes called the Rated, or Required Viscosity) is the viscosity that is required to separate the surfaces, of

the rolling elements and races in the Follower-Roller bearing. It assumes that the oil is a mineral oil, with a Viscosity-Index of approximately 100. Synthetic oils can be used.	
$v_1 = 45000.n^{-0.83}.D_m^{-0.5} \cdots$ if $n < 1000RPM$	
$v_1 = 4500.n^{-0.5}.D_m^{-0.5} \cdots$ if $n > 1000RPM$	
$D_m = {(D+d)}/{2}$	d - inside diameter of Follower-Roller D - outside diameter of Follower-Roller

Kinematic Viscosity at operating temperature, υ @ T_3

We calculate for you the Viscosity, υ , at the **Operating Temperature,** T_3 , from the Viscosity at two other temperatures.

Nearly always, the two other temperatures are 40°C and 100°C, but not necessarily.

The lubricant's data-sheet usually specifies the Viscosity at 40°C (ν_{40}) and 100°C (ν_{100})

You must enter all four parameters in the dialog:

- 2 x temperature: T_1 and T_2
- 2 x viscosity: ν_1 and ν_2 at temperature T_1 and T_2
- Operating-Temperature: T_3.

We calculate the Viscosity at the Operating-Temperature, ν.

Contamination Factor, e_C

If a contaminant particle moves to the inside of a bearing the rollers (or balls), outer-race, and inner-race are prone to dent because of the **small internal bearing clearances** and the small rolling radii of the rollers (or balls). An indent leads to localized stress, which will decrease the life of the bearing.

The contamination may even prevent the rollers (or balls) rotating.

The contamination factors that reduce the lifetime of a Follower-Roller bearing are a function of the:

- diameter of the Follower-Roller
- lubricant film thickness (viscosity ratio, κ)
- size, type, and hardness of the particle contaminant.

Guide values for the contamination factor are in the table below. They are typical levels of contamination for well lubricated bearings.

Contamination and Lubrication Method.

We can find for you the contamination factors with these lubrication methods:

- Circulating oil lubrication with the oil filtered on-line before it is supplied to the bearings.
- Oil bath lubrication or circulating oil lubrication with off-line filters.
- Grease lubrication.

Circulating oil lubrication with On-Line Filtration, before being supplied to the bearings.

In order to achieve the calculated bearing rating life, the bearings must be operated both from the beginning and after oil changes under the assumed conditions. It is therefore important to clean the bearings and the application thoroughly **before** mounting. It is also important to filter the oil **before** it is introduced into the system. The filter used for this purpose should be at least as effective as the filter in the system itself.

For recirculating oil lubrication with continuous oil filtration, the contamination factor, e_c can be determined by means of equations (or diagrams). The diagram or equation to be used is selected on the basis of the filter retention rate βx(c) according to ISO 16889 and the oil cleanliness code according to ISO 4406. The index (c) is the (automatically counted) particle size in μm according to ISO 1171.

Oil bath Lubrication, or Recirculating Oil Lubrication, with Off-Line Filtration.

For oil bath lubrication or recirculating oil lubrication with offline filtration, the contamination factor, e_c , can be determined by means of equations or diagrams. You base which diagram you select on the oil cleanliness code. according to ISO 4406.

The filtration ratio $\beta x(c)$, with particle size x in $\mu m(c)$ according to ISO 16889[6], is the most influencing factor. The contamination level corresponds mainly to the condition of the oil before it passes the on-line filter.

NOTE

Research concludes that it is difficult to accurately find the oil cleanliness especially if you analyze very clean oils. It is easy to pollute an oil-sample, with oil additives that precipitate into the oil and particle calculation.

Grease Lubrication, Contamination Factors

It is much easier to seal a bearing that is lubricated with a grease than seal a machine that is lubricated with an oil. It is easier to design the machine.

With grease-lubricated Follower-Roller bearings, we differentiate between bearings:

- that you (or the OEM) lubricate one time for the lifetime of the bearings
- that you must re-lubricate.

In general terms lifetime lubrication does not depend on the bearing but on the requirements of the particular application.

For grease lubrication, you must estimate the Contamination Level from the descriptions below.

Step 1: Consider the potential contamination from the application. For example, is the Follower-Roller running in an open cam-track near to the stack of case-blanks in a Case-Packer? If yes, I would use the **Severe Contamination**.

Step 2: Find the **Viscosity Ratio,** κ - see above

Step 3: Find **mean diameter,** D_m - see above

Step 4: Calculate the level of Contamination, e_c

The contamination level can be very low with open, small bearings. Therefore, you should at least purchase Shielded Follower-Roller bearings if the diameter is less than 40mm.

Simplified Values of Oil Contamination Factor , e_c

Contamination Level	$D_m < 100$	$D_m \geq 100$
Extremely high cleanliness: Particle size less than lubricant film thickness, laboratory conditions	**1**	**1**
High Cleanliness: Oil filtered with extremely fine filter Equivalent to bearing greased for life with good seals. Very clean mounting with careful flushing, Continuous re-lubrication	**0.8 to 0.6**	**0.9 to 0.8**
Normal Cleanliness: Oil filtered with fine filter. Equivalent to bearing greased for life and shielded	**0.6 to 0.5**	**0.8 to 0.6**
Slight Contamination: Oil is slightly contaminated.	**0.5 to 0.3**	**0.6 to 0.4**

Contamination Level	$D_m < 100$	$D_m \geq 100$
Typical Contamination: Conditions typical of bearings without integral seals, course filtering, wear particles and ingress from surroundings	**0.3 to 0.1**	**0.4 to 0.2**
Severe Contamination: Bearing Environment heavily contaminated, Bearing inadequately sealed	**0.1 to 0**	**0.1 to 0**
Very high or Extremely high contamination	**0**	**0**

Contamination Level for Grease Lubrication

High Cleanliness:

Very clean assembly, careful flushing; very good sealing system relative to the operating conditions; re-greasing is continuous or at short intervals

Sealed bearings that are greased for life, with appropriate sealing capacity for the operating conditions.

Normal Cleanliness:

Clean assembly; good sealing system relative to the operating conditions; re-greasing according to manufacturer's specifications

Shielded bearings, greased for life with proper sealing capacity for the operating conditions,

Slight to Typical Contamination:

Clean assembly; moderate sealing capacity relative to the operating conditions; Re-greasing according to manufacturer's specifications

Severe Contamination:

Assembly in workshop; bearing and application not adequately washed prior to mounting; ineffective seal relative to the operating conditions; re-greasing intervals longer than recommended by manufacturer

Very Severe Contamination

Assembly in contaminated environment; inadequate sealing system; too long re-greasing

intervals

Contamination Levels, ISO 4406 (Contamination of Oil)

The table below provides scale values as a function of particle concentration (particles/ml) - it is from ISO 4406

A three number code defines the amount of contamination for three particle sizes: 4, 6, and 14 µm. Each time a number increases by 1, the quantity of particles is doubled for a particular particle size.

Example: **ISO code** = 21 / 19 / 17

This Contamination Class describes a fluid containing:

- between 10,000 and 20 ,000 particles of ≥ 4 µm(c) per 1 ml sample
- between 2,500 and 5 ,000 particles of ≥ 6 µm(c) per 1 ml sample
- between 640 and 1 300 particles of ≥ 14 µm(c) per 1 ml sample

If the leading number is missing, then that size of particle is not counted.

Scale Number	More than	Up to
28	1,300,000	2,500,000
27	640,000	1,300,000
26	320,000	640,000
25	160,000	320,000
24	80,000	160,000
23	40,000	80,000
22	20,000	40,000
21	10,000	20,000
20	5,000	10,000
19	2,500	5,000
18	1,300	2,500
17	640	1,300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	4	10
9	2.5	4
8	1.3	2.5
7	0.64	1.3
6	0.32	0.64
5	0.16	0.32
4	0.08	0.16
3	0.04	0.08
2	0.02	0.04
1	0.01	0.02
0	0	0.01

1.5.11.20 -> Cam Life tab

2D-Cam > Cam Life tab

To **Calculate Cam Life**, you must :

Parameters tab

STEP 1: Enable Show Roller and Cam Life

STEP 2: Enter a Safety Factor (Cam)

See Parameters tab > 405 ENABLE LIFETIMES, EDIT SAFETY-FACTOR 403

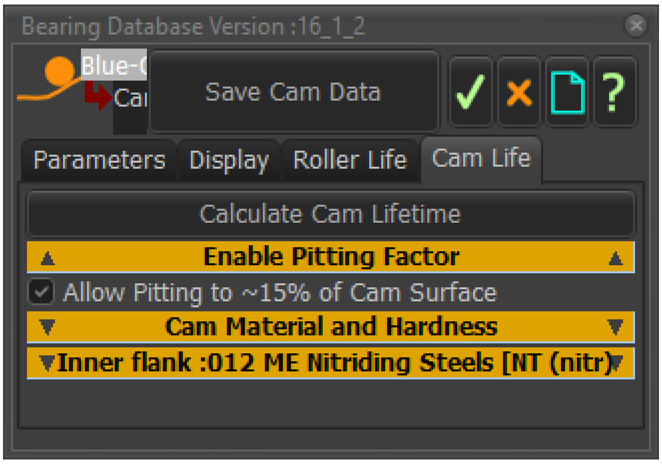
Cam Life tab

STEP 1: Enable / Disable "Allow Pitting to ~15% of the Cam Surface"

STEP 2: Select a Steel Category, Heat-Treatment, and Steel Quality for the Cam

STEP 3: Enter the Steel's Hardness as HV, HB, or HRC, within the Minimum and Maximum Hardness Limits

Review the Cam's Lifetime



2D-Cam dialog > Cam Life tab

Cam Life: tab

ENABLE PITTING FACTOR

Allow Pitting to ~15% of Cam Surface?

These steels categories allow pitting: Categories 1, 2, 3, 4, 6, 8, 9, 10, and 11 (See Cam Life Results below)

These steel categories allow so-called **non-progressive pitting**, in which a small amount of pitting occurs, and then it stabilizes.

If you allow up to ~15% pitting, the cam-life is extended.

When to allow pitting?

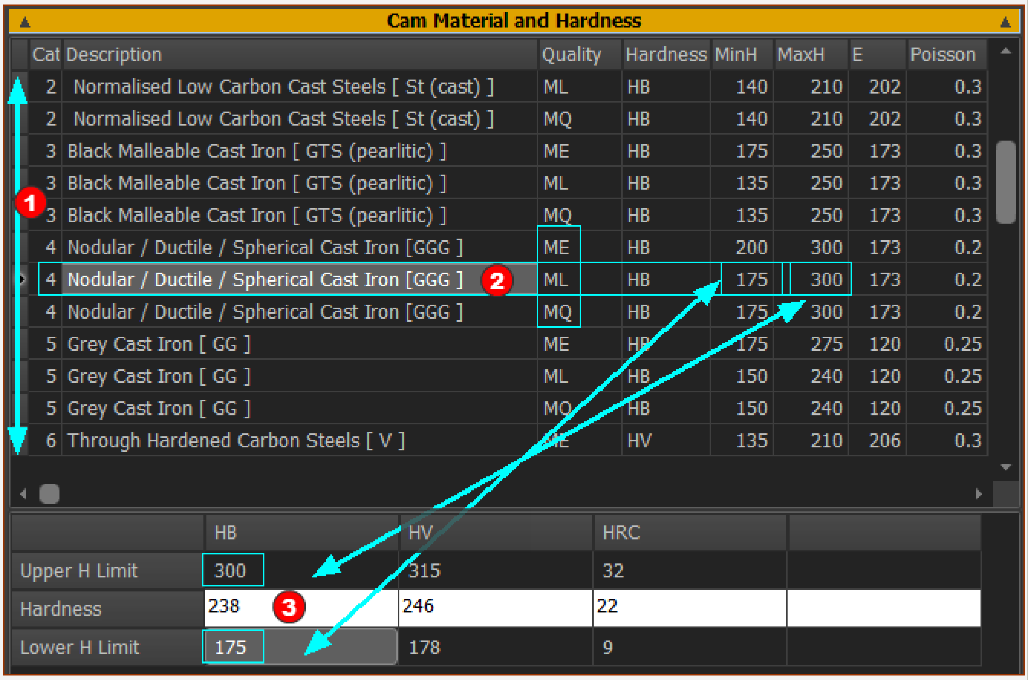
No: In **mission-critical** applications, for example **manned flight**.

No: if this is a new and important application.

Maybe: You have experience with the application and pitting has not occurred.

Yes: You have experience with the application and pitting has occurred and then stabilized.

CAM MATERIAL AND HARDNESS



Cam Material and Hardness

Cat	Description	Quality	Hardness	MinH	MaxH	E	Poisson
2	Normalised Low Carbon Cast Steels [St (cast)]	ML	HB	140	210	202	0.3
2	Normalised Low Carbon Cast Steels [St (cast)]	MQ	HB	140	210	202	0.3
3	Black Malleable Cast Iron [GTS (pearlitic)]	ME	HB	175	250	173	0.3
3	Black Malleable Cast Iron [GTS (pearlitic)]	ML	HB	135	250	173	0.3
3	Black Malleable Cast Iron [GTS (pearlitic)]	MQ	HB	135	250	173	0.3
4	Nodular / Ductile / Spherical Cast Iron [GGG]	ME	HB	200	300	173	0.2
4	Nodular / Ductile / Spherical Cast Iron [GGG]	ML	HB	175	300	173	0.2
4	Nodular / Ductile / Spherical Cast Iron [GGG]	MQ	HB	175	300	173	0.2
5	Grey Cast Iron [GG]	ME	HB	175	275	120	0.25
5	Grey Cast Iron [GG]	ML	HB	150	240	120	0.25
5	Grey Cast Iron [GG]	MQ	HB	150	240	120	0.25
6	Through Hardened Carbon Steels [V]	ME	HV	135	210	206	0.3

	HB	HV	HRC	
Upper H Limit	300	315	32	
Hardness	238	246	22	
Lower H Limit	175	178	9	

Enter the Hardness as HB, HV, or HRC

Select a Steel Category, Heat-Treatment, and Quality

❶ There are 14 Steel/Cast-Iron and Heat-Treatment categories, each with 3 Quality levels (ML,MQ,ME) - identical to the ISO 6336-5 Standard for Gears.

STEELS CATEGORIES AND HEAT-TREATMENT - see Example steels of each Steel Category 433.

1. Normalized, Low-Carbon Wrought-Steels[a] - St
2. Normalized, Low-Carbon, Cast-Steels[a] - St(cast)
3. Black Malleable Cast-Iron - GTS (perl)
4. **Nodular Spheroidal Cast-Iron - GGG** (e.g. ❷ in image above)
5. Grey Cast-Iron - GGG
6. Through-Hardened Wrought Carbon-Steel[b] - V
7. Through-Hardened Wrought Alloy-Steels[b] - V
8. Through-Hardened Cast Carbon-Steel - V(cast)
9. Through-Hardened Cast Alloy-Steel - V(cast)
10. Case-Hardened Wrought-Steels[c] - Eh
11. Flame or Induction-Hardened Wrought or Cast-Steels (IF)
12. Nitrided Nitriding Wrought-Steels[d] - NT(nitr)

13. Through-Hardened Nitrided-Steel[b] - NV(nitr)

14. Through-Hardened Nitro-Carburized Wrought-Steel[e] - (NV (nitr-car)

---

a - ISO 4948-2 (ISO10020) Part 2 - Classification of unalloyed and alloy steels according to main quality classes and main property or application

b - ISO 683-1 - Heat-treated Steels, alloy steels and free-cutting steel Part 1 - Quenched and Tempered unalloyed steels

c - ISO 683-11 - Heat-treated Steels, alloy steels and free-cutting steel Part 11 - Wrought Case Hardening steels

d - ISO 683-10 - Heat-treated Steels, alloy steels and free-cutting steel Part 1 - Quenched and tempered unalloyed steels

e - **ISO 683-1**, **ISO683-10**, or **ISO 683-11**

STEEL QUALITY❷

The **Steel Quality Standards** are:

ML - Modest demands on the material quality and the heat treatment process.

MQ - Material Quality and Heat-Treatment standards met by experienced manufacturer.

ME - High degree of reliability of Material Quality and Heat-Treatment process.

The requirements to be met for different steel qualities include: Chemical Analysis, Melting Practice, Surface Crack Detection after machining, and Hardness. Sometimes, to confirm the analysis a test piece is prepared and heat-treated together with cam - See ISO 6336-5.

Enter the Steel's Hardness within the High and Low Hardness Limits

❸ Enter a Hardness value in the HB, HV, or HRC hardness scale - see image above

The default Hardness is the average of the Upper and Lower Hardness Limits

The **Hardness** you enter must be within the **Upper Hardness Limit** and **Lower Hardness Limit**. The limits are specified in ISO 6336-5.

Lower H Limit ≤ Actual Hardness (HB, HV, HRC) ≤ Upper H Limit

In the example above, you can enter a Hardness in the range of **175-300HB**, **178-315HV**, or **9-32HRC**.

When you enter a Hardness value under one of the **Hardness Scales**, the other two **Hardness Scales** update automatically.

Cam-Life Results

INNER / OUTER FLANK + STEEL CATEGORY # , QUALITY, AND CATEGORY NAME

Cam Life - Inner flank : 010 ME Case Hardened Steels [Eh]		
Quantity	Valid Data	Units
Contact Stress (Max.)	862.11288	[MPa]
Dynamic Contact Stress(Max.)	862.11288	[MPa]
Allowable Contact Stress(Max.)	1650	[MPa]
Dynamic / Allowable (Max. Contact Stress)	0.52249265	Ratio
Depth at Max. Stress	0.10278249	[mm]
Shear Stress(Max.)	268.36295	[MPa]
Dynamic Shear Stress(Max.)	268.36295	[MPa]
CamLife N	10000	[10^6 Rotations]
CamLife Hrs	641025.64	[Hrs]
CamLife Yrs	73.176443	[Yrs]

The Orange Separator indicates the Flank, Steel Category, Steel Quality, Heat-Treatment Type and/or Steel-Type with Steel Acronym are indicated in the separator.

E.G: INNER FLANK: 004 ML NODULAR / DUCTILE / SPHERICAL CAST IRON (GGG)

Flank : Inner

Steel Category : 004

Steel Quality : ML

Steel Name : Nodular / Ductile / Spherical Cast Iron

Steel Acronym : GGG

THE RESULTS ARE:

Maximum Contact Stress (MPa - Mega-Pascals)

When you select the Follower-Roller - see Roller-Life tab[411] - we can use the combined Geometry and Materials of the Cam and the Follower-Roller to calculate the maximum contact-stress.

Maximum Dynamic Contact-Stress - (MPa - Mega-Pascals)

Maximum Contact-Stress × Safety Factor - see **Parameters tab > Enable Lifetime, Edit Safety-Factor**[405]

Maximum Allowable Contact Stress

A property of the **Steel-Category**, **Heat-Treatment**, and **Steel Quality** that you select, together with the **Surface Hardness** that you enter - see above **Cam Materials and Hardness**[429] ❸

Dynamic / Allowable (-)

Ratio of **Maximum Dynamic Contact-Stress : Maximum Allowable Contact Stress.**

We apply the ratio to the **Y-axis** on the plot of **Life(X-axis) vs Ratio of Dynamic/Allowable(Y-axis)** - see plot below. Each Steel Category has a different plot.

Depth of Max Shear Stress (mm)

The **Maximum Shear-Stress** is below the surface. The Depth of Maximum Shear-Stress is a function of the size and shape of the contact between the Follower-Roller and Cam-Profile.

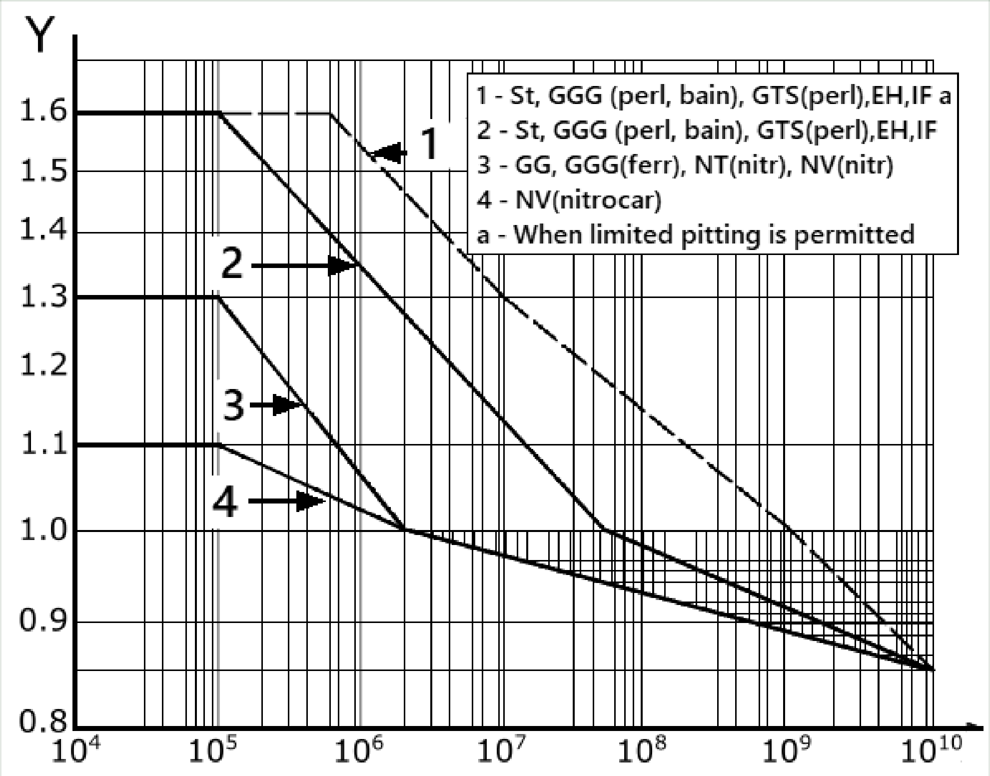
Recommended: **Minimum Depth of Surface-Hardness > ~2 × Depth of Maximum Shear-Stress**.

Maximum Shear Stress

Approximately 0.78 x Maximum Contact-Stress (depending on the contact geometry).

Dynamic Shear-Stress

Maximum Shear-Stress x Safety-Factor - see Parameters tab > Enable Lifetime, Edit Safety-Factor 403



S-N (Log-Log) Curves for different Steel Categories (based on ISO 6336)
Y-axis = Maximum Dynamic Contact-Stress/Allowable Contact-Stress of Steel, Quality, Hardness
X-axis = Life in Number of Machine-Cycles

Cam Lifetime:

Y (in graph below) = Maximum Dynamic Contact Stress / Allowable Contact Stress

Y=1, Cam Lifetime = 1.

1 Life of Steel Categories in Graph 1: 1.0 × 10^9 cycles,

1 Life of Steel Categories in Graph 2: 5.0 × 10^7cycles;

1 Life of Steel Categories in Graph 3: 5.0 × 10^6 cycles

1 Life of Steel Categories in Graph 4: 5.0 × 10^6 cycles

Y > 1, Cam Lifetime is reduced.

Y < 0.85, Cam Lifetime is infinite (Greater than 10^10 cycles, 10 billion cycles)

Life < 10^5 cycles, fatigue does not apply.

Cam-Life, N (Millions of Cam Rotations)

Millions of Cycles, 99% reliability.

Maximum - 10,000,000,000 (10^{10} rotations / 10 billion)

Cam-Life, Hrs.

Number of Hours, based on Millions of Cam-Life Rotations and Machine Speed (RPM).

Cam-Life, Yrs.

Number of Years, based on 8760 hours per year.

Steel Categories and Example Steels (mostly ISO 6336-5)

Examples Steels that PSMotion have assigned to the different steel and cast-iron categories. You must check that your steel is in the correct-category.

STEEL / CAST IRON CATEGOR-IES	MATERIAL TYPE (AB-BREVI-ATION)	STEEL QUAL-ITY	HARD-NESS RANGE	EXAMPLE STEELS NOT FROM ISO 6336
Normalized Low Carbon Steels & Cast Steels (St (cast)) $\sigma_U < 800MPa$	Wrought, normalized, Low Carbon Steels (St)	ML, MQ	110 - 210 HB	St50.2, 1.0050, E295 St60-2, 1.0060, E335 St70-2, 1.0070, E360
		ME	110 - 210 HB	
	Cast Steels (St (cast))	ML, MQ	140 - 210 HB	GE200, 1.0420 GE240, 1.0446 GE300, 1.0558
		ME	140 - 210 HB	
Cast Irons	Black Malle-able Cast Iron (pearl-itic struc-ture) (GTS (perl))	ML, MQ	135 - 250 HB	EN-GJMB-350-10 : HB 150 EN-GJMB-500-5 : HB 165-215 EN-GJMB-600-2 : HB 195-245 EN-GJMB-700-2 : HB 240-290
		ME	175 - 250 HB	
	Nodular Spheroidal Pearlitic Bainitic Fer-ritic Cast Iron (GGG (perl, bai, ferr))	ML, MQ	175 - 300 HB	EN-GJS-400-15 : HB 135-180 EN-GJS-500-14 : HB 170-215 EN-GJS-600-10 : HB 190-230 EN-GJS-700-2 : HB 210-305 EN-GJS-800-2 : HB 240-335 EN-GJS-900-2
		ME	200 - 300 HB	
	Grey Cast Irons	ML, MQ	150 - 240 HB	EN-GJL-200, GG20 EN-GJL-300, GG30

STEEL / CAST IRON CATEGOR-IES	MATERIAL TYPE (AB-BREVI-ATION)	STEEL QUAL-ITY	HARD-NESS RANGE	EXAMPLE STEELS NOT FROM ISO 6336
	(GG)	ME	175 - 275 HB	EN-GJL-350, GG35 EN-GJL-400, GG40
Through-Hardened Wrought Steels Nominally >0.2%C $\sigma_U \geq 800MPa$	Carbon Steels (V)	ML	135 - 210 HV	C40E, 1.1186 C45E, 1.1191, 1045,
		MQ	135 - 210 HV	
		ME	135 - 210 HV	
	Alloy Steels (V)	ML	200 - 360 HV	42CrMo5, 1.7225
		MQ	200 - 360 HV	
		ME	200 - 390 HV	
Through-Hardened Cast Steels Nominally > 0.2%C $\sigma_U \geq 800MPa$	Carbon Steels (Low to Medium) (V (cast))	ML, MQ	130 - 215 HV	100Cr6
		ME	130 - 215 HV	
	Alloy Steels (V (cast))	ML, MQ, ME	200 - 360 HV 200 - 360 HV	G25CrMo4, G34CrMo4, G35CrNiMo6-6 G42CrMo4 :1.7231
Case Hardened Wrought Steels	< 0.25%C (Eh)	ML	600 - 800 HV	C14E/C10R/C15E/C15R/ 17Cr3 (1.7016, AISI 5115) 16MnCr5 (1.7131), 5115, 8620 18CrMo4 20MnCr5 (1.7147) 15NiCr13 (1.5752) 17CrNi6-6 (1.5918) 18CrNiMo7-6 (1.6587) 20NiCrMo2-2, 22CrMoS3-5 18NiCrMo5 17NiCrMo6-4, EN36 - 1.5752 - 14NiCr4, SAE8620, 14NiCrMo13-4, AISI 9310, 1.6657 655M13 EN39B(835M15), 15NiCrMo16-5, SNCM815.
		MQ	660 - 800 HV	
		ME	660 - 800 HV (58-64HRC)	
Flame or Induction Hardened	>0.25%C (IF)	ML, MQ, ME	485 - 615 HV	34Cr4 (1.7033) (530M32) 41Cr4, 34CrNiMo6 43CrMo4(1.3563)

STEEL / CAST IRON CATEGORIES	MATERIAL TYPE (ABBREVIATION)	STEEL QUALITY	HARDNESS RANGE	EXAMPLE STEELS NOT FROM ISO 6336
Wrought or Cast Steels			500 - 615 HV 500 - 615 HV	
Nitrided Wrought steels Through Hardened, Nitrided	Nitriding Steels (NT(nitr.))	ML	650 - 900 HV	EN40B, EN41B, Nitralloy, N135M 31CrMo12, 42CrMoV12, 38CrAlMo 31CrMoV9. 905M39
		MQ	650 - 900 HV	
		ME	650 - 900 HV	
	Through Hardening Steels NV(nitr.))	ML, MQ, ME	450 - 650 HV 450 - 650 HV 450 - 650 HV	32CrMoV13 (Quench And Hardened)
Wrought Steels Nitro-Carburized	Through Hardening Steels (NV(nitro-car)	ML	300 - 650 HV	100CrMnSi6-4 (CarboNitriding)
		MQ	300 - 450 HV	
		ME	450 - 650 HV	

ML - limited demands on the material quality, number and type of inclusions, and on the material heat treatment process during gear manufacture.

MQ - requirements met by experienced manufacturers at moderate cost

ME - requirements realized when a high degree of operating reliability is required.

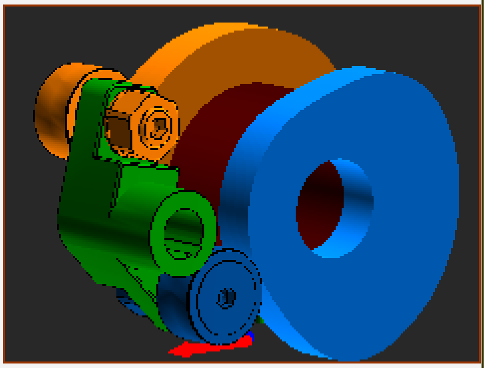
Refer to ISO 6336-Part 5 for **ML, MQ, ME** steels qualities.

1.5.11.21 Dialog: Conjugate-Cam-FB

Conjugate-Cam FB

See: Add Conjugate Cam FB 165 .

What is a Conjugate Cam?



A Conjugate Cam pair

Conjugate Cams (typically two Cams) rotate on one shaft, with each cam in contact with a **Follower-Roller**, and in which the **Follower-Rollers** are rigidly attached to one **Follower-Part**.

For example: In the image, the blue and orange Cams rotate together on one shaft (the shaft is hollow!). The blue **Cam-Profile** is in continuous contact with the blue Follower-Roller, and the orange **Cam-Profile** is in continuous contact with the orange **Follower-Roller**. The two **Follower-Rollers** are rigidly attached to the green **Follower-Part**.

Why use a Conjugate Cam FB?

Typically, one **Cam** is the Power-Source for the **Follower-Part** and kinematic-chain.

However, if **Conjugate Cams** are the Power-Source, you must add, edit, and configure a CONJUGATE CAM FB and then select the CONJUGATE-CAM FB as the **Power-Source**. Only then should you do the force and stress analysis.

GROOVE CAMS are also conjugate-cams. However, you cannot use the Inner and Outer flanks of ONE 2D-CAM as the **Conjugate-Cams**.

In a machine, a **Groove Cam** may use one or two **Follower-Rollers**.

To model a Groove-Cam and also complete its force and stress analysis, you need to add two co-axial **Follower-Rollers** and two Cams. You must select the **Inner Cam** as one Cam-Profile, and the **Outer Cam** as the Conjugate Cam-Profile.

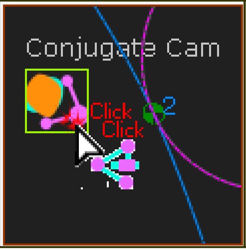
Then add, edit and select the Inner and Outer Cams in the CAM-CONJUGATE DIALOG, and select the CAM-CONJUGATE FB as the Power-Source.

Cam Work-flow

Action	Help Topic
1. Add a 2D-Cam	see Add 2D-Cam 128
If the new 2D-CAM is one of a pair of Conjugate-Cams, or it is one flank of a Groove-Cam:	

Action	Help Topic
1.a. Add a CONJUGATE-CAM FB	see Add Conjugate Cam FB 165
1.b. Edit the CONJUGATE-CAM FB to select the two 2D-CAMS.	see Conjugate-Cam dialog 436
2. Select a 2D-CAM or a CONJUGATE-CAM FB as the Power Source for the kinematic-chain that includes the Follower	see Configure-Power Source 589
3. Review the 2D-CAM : Display, Properties, Roller-Life, Cam-Life, ...	see 2D-Cam dialog 401
4. Add a Cam-Data FB	see Add Cam-Data FB 199
5. Edit the CAM-DATA FB to link it to a 2D-CAM - close the dialog	see Cam-Data dialog 440
6. Connect wires from the output-connectors of the CAM-DATA FB to a GRAPH FB	
7. Analyze the 2D-CAM	see Cam-Data dialog : Cam Analysis 440
8. Edit the CAM-DATA FB again to calculate the Cam's Coordinates	see Cam-Data dialog : Cam-Coordinates 446

How to open a Conjugate Cam dialog



To open the CONJUGATE-CAM DIALOG:

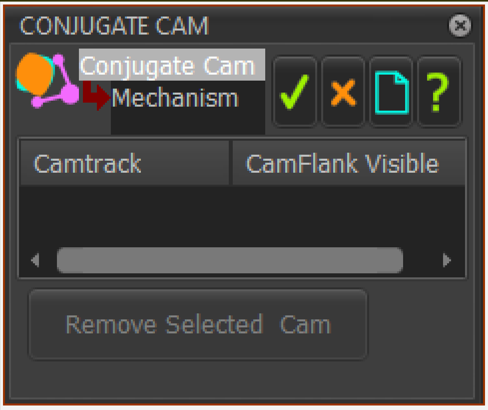
1. Double-click the CONJUGATE-CAM FB

OR

1. See How to Open a dialog 627

The CONJUGATE-CAM DIALOG is now open.

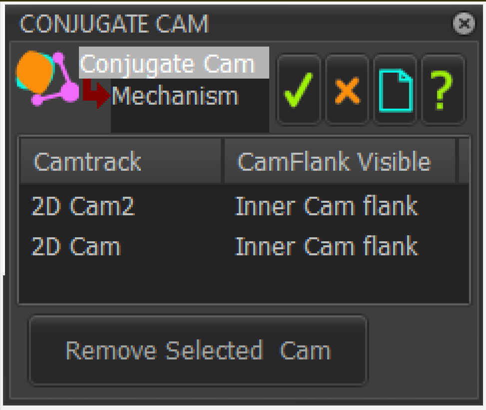
Conjugate-Cam dialog



Conjugate-Cam dialog

In the graphics-area or ASSEMBLY-TREE:

1. Click a 2D-CAM
2. Click a different 2D-CAM



The two **2D-CAMS** are in one kinematic-chain and must be capable of being the Power-Source for one other kinematic-chain.

Each **2D-CAM** drives the **Inner-Cam-Flank** OR the **Outer Cam-Flank**.

3. Click ✓ to close the dialog.

Note 1 : If the **2D-CAMS** you select do **not** drive the same **Follower-Part**, you get this message in the Feedback Area.

Message

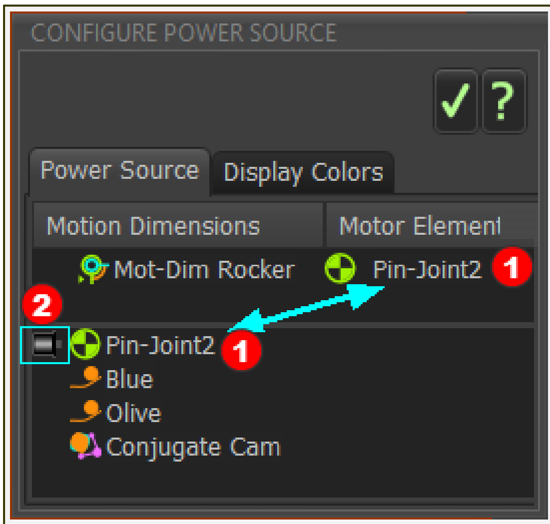
Count	Topic	Message
29	Conjugate Cam	Camtrack does not share follower with previous camtrack

To do **Force Analysis** of the **Conjugate Cams**, you must select the **CONJUGATE-CAM FB** in the **CONFIGURE POWER SOURCE DIALOG**.

To remove a 2D-Cam

1. Select the **2D-CAM** in the list
2. Click Remove Selected Cam

Select Conjugate Cam in the Configure Power Source dialog



DEFAULT: Configure Power Source dialog

Configure the Power Source

1. Click the **Kinematics-Tree** tab in the ELEMENT-EXPLORER
2. Click the **Kinematics-Chain** that includes the **Follower Part**
3. Right-click the **Kinematic-Chain**
4. Click **CONFIGURE POWER-SOURCE** to open the CONFIGURE POWER-SOURCE DIALOG - **see image above**

The PIN-JOINT ❶ is the **DEFAULT** Motor Element (**Power-Source**) - **see image above**

Notice also the **Motor Symbol**❷ to the left of the PIN-JOINT - **see image above**

In the CONFIGURE POWER-SOURCE DIALOG - **see image below**

5. Click the CONJUGATE CAM❸ in the list of elements - **see image below**

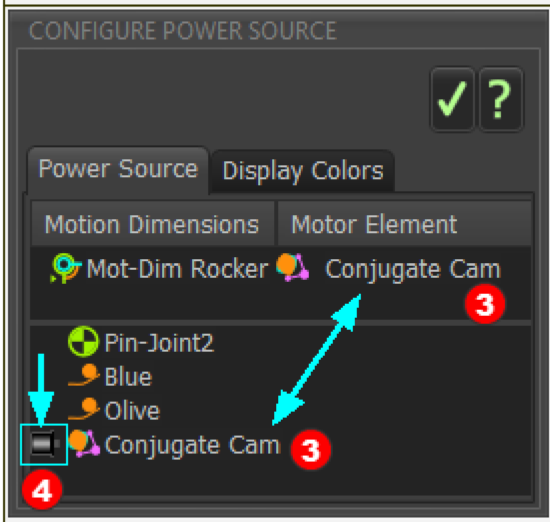
The CONJUGATE-CAM❸ replaces the PIN-JOINT as the Motor Element❸ (**Power-Source**) - **see image below**

Notice the **Motor Symbol**❹ is now to the left of the CONJUGATE-CAM - **see image below**

---

6. Click ✅ to close the dialog.

Now you can do **Contact-Force Analysis** for the **Conjugate-Cams**.



Conjugate-Cam as the Power-Source

1.5.11.22 Dialog: Function-Block: Cam-Analysis

Cam-Data FB > Cam-Analysis

To analyze a 2D-Cam:

Action	Step in this topic:
1. Add a Cam-Data FB	see STEP 1[199]
2. Link the Cam-Data FB to a 2D-Cam	see STEP 2[440]
3. Connect wires to a Graph FB	see STEP 3[442]

STEP 1: Add Cam-Data FB

To add a **CAM-DATA FB** to the graphics-area:

1. Click Kinematics FB toolbar[169] > **Cam-Data FB**

OR

1. Click **Function-Blocks menu > Cam-Data (FB)**

2. Click the graphics-area

The **CAM-DATA FB** is now in the graphics-area and **ASSEMBLY-TREE**.

Note:

Typically, add a **CAM-DATA FB** for each **2D-CAM** in your model.

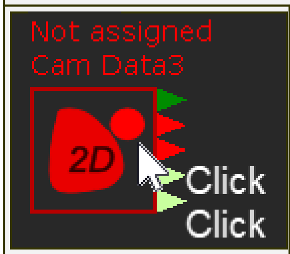
TOP-TIP - if there is more than one **2D-CAM** in your model

1. Edit the color of each **2D-CAM** in your model
2. Rename the element-name of the **2D-CAM** to its color
3. AND, rename element-name of each **CAM-DATA FB** that you link to a **2D-CAM** to the same color as the **2D-CAM**.

STEP 2: Link the Cam-Data FB to a 2D-Cam

To link the **CAM-DATA FB** to a **2D-CAM**, you must first open the **CAM-DATA DIALOG**.

To open the **CAM-DATA DIALOG**:



1. Double-click the **CAM-DATA FB**

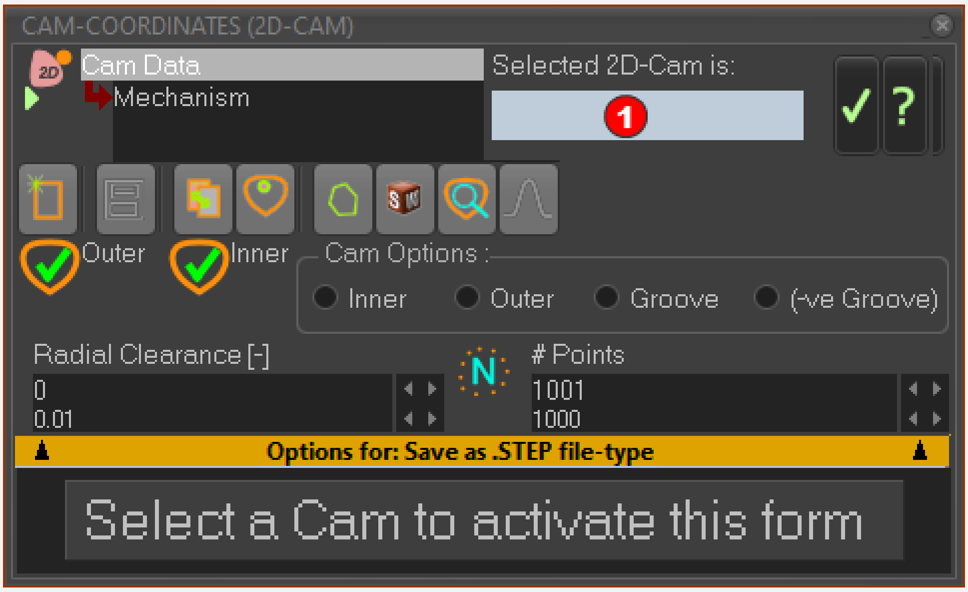
OR

1. **See How to open a dialog**[627]

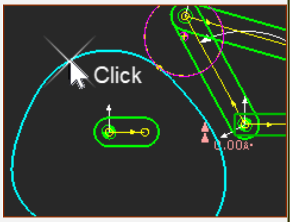
The **CAM-DATA DIALOG** is now open - see image below.

You can see that the name of a **2D-CAM** element is not in the **SELECTED 2D-CAM IS** box❶.

Also, see the message "**Select a Cam to activate this form**".



Cam-Data dialog - 2D-Cam "Not Seleted"



Click to select a 2D-Cam

To select a **2D-CAM**:

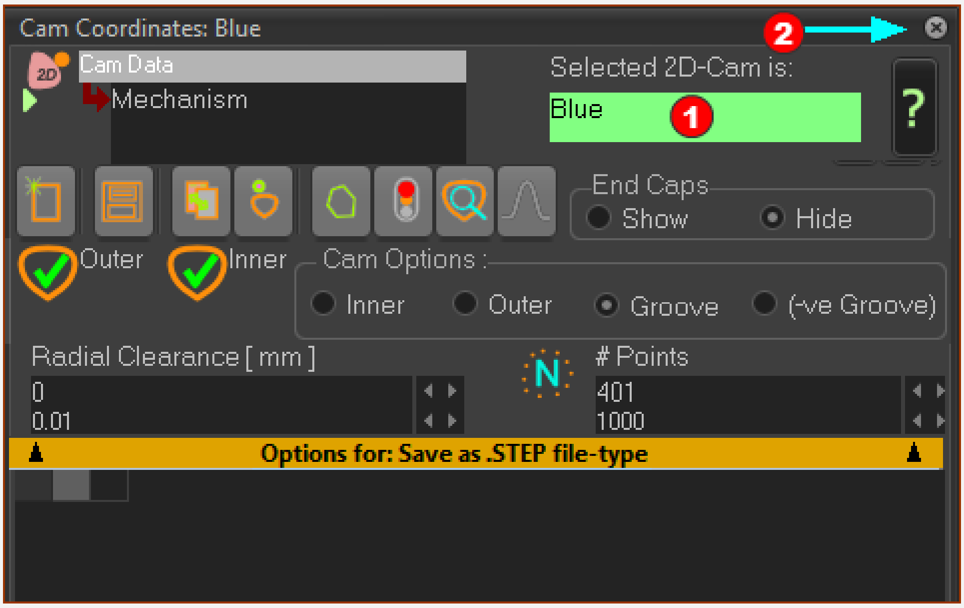
2. Click a **2D-CAM** in the graphics-area or the **ASSEMBLY-TREE**

The **2D-CAM** is now in the Selected 2D-Cam is box - see ❶ in image below.

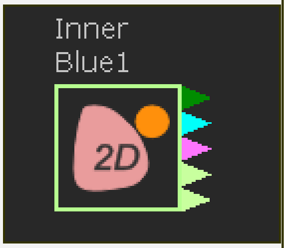
3. Click ❷ (⊗) to close the **CAM-DATA DIALOG**,

OR

3. **See Calculate Cam-Coordinates** 446



Cam-Data FB : The name of the selected 2D-Cam is "Blue".



RESULT:

In the graphics-area, the caption above the **CAM-DATA FB** has two parts:

- **Top** (**Inner** in the example): the last calculated **Flank** of the **2D-CAM** that you have selected.
- **Bottom Line** (**Blue** in the example): the element-name of the **CAM-DATA FB** - see **TOP-TIP**

You can:

- **Analyze 5 Cam parameters - see** **Cam-Analysis Parameters** [442]
- **Calculate the Cam's Coordinates - see** **Cam-Coordinates dialog** [446]

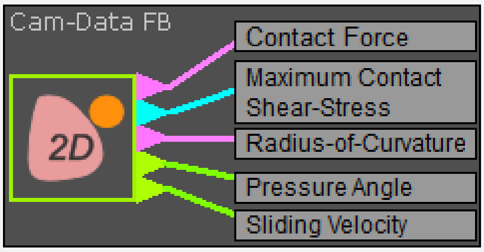
TOP-TIP:

If you have many **2D-CAMS** in your model, you can make it easier to see which **CAM-DATA FB** is linked with which **2D-CAM**.

1. Edit the color of a **2D-CAM** - **see** **2D-Cam dialog : Display tab** [407] > **DISPLAY OPTION**
2. **AND** rename the **2D-CAM** to the color of the **2D-CAM** - **see** **Rename element** [335]
3. **AND** rename the **CAM-DATA FB** that has a link with a **2D-CAM**, to the color of the **2D-CAM**

Now, it is easier to see in the graphics-area and the **ASSEMBLY-TREE**, the link between **2D-CAMS** and **CAM-DATA FBS**

STEP 3: Connect wires to a Graph FB



Analysis Parameters from Cam-Data FB

The output-connectors from the **CAM-DATA FB** provide over a machine-cycle:

- **F : CONTACT FORCE** : see Note 1 [443]
- **Ʈ : MAXIMUM CONTACT SHEAR STRESS** : See Note 2 [443]
- **ρ : RADIUS-OF-CURVATURE** : see Note 3 [443]
- **μ : PRESSURE ANGLE** : see Note 4 [444]
- **Ue : SLIDING VELOCITY** : see Note 5 [444]

Drag wires from the output-connectors of the **CAM-DATA FB** to a **GRAPH FB** [202], a **MATH FB** [509] or a **STATISTICS FB** [209]

Make sure you select the correct Cam-Profile (INNER, OUTER, or PITCH-CENTER PATH) in the Y–AXIS DISPLAY OPTION 204 of the GRAPH FB interface.

Note 1: CONTACT-FORCE

Configure the Power Source 589 before you analyze the CONTACT-FORCE.

> If, in a GRAPH FB, the CONTACT-FORCE is $0.0\ N$ for a machine-cycle, and the **Configure Power Source** is correct, change the GRAPH FB > Y-AXIS DATA-CHANNELS 479 from INNER to OUTER, or vice versa.

Note 2: MAXIMUM CONTACT SHEAR-STRESS

Configure the Power Source 589 before you analyze the MAXIMUM SHEAR-STRESS.

> If in a GRAPH FB, the SHEAR-STRESS is $0.0\ Nm^{-2}$ for a machine-cycle, and the **Configure Power Source** is correct, change the GRAPH FB > Y-AXIS OPTIONS from INNER to OUTER, or vice versa.

About Maximum Contact Shear-Stress

> The **Maximum Shear Stress** is not at the surface of the Cam-Profile - it is a little below its surface. The depth below the surface is a function of the material properties and shapes of the contacting bodies, and the Contact-Force.
>
> To calculate MAXIMUM CONTACT SHEAR-STRESS, we assume that friction is zero and the Cam-Profile and Follower Profile are perfectly smooth.
>
> Also, we assume that the material properties of the Cam-Profile and the Follower-Profile are:
>
> - YOUNG'S MODULUS, $E = 210\ GPa$
> - POISSON'S RATIO, $\nu = 0.3$
>
> Or, if you calculate the LIFE OF THE ROLLER AND CAM, we take the properties from the Steel Category in **2D-Cam dialog** 428 **> Cam-Life tab**.
>
> In the **Cam-Life tab**, we calculate the MAXIMUM CONTACT-STRESS, MAXIMUM SHEAR-STRESS, and the DEPTH OF THE MAXIMUM SHEAR-STRESS.

Note 3: RADIUS-OF-CURVATURE

> By convention, the RADIUS-OF-CURVATURE (ROC) of a Follower-Roller is positive.
>
> When the cam is convex relative to the Roller, the ROC of the cam is positive.
>
> When the cam is concave relative to the Roller, the ROC of the cam is negative.
>
> RADIUS-OF-CURVATURE of the **Pitch-Curve** is not available. If you need to know the RADIUS-OF-CURVATURE of the PITCH-CURVE, export the RA-

DIUS-OF-CURVATURE of the INNER and OUTER cams to Excel, and calculate the average.

Note 4: PRESSURE ANGLE

The PRESSURE ANGLE is through the center of the **Follower-Roller**. There are two other PRESSURE ANGLES, which are the Contact Pressure Angle of the INNER and OUTER Cams - these are labeled as INSIDE CONT. PR, ANG and OUTSIDE CONT. PR, ANG in the Graph FB > Y-axis display options.

Use CONTACT PRESSURE ANGLE with **Flat-Faced Follower-Profiles**.

We do not calculate for you the PRESSURE ANGLE of a Stationary Cam.

Note 5: SLIDING-VELOCITY

The SLIDING-VELOCITY assumes the **Follower-Profile** does not roll, even if the Profile represents a Roller; it assumes it slides over the **Cam-Profile**. Use the SLIDING-VELOCITY to calculate the Film Thickness of the lubricating oil between the **Follower-Profile** and **Cam-Profile**. If you know the surface finish of the **Cam-Profile** and the **Follower-Profile**, you can also calculate the **Film Thickness Ratio**, λ. This is an important parameter as it strongly influences the life of the cam. A **Film Thickness Ratio** of less than 1 means that metal asperities of the Follower-Profile and Cam-Profile contact each other, and wear occurs.

Sliding Velocity = **(Velocity of Cam-Profile – Velocity of Follower-Profile)**

Entrainment Velocity = **(Velocity of Cam-Profile +Velocity of Follower-Profile)** ÷ **2**

Slip-Slide-Ratio = **Sliding-Velocity** ÷ **Entrainment Velocity**

TOP-TIP:

To plot and compare the PRESSURE-ANGLE for up to 4 × 2D-CAMS:

1. Add 4 × CAM-DATA FBS and 1 × GRAPH FB to the graphics-area.
2. Link the CAM-DATA FBS to 4 × 2D-CAms
3. Connect a wire from the PRESSURE-ANGLE output-connector of the 4 × CAM-DATA FBS to the 4 × Y-axis input-connectors of the 1 × GRAPH FB

Now, in the GRAPH FB, set the scale of the **Y-axes** to the same minimum and maximum values. Do this:

4. In the Graph Settings > TITLE AND INPUT SELECTION > Y-axis Input 481 drop-down, select SET ALL

In the Graph-Settings > Y-AXIS

5. Deselect AUTO-SCALE Y-AXIS

6. Enter 'soft-limits' for Y-MAXIMUM and Y-MINIMUM - e.g. for PRESSURE ANGLE, enter +30º and –30º respectively.

Now, it easier to compare the PRESSURE-ANGLES of all 4 × 2D-CAMS, and to see if the PRESSURE-ANGLE of a 2D-CAM is greater-than Y-MAXIMUM and/or less-than the Y-MINIMUM values.

Contact Force / Contact Shear-Stress

After you correctly Configure the Power Source 589, you can find the **Contact-Force** and **Contact Maximum Shear-Stress** between the Cam-Profile and the Follower-Roller.

There are four methods to

Display in the graphics-area:

METHOD 1: **Forces toolbar > Display Force-Vectors** 237 button.

Two equal and opposite Force-Vectors radiate from the Contact-Point between the Cam-Profile and the Follower-Roller. They are:

- the force vector that ACTS-ON the Follower-Profile and Follower-Part
- the force vector that ACTS-ON the Cam-Profile and Cam-Part

You must analyze if the force between the Cam-Profile and the Follower-Profile is active or not active (less than zero Newtons).

METHOD 2: Use: 2D-Cam dialog > Display tab > Cam Display Options > Contact-Force 408 .

Plot with a Graph-FB:

METHOD 3: Add a Force-Data FB 230, select the 2D-CAM as the FORCE ELEMENT, plot with a GRAPH FB.

METHOD 4: Use the CAM-DATA FB to plot CONTACT FORCE from the top output-connector with a GRAPH FB.

Contact-Force is = 0 N if Contact-Force ≤ 0 N.

Note:

METHOD 4 is best if you need to know if the Contact-Force is less than or equal to zero

1.5.11.23 Dialog: Function-Block: Cam-Coordinates

Cam-Data FB > Cam-Coordinates

See Add Cam-Data FB 128

Use a CAM-DATA FB to:

Calculate the INNER, OUTER, and/or PITCH-CENTER Cam-Profiles as:

- XY-Points
- BiArcs

Export a Cam-Profile directly to SOLIDWORKS as XY-Points or BiArcs.

Save the Cam-Coordinates to your hard-drive with these file types:

- .TXT - XY-Points and BiArcs
- .CSV - XY-Points and BiArcs - see Note
- .DXF - XY-Points or BiArcs
- .SLDCRV (import SOLIDWORKS as XYZ Curve
- .STP : see OPTIONS FOR: SAVE AS CAM AS A STEP FILE 452

Note:

CSV delimiter (List Separator) - see Application-Settings > Number Format tab > Data Output Format > List Separator / Delimiter Option 341

We calculate for you and export the **Cam-Coordinates** for the 2D-CAM:

- from CAM-START (default = 0)
- to CAM+START + CAM-RANGE (default = 360)

Edit the 2D-CAM to edit these parameters in 2D-CAM DIALOG - PARAMETERS TAB 403 .

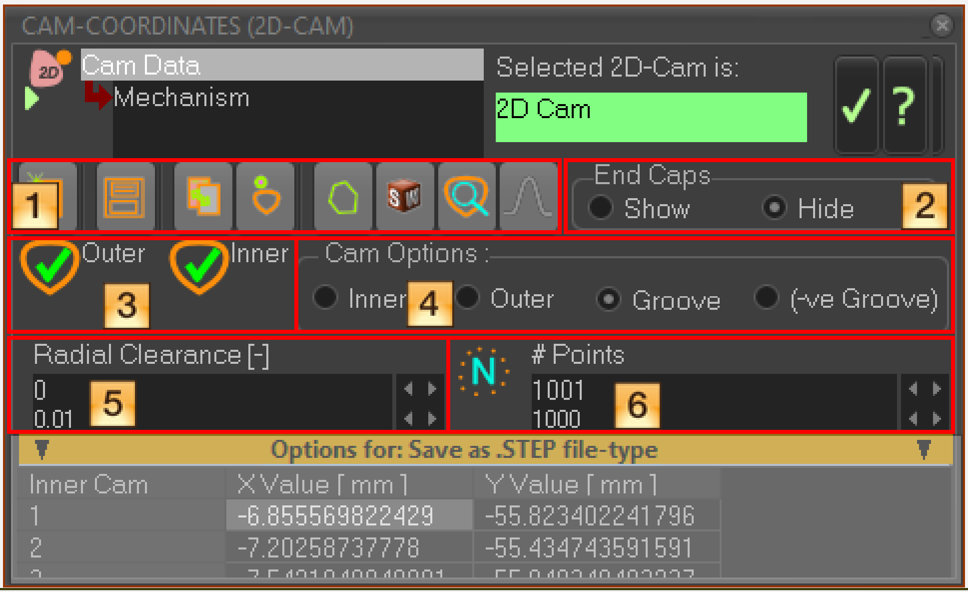
Cam Work-flow

Action	Help Topic
1. Add a 2D-Cam	see Add 2D-Cam 128
If the new 2D-CAM is one of a pair of **Conjugate-Cams**, or it is one flank of a **Groove-Cam**:	
1.a. Add a CONJUGATE-CAM FB	see Add Conjugate Cam FB 165
1.b. Edit the CONJUGATE-CAM FB to select the two 2D-CAMS.	see Conjugate-Cam dialog 436
2. Select a 2D-CAM or a CONJUGATE-CAM FB as the Power Source for the kinematic-chain that includes the Follower	see Configure-Power Source 589
3. Review the 2D-CAM : **Display, Properties, Roller-Life, Cam-Life, ...**	see 2D-Cam dialog 401
4. Add a Cam-Data FB	see Add Cam-Data FB 199
5. Edit the CAM-DATA FB to link it to a 2D-CAM - close the dialog	see Cam-Data dialog 440

Action	Help Topic
6. Connect wires from the output-connectors of the CAM-DATA FB to a GRAPH FB	
7. Analyze the 2D-CAM	see Cam-Data dialog : Cam Analysis 440
8. Edit the CAM-DATA FB again to calculate the Cam's Coordinates	see Cam-Data dialog : Cam-Coordinates 446

Cam-Data dialog: Cam-Coordinates

If you see "**Select a Cam to activate this form**", then click a 2D-CAM in the ASSEMBLY-TREE or graphics-area to link it to the CAM-DATA FB - **see** Cam-Analysis 440



1 - **Cam-Coordinates toolbar** (see toolbar 447 1 **below**)

2 - **End-Caps** - shows **ONLY** when the first XY-coordinate of the Cam is not equal the last XY-coordinate. For example, a linear Slot-Cam.

3 - **Inner / Outer** - status of the cams after the Cam-Coordinate calculations (**see** **Cam Status** 450)

4 - **Cam Options** - calculate, display, and/or save the cam-profile coordinates for the INNER, OUTER, GROOVE, or NEGATIVE GROOVE cam-type. NEGATIVE GROOVE is for a STEP file only.

5 - **Radial Clearance** - offset the Cam-Profile from the true Cam-Profile.

6 - **# Points** - calculate as **XY-Points** (see toolbar 447 1 5 **below**)

OR

6 - **BiArc Error** - calculate as **BiArcs** (see toolbar 447 1 5 **below**)

See also: OPTIONS FOR: SAVE AS STEP FILE-TYPE 452.

1 Cam-Coordinates toolbar:

Click icon 5 to switch between XY-Points and BiArcs.

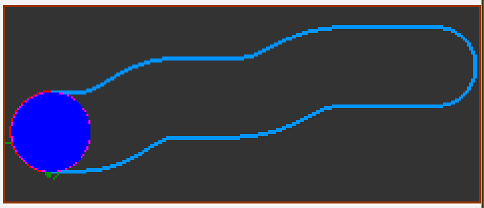
1		**Clear ALL coordinates from the table**
2		**Save Cam-Coordinate data as:** • STP(STEP)- **XY Points** 5 **only** • DXF • CSV • TXT • SLDCRV (SOLIDWORKS Curve file, tab delimited) - XY Points + Z-data = 0 **Note:** If this icon is not enabled, then make sure the PLATE-RADIUS [452] parameter is larger than the **Maximum Radius** of the **Outer Cam**. OR: Click INNER or OUTER to recalculate the coordinates of a different Cam-Profile, then, click again the Cam you actually want. See STEP File Options [452].
3		**Copy the Cam-Coordinates to your clipboard**
4		If CAM OPTION 4 is GROOVE or NEGATIVE GROOVE, click 4 to toggle between:
4		Calculate Cam-Coordinates for the INNER **Cam-Profile.**
		Calculate Cam-Coordinates for the OUTER **Cam-Profile.**
		Calculate Cam-Coordinates for the PITCH-CURVE (XY-POINTS **only).**
5		Click 5 to toggle how we calculate the Cam-Coordinates for you. Calculate as:
5		XY-POINTS You enter the # POINTS 6 (NUMBER-OF-POINTS) We calculate the **XY Coordinates** of the **Cam-Profile** for the NUMBER-OF-POINTS at equal increments of the MASTER MACHINE ANGLE.
		BIARCS (**see BiArcs**)

		You enter the BIARC ERROR 6 We calculate the **BiArcs** so that the maximum error between the cam we calculate and the true **Cam-Profile** is less than, or equal to, the BIARC-ERROR.
6		Before you click this button, make sure that **SOLIDWORKS** is open and the active **SOLIDWORKS** document is a part document (.SLDPRT). We export the **BiArcs** to SOLIDWORKS as **Arc** sketch entities, OR We export the **XY-Points** to SOLIDWORKS and instruct **SOLIDWORKS** to use the **XY-Points** to add a **Curve** feature. In a SOLIDWORKS sketch, you can use **Convert-Entities** to convert the **Curve** feature to a **Spline** sketch entity. **See also** Note 4 456
		Usually, we calculate for you the **XY Points** automatically Usually, we calculate for you the **Bi-Arcs** automatically, but it takes more time to complete. If the TRAFFIC-LIGHT is RED, click the TRAFFIC-LIGHT icon again.
7		Display a preview of the **Cam-Profile**.
8		**Read-only** - the cam is “Open” or the cam is “Closed”.

2 End Caps

End Caps relate only to **Slot-Cams**, also known as **Linear-Cams**, or **Ramp-Cams**.

Top-Tip - Save a Slot-Cam as a STEP file if it will not transfer to SOLIDWORKS.



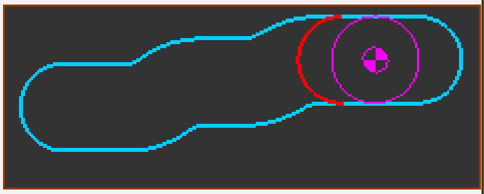
End-Caps - Show

SHOW or HIDE END-CAPS

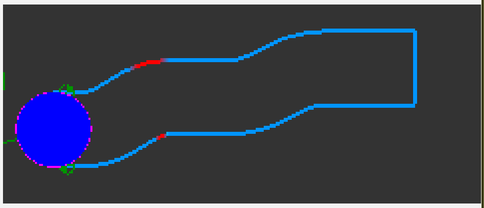
End-Caps work well when the independent axis to the Follower moves in one direction only - **see image “End-Caps - Show”**

If the independent axis changes its direction in the middle of its travel, you see **False End-Caps** in the middle of the **Slot-Cam**. - **see image: “Slot-Cam with 'False' End-Caps”**.

Before you export Cam-Coordinates we recommend you add a **dummy** slot-cam - **and move the main axis of the Slot-Cam in one direction at Constant-Velocity, over one machine-cycle.**



Slot-Cam with 'False' End-Cams



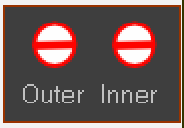
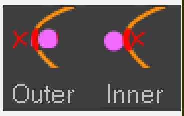
End-Caps - Hide

To make sure the Constant-Velocity is correct:

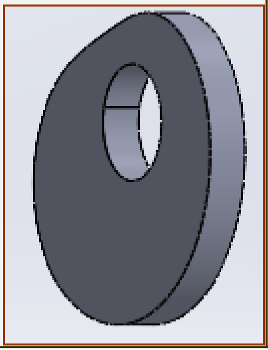
1. Connect a wire from a LINEAR-MOTION-FB to a GEARING FB
2. In the GEARING FB, enter a GEARING RATIO = LINEAR TRAVEL DISTANCE OF SLOT-CAM / 360).
3. Connect a wire from the GEARING FB to the MOTION-DIMENSION FB as the motion of the **Slot-Cam**.

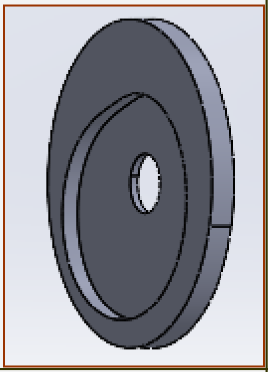
As the **MMA** increases from 0 to 360, the Cam travels from 0 to MAXIMUM TRAVEL DISTANCE OF CAM (mm).

3 Cam Status

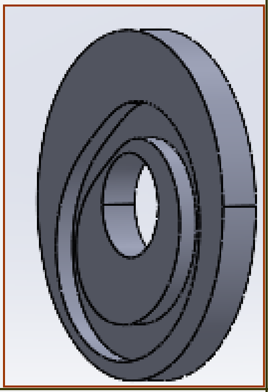
	The cam-coordinates have been calculated. The **Radius-of-Curvature** is greater than the CAM ROC SOFT-LIMIT parameter - see 2D-Cam dialog 403
	The cam-coordinates have not been calculated - Usually after you change from # POINTS to BIARC ERROR, or vice-versa.
	It is not possible to calculate the cam-coordinates correctly, Possibly because of undercutting.
	The cam-coordinates have been calculated. The Cam's **Radius-of-Curvature (RoC)** is **less** than CAM ROC SOFT-LIMIT parameter - see 2D-Cam dialog 403 - **Undercutting is possible**.

4 Cam Options

Calculate, Display, and/or Save the Cam-Coordinates:	
	• INNER **Cam-Profile ONLY**

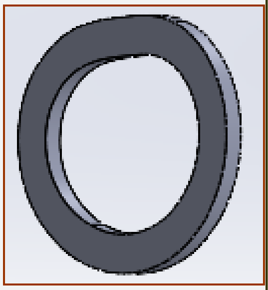


- OUTER Cam-Profile ONLY



- GROOVE-CAM

If you select GROOVE-CAM AND if you toggle 1 5 to XY-POINTS, then you can also toggle 1 4 to calculate the PITCH-CIRCLE coordinates.



- NEGATIVE-GROOVE

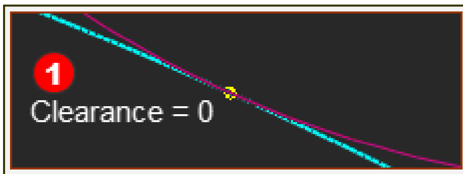
The **Negative-Groove** option applies only when you save the Cam as a STEP file-type - **see** 1 2.

The STEP file is the space filled by the path of the **Follower-Roller** along the **Cam-Profile** (plus Radial Clearance).

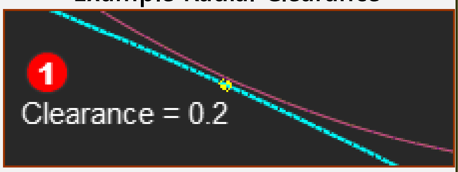
Note:

This is not the same as a **Rib Cam**. You need to model a **Rib-Cam** with Follower-Rollers, with one each side of the Rib.

5 Radial-Clearance



Example Radial-Clearance



Cam with 0.2mm Radial Clearance

See also : 2D-Cam dialog > Parameters tab > Cam Range and Radius 403

RADIAL CLEARANCE (MM) Default = 0 , Negative or Positive

Positive Value - we re-calculate the cam for you to give a **clearance** between the Follower-Profile and the Cam-Profile.

AND:

Negative Value - we re-calculate the cam for you to give an **interference** between the Follower-Profile and the Cam-Profile.

APPLICATIONS:

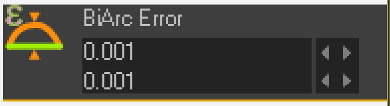
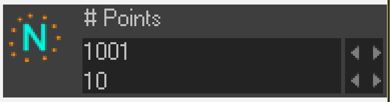
Groove-Cam - add clearance (**Positive Value**) for a Follower-Roller in a Groove cam-type (See **Note**)

Conjugate-Cam - to add a small clearance (**Positive Value**) to compensate for tolerances in the cam assembly.

Rough-Cut - to oversize an Inner-Cam or undersize an Outer-Cam for a Rough-cut. RADIAL-CLEARANCE should be a **Negative-Value**

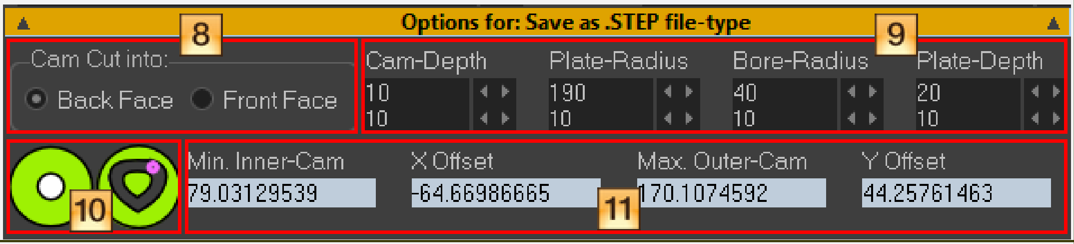
Note: Frequently, Stud-type **Follower-Rollers** have a dimensional tolerance negative bias - for example, $0 - 50\mu m$. You may consider that to be enough clearance.

6 Cam-Coordinates

 **Max Chord-Error with BiArcs**	**1 5 set to calculate as BiArcs** Apply this maximum BiArc-Error between the **Cam-Profile** we calculate with **BiArcs** and the true cam-profile.
 **Number of XY Points**	**1 5 set to calculate as XY-Points** Calculate these number of points for the Cam-Profile at equal increments of the MASTER-MACHINE ANGLE.

OPTIONS FOR: SAVE AS .STEP FILE-TYPE

Edit these parameters before you save a cam as a STP (STEP) file.



8 - FRONT FACE, BACK FACE - the face to cut the **Groove-Cam** into the **Cam-Plate** **(see more 9 below)**

9 - Dimensions of the **Cam-Plate** **(see more 9 below)**

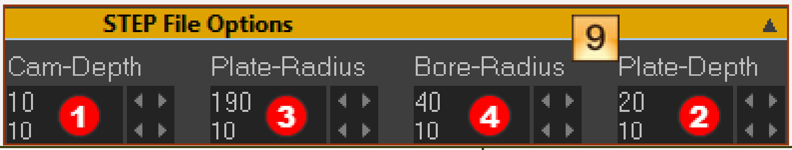
10 - Schematics to indicate the Cam type, and if the PLATE-RADIUS and BORE-RADIUS are suitable **(see more 9 below)**

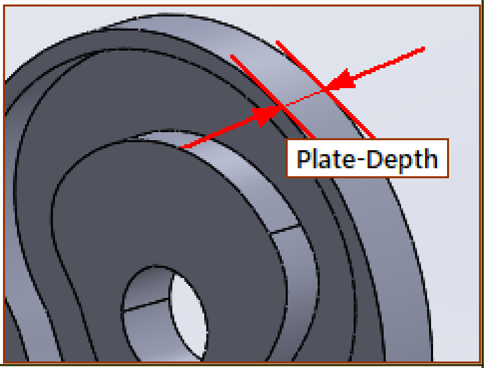
11 - Stationary Cam only - enter an X-OFFSET and Y-OFFSET to move the center of the Cam-Plate **(see more 11 below).**

11 - MIN(minimum) INNER-CAM and MAX(maximum) OUTER-CAM (read-only) - radii of the INNER and OUTER **Cam-Profiles. They should** help you specify the PLATE-RADIUS and BORE-RADIUS **(see more 9 below)**

9 Dimensions for STEP file ONLY

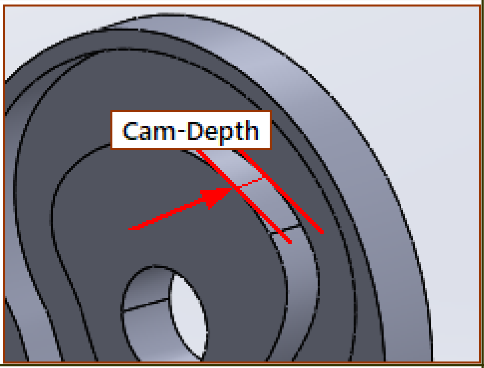
These images show the features of a **Groove-Cam** that has been exported and opened in **SOLIDWORKS**:





❷ **PLATE-DEPTH**

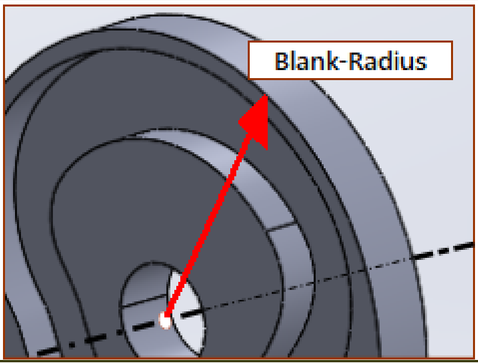
The total depth, or thickness, of the **Cam-Plate**.



❶ **CAM-DEPTH**

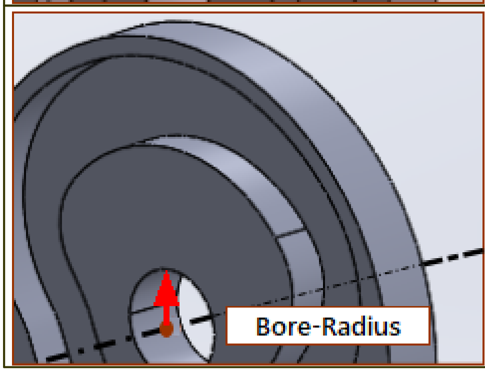
The depth of the **Groove Cam** cut into the **Cam-Plate**. The width of the Cam-Flanks.

Minimum **PLATE-DEPTH** – **CAM-DEPTH** ≥ **2** mm



❸ **PLATE-RADIUS**

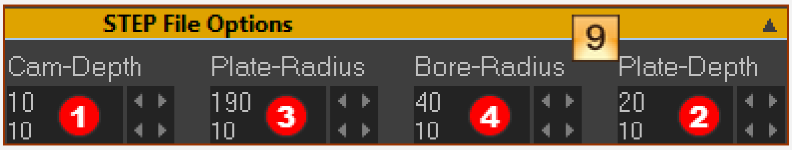
The radius of the **Cam-Plate**, when you select: **OUTER** or **GROOVE-CAM**



❹ **BORE-RADIUS**

The radius of the hole through the center of the **Cam-Plate**.

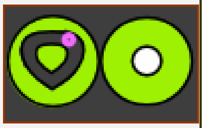
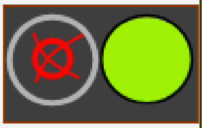
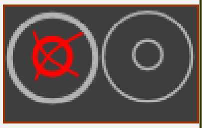
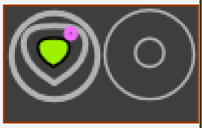
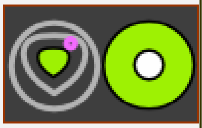
10 Schematics of Cam type; Are the Dimensions OK or Not-OK?

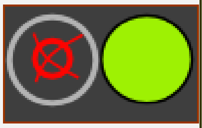
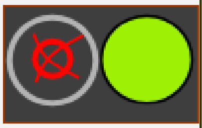


Status of Cam, Blank-Radius and Bore-Radius relative to Cam-Size

The PLATE-RADIUS ❸ parameter applies to **Outer** and **Groove Cams** only 4

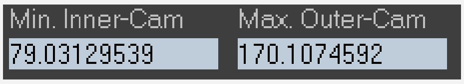
The BORE-RADIUS ❹ parameter applies to all Cam types 4

	4 GROOVE-CAM ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11
	4 GROOVE-CAM ❸ PLATE-RADIUS is **NOT OK** - it is less than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11
	4 GROOVE-CAM ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **NOT OK** - it is greater than the **Minimum Radius of the Inner Cam** 11
	4 GROOVE-CAM ❸ PLATE-RADIUS is **NOT OK** - it is less than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **NOT OK** - it is greater than the **Minimum Radius of the Inner Cam** 11
	4 INNER-CAM ONLY ❸ PLATE-RADIUS is **0mm** ❹ BORE-RADIUS is **0mm** - the Cam does not include a Hole through its center
	4 INNER CAM ONLY ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11

	4 INNER-CAM ONLY ❸ PLATE-RADIUS is **NOT OK** - this dimension is ignored with INNER Cams 4 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11 You can save the STEP file.
	4 INNER-CAM ONLY ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **NOT OK** - it is greater than the **Minimum Radius of the Inner Cam** 11 You can NOT save the STEP file.
	4 OUTER-CAM ONLY ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11
	4 OUTER CAM ONLY ❸ PLATE-RADIUS is **NOT OK** - it is less than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11 You can NOT save the STEP file.
	4 OUTER-CAM ONLY ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **NOT OK** - it is greater than the **Minimum Radius of the Inner Cam** 11 You can save the STEP file.
	4 NEGATIVE GROOVE-CAM ❸ PLATE-RADIUS is **OK** - it is greater than the **Maximum Radius of the Outer Cam** 11 ❹ BORE-RADIUS is **OK** - it is less than the **Minimum Radius of the Inner Cam** 11

11 Minimum/Maximum Radius of Cams, Offset X and Offset Y.

- MIN INNER-CAM - Minimum radius of Inner Cam
- MAX. OUTER-CAM - Maximum radius of Outer Cam (see also 9)

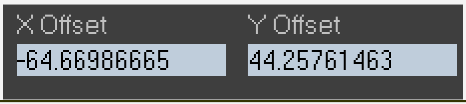


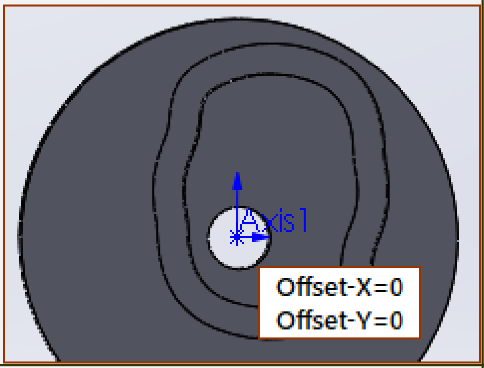
These values are useful to know when you want to make sure there is a minimum difference between the:

- BORE-RADIUS and the minimum radius of the INNER Cam.
- PLATE-RADIUS and the maximum radius of the OUTER Cam.

X-OFFSET and Y OFFSET

When the Cam is stationary, enter an X-OFFSET and Y-OFFSET to move the center of the Cam-Plate relative the 0,0 of the MECHANISM-PLANE / BASE-PART.

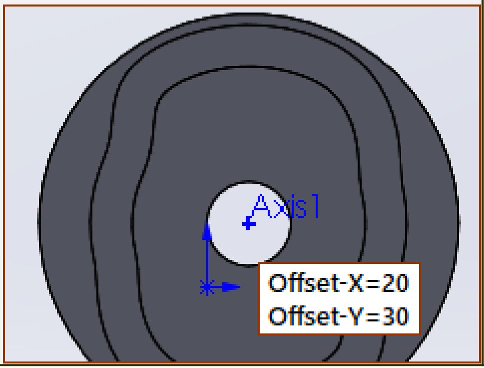




X OFFSET = 0, Y OFFSET = 0

Read-only if the Cam is a not stationary.

Image left: the **Blank-Radius** and **Blank-Bore** with **Offset-X=0,-Y=0.**



X OFFSET = 20, Y OFFSET = 30

Image left: the **Blank-Radius** and **Blank-Bore** with Offset-X=20,Y=30.

The maximum radius of the **Blank-Bore** can be increased, and the minimum radius of the **Blank-Radius** can be decreased.

Notes:

Note 1: When the **Cam-Part** for a 2D-CAM is a rotating-Part (e.g. a **Cam-Shaft**), make sure that the START-POINT) of the rotating-Part is at the PIN-JOINT of the the Coordinates to the

Note 4: Cam-Data and SOLIDWORKS.

When you export the Cam-Profile directly to SOLIDWORKS, the Cam will be coplanar with the Front-Plane of the SOLIDWORKS part document.

To move the Cam-Profile to a different Plane - XY-Points:

1. Calculate the Cam-Profile as XY-Points
2. Save it as a SLDCRV file-type.
3. Open the SLDCRV file in EXCEL - the cam-coordinates use the A, B, and C columns for the X, Y, and Z cam-coordinates, respectively. Z co-ordinates are all 0s.
4. To move the Cam to the:
   a. TOP Plane: Move the C column to the D column, the B column to the C column, and the D column to the B-column (that is, swap the B and C columns)
   b. RIGHT Plane: Move the C column to the D column, the B column to the C column, move the A column to the B column, and the D column to the A column (that is, swap the A and C columns)
   c. (and/or) To mirror the cam: Multiply the X-column data by –1)
5. Save the Data as a CSV (MS-Dos) file
6. Close the file in EXCEL
7. Use Windows File Explorer to rename the file to **file-name.SLDCRV**
8. In SOLIDWORKS, do **Insert > Curve > Curve Through XYZ Points...** and browse to **file-name.SLDCRV**

To move the Cam-Profile to a different Plane - Bi-Arcs:

After you export the BiArcs to SOLIDWORKS, you can Right-Click the BiArcs sketch, and select 'Edit Sketch Plane' to move the sketch to a different Plane.

Note5: The Cam as **BiArc Data** has six columns:

1	2	3	4	5	6
Arc Radius mm	Arc Start Point X Coordinate	Arc End Point X Coordinate	Arc Start Point Y Coordinate	Arc End Point Y Coordinate	Arc Angle Range Degrees

1.5.11.24 Dialog: Function-Block: Linear-Motion

Linear-Motion FB

See Add Linear-Motion FB 170

The default motion-value at the output-connector from a **LINEAR-MOTION FB** is equal to the Master-Machine-Angle (MMA).

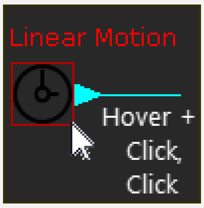
$$[\![MMA + a]\!] \Longrightarrow y_{out}$$

Use the **LINEAR-MOTION DIALOG** to edit a.

The parameter, a, advances or delays the output relative to the **Master-Machine-Angle**.

The **LINEAR-MOTION FB** does not have an input-connector.

How to open the Linear-Motion dialog-box



To open the **LINEAR-MOTION DIALOG**

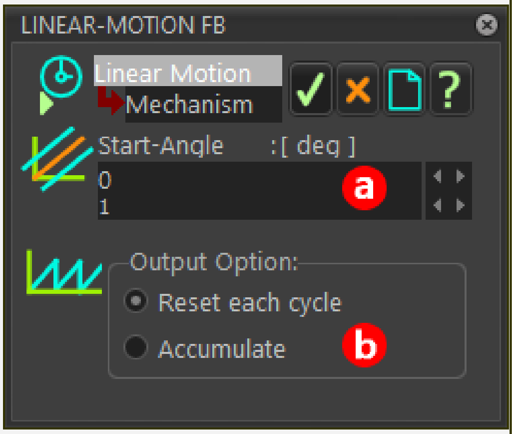
1. Double-click the **LINEAR-MOTION FB** in the graphics-area.

OR

1. **See How to Open a dialog** 627

The **LINEAR-MOTION DIALOG** is now open.

Linear-Motion dialog



Linear Motion FB dialog

START-ANGLE ⓐ

Units are **degrees**

Enter degrees as any real number.

A positive value advances the output relative to the **MMA**.

A negative value delays the output relative to the **MMA**.

OUTPUT-OPTIONS ⓑ

⦿ **RESET EACH CYCLE** (default)
Output = Master Machine Angle + START-ANGLE ⓐ

⦿ **ACCUMULATE**
Output = (Revs × 360) + MMA + START-ANGLE ⓐ

1.5.11.25 Dialog: Function-Block: Gearing

Gearing FB

See Add Gearing FB 172

A **GEARING FB** applies a mathematical function to the data-values at its input-connector to give different data-values at its output-connector.

The **GEARING FB** does not change the units of the data.

The **GEARING FB** can modify the data-values of all data-types.

$x_{in} \Rightarrow [\![a(x+b)+c]\!] \Rightarrow y_{out}$

Use the **GEARING FB DIALOG** to edit parameters a, b, and c.

a : "Gearing Ratio"

b : "Add before Gearing Ratio"

c : "Add after Gearing Ratio"

The default values of a, b, and c do not change the output relative to the input motion-values.

How to open the Gearing FB dialog-box

To open the **GEARING FB DIALOG**

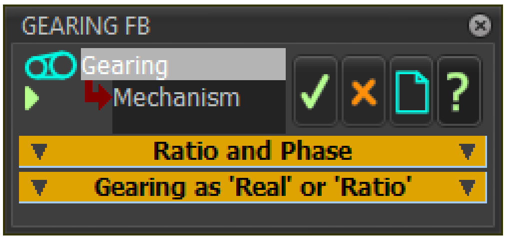
1. Double-click the **GEARING FB** in the graphics-area.

OR

1. See How to Open a dialog 627

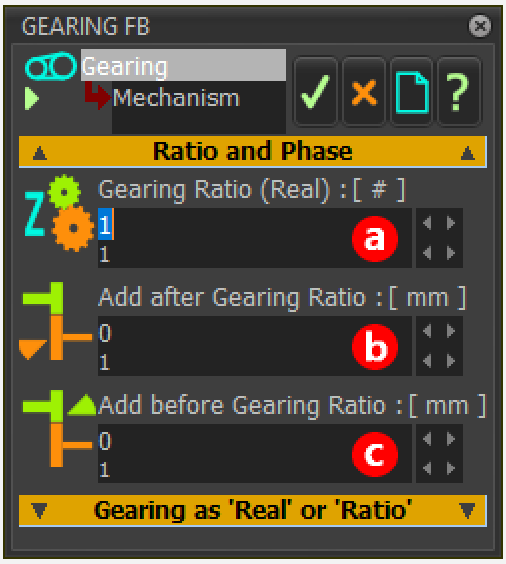
The **GEARING FB DIALOG** is now open.

Gearing FB dialog



Gearing FB dialog

RATIO AND PHASE



Ratio and Phase

Gearing mathematical function

The **GEARING FB** has three parameters that you can edit.

The output from the **GEARING-FB** is:

$$Output = (a * (input + c)) + b$$

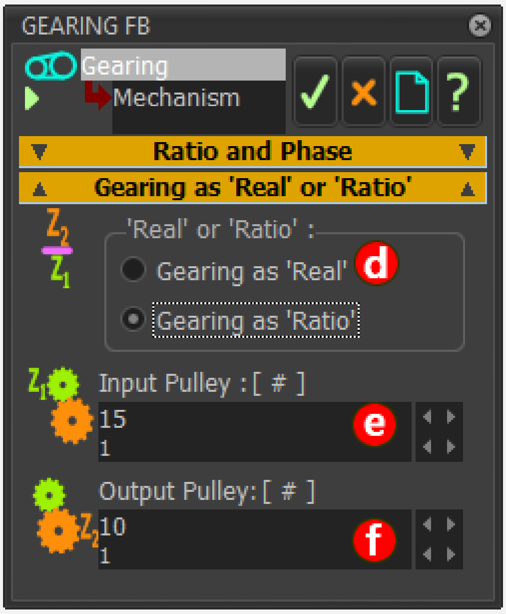
The flow of motions-values from input, through the Gearing FB, to the output is:

$$x_{in} \Rightarrow [\![a(x_{in} + b) + c]\!] \Rightarrow y_{out}$$

Gearing Parameters

- a GEARING RATIO (maximum = 32,000; minimum = –32,000). **See also** d **in** GEARING AS 'REAL' OR 'RATIO'.
- b ADD AFTER GEARING RATIO (maximum = 10,000; minimum = –10,000)
- c ADD BEFORE GEARING RATIO (maximum = 10,000; minimum = –10,000)

GEARING AS 'REAL' OR 'RATIO'



Gearing as Ratio of Pulley Teeth

d Enter the GEARING RATIO in two ways: "REAL "or "RATIO"

- ⊙ GEARING AS 'REAL'
- ⊙ GEARING AS 'RATIO'

If you select GEARING AS "REAL" :

Enter:

a GEARING RATIO as a ± real number - **see above**

If you select GEARING AS "RATIO" :

Enter the number of teeth on the:

e INPUT PULLEY as ± integer, and 0

AND

f OUTPUT PULLEY as + integer, minimum =1

We will calculate:

a GEARING RATIO = e INPUT PULLEY / f OUTPUT PULLEY

Example:

a GEARING-RATIO = 1.5

b ADD AFTER GEARING-RATIO = 83

c ADD BEFORE GEARING-RATIO = 23

If motion-value at input is= 37

$$Output = [1.5 \times (37 + 23)] + 83 = 173$$

Motion-value at output-connector is = 173

1.5.11.26 Dialog: Function-Block: Motion

Motion FB

see Add Motion FB 173

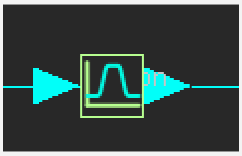
A **MOTION FB** links to a motion that you select from the motions that you have designed in **MotionDesigner**.

The motion-value at the input-connector to the **MOTION FB** points to the **X-axis** of the motion you select. The motion-value at the output-connector from the **MOTION FB** corresponds to the **Y-axis** value of the motion.

$$x_{in} \Rightarrow [\![Motion(x)]\!] \Rightarrow y_{out}$$

Use the **MOTION FB DIALOG** to select the $Motion$ from a list of the **Motion-names** in **MotionDesigner**.

How to open the Motion FB dialog



Motion FB

To open the **MOTION FB DIALOG**

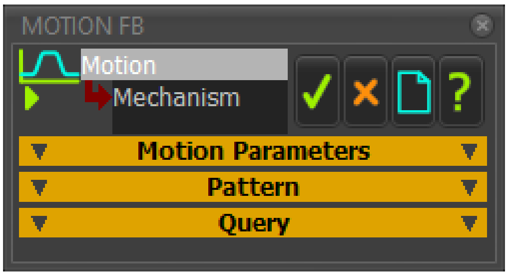
1. Double-click a **MOTION FB** in the graphics-area

OR

1. **See How to Open a dialog** 627

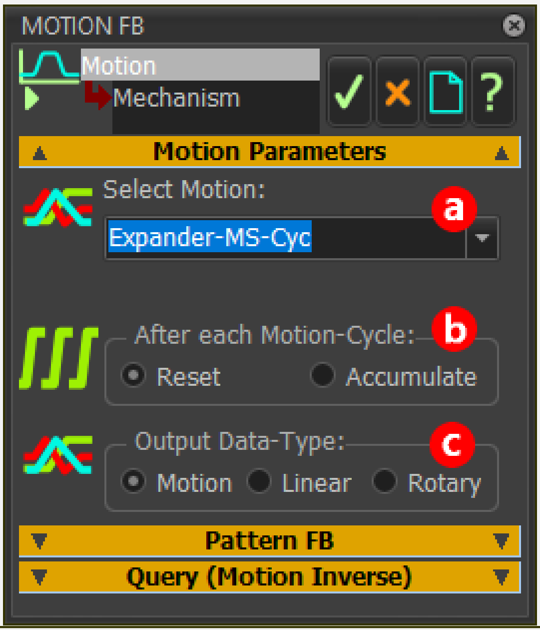
The **MOTION FB DIALOG** is now open.

Motion FB dialog



Motion FB dialog

MOTION PARAMETERS



SELECT MOTION ⓐ

Click the drop-down arrow ⓐ to select a motion. The names in the list are the names of the **Motion-name tabs** in **MotionDesigner**.

Default motion: We select for you the left-most name of the **Motion-name tabs.**

AFTER EACH MOTION CYCLE ⓑ

A **Machine-Cycle** is one cycle of the **Master-Machine Angle** from 0 to 360.

You can increase the motion-values.

If the **X-axis** of the motion-design is from 0 to 360, and the Y-axis is a progressive (indexing) motion of one index, then if

⦿ RESET OUTPUT: **(default)**

Start Position of Machine-Cycles #N = Start Position of Machine-Cycle #1

⦿ Accumulate Output464 :

Start-Position of Machine-Cycles #N = End-Position of Machine-Cycles #N-1

* START-POSITION: See **MotionDesigner** > BLEND-POINT or SEGMENT EDITOR > Y-AXIS VALUES ...

OUTPUT DATA-TYPE ⓒ

⦿ MOTION (default, for ROCKERS and SLIDERS)

⦿ LINEAR *

⦿ ROTARY *

---

* You must select LINEAR or ROTARY if you connect a wire from the MOTION FB to a MOTION-PATH FB or a MATH FB.

Notes :

Usually, the motion-values at the input to a MOTION FB increases at a constant rate from 0 to 360, again and again.

However, the motion-values at the input may increase, decrease, and stay at a constant value, within one machine-cycle.

For example, the motion-data at the input to a MOTION FB can be from:

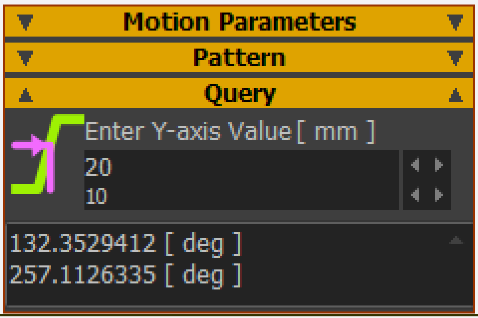
- a different MOTION FB, or
- a POINT-DATA FB 197, or
- a MEASUREMENT FB 193,

... in which case the motion-values may increase and decrease.

PATTERN

Ignore this separator

QUERY



ENTER Y-AXIS VALUE

The values in the box (below) are the **X-axis** values that relate to the Y-axis value for the SELECTED MOTION - see MOTION PARAMETERS

Note:

If we cannot find an X-axis value from the Y-AXIS VALUE that you enter, we will report "FAILED TO FIND ROOT : POSSIBLY OUTSIDE Y RANGE" at the bottom of the MOTION FB DIALOG.

Also in the **Message area**, we will report **Topic**: GET X-VALUE FAILURE ; **Message**: FAILED TO FIND ROOT

"Reset" or "Accumulate" after each Motion-Cycle?

We can explain with an example.

---

1. Design an **Indexing Motion** in **MotionDesigner** with two Segments:

   Segment 1: Index (X-axis: 0-240 ; Y-axis: 0-90)

   Segment 2: Dwell (X-axis: 240-360 ; Y-axis: 90)
2. Connect a LINEAR-MOTION FB to a GEARING FB
3. Connect the GEARING FB to a MOTION FB

4. Connect the **MOTION FB** to a **MOTION-DIMENSION FB** that controls a rotating **Motion-Part (Rocker)**.
5. Edit the **BASE-VALUE** in the **MOTION-DIMENSION** dialog to 0º.
6. Edit the **MOTION FB**:
   - Select the **Indexing Motion** (see 1, above)
   - Select **RESET** as the **AFTER EACH MOTION-CYCLE** parameter
7. Edit the **GEARING FB**:
   - Enter **GEARING RATIO = 4** (enter 4 because the motion is 0 to 90, and 4 × 90 = 360)
8. Cycle the model with **ALT+C** on your keyboard.

RESULT:

> As the **MMA** increases from 0 to 360, the:
>
> - output motion-values from the **GEARING FB** increase from 0 to 1440 (**GEARING RATIO** × 360)
> - output motion-values from the **MOTION FB** increase from 0 to 90, and jumps to 0
>
> Therefore, the indexing-shaft (Rocker) jumps to 0º four times, at the end of each machine-cycle, after it rotates to 90º.

9. Edit the **MOTION FB**.
   - Select **ACCUMULATE** as the **AFTER EACH MOTION-CYCLE** parameter.
10. Cycle the model with **ALT+C** on your keyboard.

RESULT:

> As the **MMA** increases from 0 to 360, the:
>
> - output from the **GEARING FB** increases from 0 to 1440 (**GEARING RATIO(4)** × 360)
> - indexing-shaft indexes 4 times: from 0 to 90, 90 to 180, 180 to 270, and 270 to 360.

1.5.11.27 Dialog: Function-Block: Motion-Dimension

Motion-Dimension FB

see Add Motion-Dimension FB 174

A **MOTION-DIMENSION FB** adds the motion-value at its input-connector to a constant we call the **BASE-VALUE**, to give the total motion-value at its output-connector.

We use the total to control the position of a **Motion-Part** - a **Rocker** or a **Slider**.

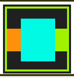
$$x_{in} \Rightarrow [\![(x_{in} + Base\,Value)]\!] \Rightarrow y_{out}$$

Use the **MOTION-DIMENSION DIALOG** to:

- edit the value of the constant, $Base\,Value$*
- optionally, negate $Base\,Value$
- optionally, negate x, the motion-value at the input-connector.

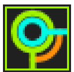
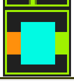
The Motion-Dimension FB icons in the graphics-area

There are two different icons in the graphics-area for a **MOTION-DIMENSION FB**. They are:

	A **MOTION-DIMENSION FB** that controls the **angular position** of a **Rocker**
	A **MOTION-DIMENSION FB** that controls the **linear position** of a **Slider**

How to open the Motion-Dimension dialog

To open the **MOTION-DIMENSION DIALOG**:

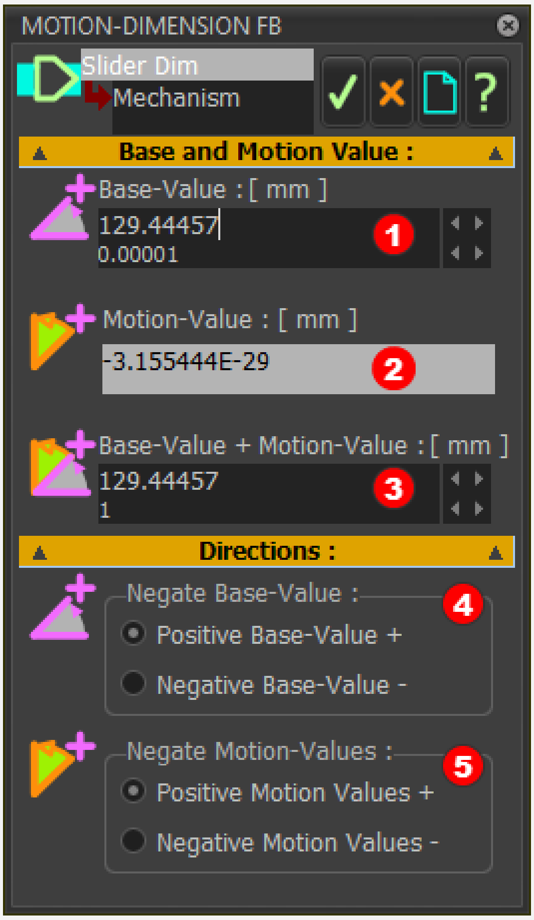
1. Double-click the Linear or Angular **MOTION-DIMENSION FB** in the graphics-area

OR

1. **See How to Open a dialog** 627

The **MOTION-DIMENSION DIALOG** is now open.

Motion-Dimension dialog



Motion-Dimension dialog

The **MOTION-DIMENSION** (of the **Rocker** or **Slider**) = BASE-VALUE❶ (read-write) + **(Input) Motion-Value**❷(read-only)

The motion-value at the output-connector is equal to the MOTION-DIMENSION.

BASE AND MOTION VALUES

❶ BASE-VALUE (read-write)

A constant that you can add to the motion-value at the input-connector.

❷ MOTION-VALUE (read-only)

The motion-value at the input-connector.

❸ BASE-VALUE + MOTION-VALUE (read-write)

BASE-VALUE + MOTION-VALUE = MOTION-DIMENSION at the output-connector.

DIRECTIONS

❹ NEGATE MOTION-VALUES

⦿ POSITIVE MOTION-VALUES : MOTION-VALUE × 1 (default)

⦿ NEGATIVE MOTION-VALUES : MOTION-VALUE × –1

❺ NEGATE BASE-VALUES

⦿ POSITIVE BASE-VALUE : BASE-VALUE × 1 (default)

⦿ NEGATIVE BASE-VALUE - BASE-VALUE × –1

Note:

The default positive direction of a:

Rocker is counter-clockwise

Slider is in the direction of the arrowhead on the SLIDE-JOINT. **See** **Positive Direction of Sliders** 188

1.5.11.28 Dialog: Function-Block: Motion-Path

Motion-Path FB

see Add Motion-Path FB [191]

The motion-values at the input-connector to a **MOTION-PATH FB** control the position of a **Motion-Point** along a sketch-path.

The **MOTION-PATH FB** can also add the motion-value at its input-connector to a constant*.

$$x_{in} \Rightarrow [\![(x + a)]\!]$$

Use the **MOTION-PATH DIALOG** to edit the value of the constant, a*.

Optionally, use the **MOTION-PATH DIALOG** to control and specify the length of a sketch-path or sketch-loop - typically a belt.

It it important to know the **data-type** of the motion-values at the input-connector. They should be **Linear** or **Rotary** - see Motion FB dialog [462]

When the **data-type** is:

- **Linear(mm) :** the displacement of the **MOTION-POINT** is equal to the **Linear** motion-value
- **Rotary(degrees) :** the displacement of the **MOTION-POINT** is equal to the **Rotary motion-value × total length of sketch-loop / 360**

See more: Data-Type and Motion-Points [475]

How to open the Motion-Path dialog

To open the **MOTION-PATH DIALOG**

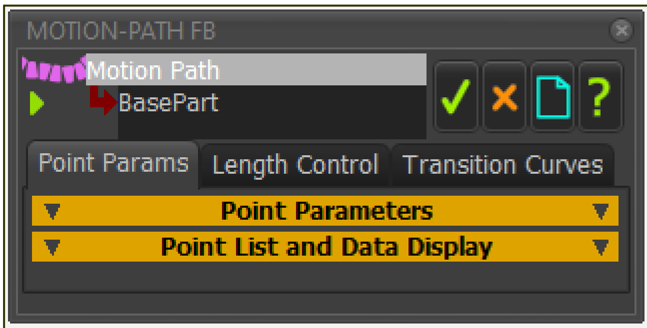
1. Double-click the **MOTION-PATH FB** in the graphics-area

OR

1. **See How to Open a dialog** [627]

The **MOTION-PATH DIALOG** is now open.

Motion-Path dialog



Motion-Path dialog

There are usually two tabs:

Point Parameters [470]

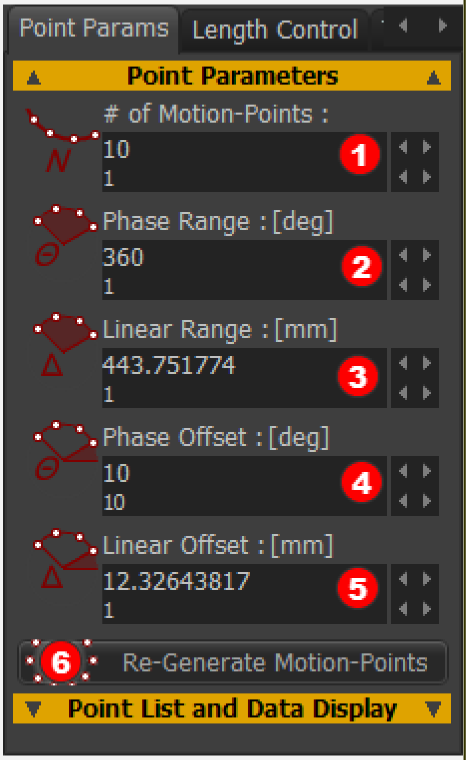
Length Control [472]

If a **TRANSITION-CURVE** is a sketch-element in the sketch-loop, you will see three tabs.

Transition-Curves [475]

Point Parameters tab

POINT PARAMETERS



❶ **# MOTION-POINTS**: | Default = 1

To edit the number of **MOTION-POINTS** along the **sketch-loop.**

1. Increase or decrease the **# OF MOTION-POINTS**❶
2. Click [Re-Generate Motion-Points] ❻ button at the bottom of **POINT PARAMETERS** separator.

We distribute the **MOTION-POINTS** equally along the **PHASE-RANGE**❷ and **LENGTH-RANGE**❸ of the **sketch-loop**.

If you Re-Generate Motion-Point, and ther is a **PIN-JOINT** between a **PART** and a **MOTION-POINT**, you must add the **PIN-JOINT** again.

❷ **PHASE RANGE** | Default = 360 which is equivalent to the total length of the **sketch-loop**

❸ **LINEAR-RANGE** | Default = Length of the **sketch-loop**.

When **# MOTION-POINTS >1**, the **MOTION-POINTS** are distributed equally along the **PHASE-RANGE** and **LINEAR-RANGE** of the **sketch-loop**.

1. Edit the **PHASE RANGE**❷ (deg)

OR

1. Edit the **LINEAR RANGE**❸ (mm)

When you edit **PHASE-RANGE**❷, the **LINEAR-RANGE** updates automatically, and vice-versa.

These two parameters indicate the proportion of the **sketch-path** over which to distribute **MOTION-POINTS** (when **# MOTION-POINT >1**).

These parameters distribute **MOTION-POINTS** (when **# MOTION-POINTS > 1**) over a range (length) that is different to the total-length of the **sketch-path**.

The distribution of the **MOTION-POINTS** is best illustrated with examples. We urge you to EXPERIMENT.

EXAMPLE

Say : **Actual length of a sketch-loop** is **127.5mm**

The NUMBER OF MOTION-POINTS = 3

Default: PHASE-RANGE =360 (and LINEAR-RANGE = 127.5)

The 3 **MOTION-POINTS** are equally spaced over **127.5mm.** The distance between each **MOTION-POINT** = **127.5/3 = 42.5mm**

Position of MOTION-POINT #1 = 0MM, MOTION-POINT #2 = 42.5MM, and MOTION-POINT #3 = 85.0MM

Edit PHASE-RANGE = 120 (and LINEAR-RANGE = 42.5)

The 3 **MOTION-POINTS** are distributed over a linear-length of = **42.5mm**

The distance between each **MOTION-POINT** is **42.5/(3-1) = 21.25mm**

Position of MOTION-POINT #1 = 0MM, MOTION-POINT #2 = 21.25, and MOTION-POINT #3 = 42.5MM

PHASE OFFSET (DEG)❹ | Default = 0

LINEAR OFFSET (MM)❺ | Default = 0

PHASE OFFSET and LINEAR OFFSET move ALL of the **MOTION-POINTS** along the **sketch-loop**. The OFFSET value indicate the position of **MOTION-POINT #1** when the motion-value at the input-connector of the MOTION-PATH FB is equal to 0; or when a wire is not connected to its input-connector.

PHASE-OFFSET: equates the length of the **sketch-loop** to **360 degrees of a circle.**

LINEAR-OFFSET: equates the length of the **sketch-loop** to its **actual linear length**.

EXAMPLE - we urge you to EXPERIMENT.

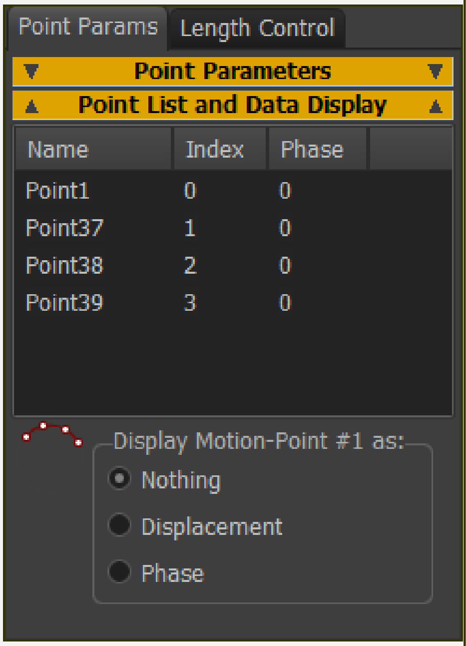
A **sketch-loop** is 127.5mm long. There is **1 MOTION-POINT**.

- A PHASE-OFFSET=40 (deg) moves the **MOTION-POINT #1** to 127.5×40/360=14.16mm along the **sketch-loop**. All other **MOTION-POINTS** move by the same distance.
- A LINEAR-OFFSET=40 (mm) moves the **MOTION-POINT #1** to 40mm along the **sketch-loop**. All other **MOTION-POINTS** move by the same distance.

Re-generate Motion-Points ❻ button

If you edit the NUMBER OF MOTION-POINTS❶ parameter, you must click the **Regenerate Motion-Points** button.

POINT LIST AND DATA DISPLAY



HEADERS: NAME | INDEX | PHASE
(read-only)

- **Name** : the element-name of each MOTION-POINT.

  If you click on a MOTION-POINT in the list, it shows as the Selected-Color in the graphics-area.
- **Index** : the number of the MOTION-POINT
- **Phase** : the relative displacement along the sketch-path, relative to the MOTION-POINT #1

DISPLAY MOTION-POINT #1 AS

You can show the position of MOTION-POINT #1 as it move along the **sketch-loop**.

- ⊙ SHOW NOTHING - nothing shows above the MOTION-POINT #1
- ⊙ SHOW DISTANCE - the linear position above MOTION-POINT #1 as it moves along the **sketch-loop**
- ⊙ SHOW PHASE - the angular phase above MOTION-POINT #1 as it moves along the **sketch-loop**

Length Control tab

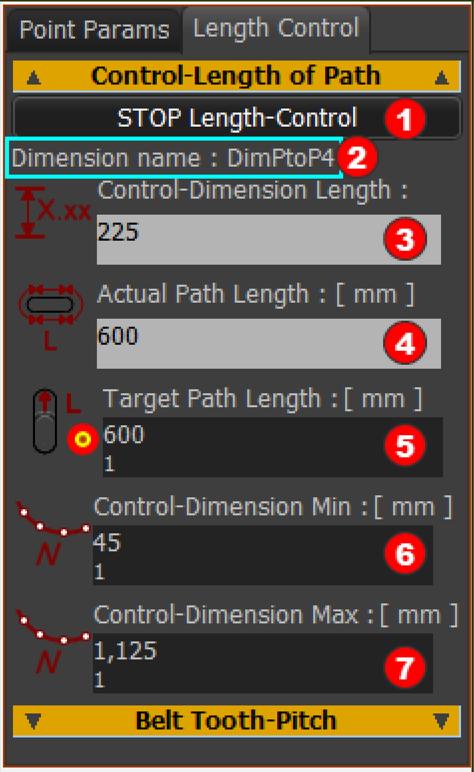
CONTROL LENGTH OF PATH

You can select a dimension to control the length of the **sketch-loop** that is associated with the MOTION-PATH FB.

The dimension you select is called the CONTROL-DIMENSION - **see Note 1: Control-Dimension**

IMPORTANT

> In the PART-EDITOR, the sketch-loop should be **fully defined** before you select the CONTROL-DIMENSION.
>
> Then, as you edit the CONTROL-DIMENSION, the shape of the **sketch-loop** is more predictable - **see Note 1**



❶ START: Length Control / STOP: Length Control

To control the length of the Motion-Path with a Dimension:

1. Click the START Length Control BUTTON❶

   We open the **PART-EDITOR** for you.

2. Click a dimension in the graphics-area that can control the total length of the **sketch-loop** - **see NOTE 1**

   We close the **PART-EDITOR** for you.

The Dimension name of the CONTROL-DIMENSION❷ is now below the button❶.

For example, **DimPtoP4**

The value of the CONTROL-DIMENSION (read-only) is now in box ❸

For example, 225

When you do not want to control the length of the Motion-Path with a dimension:

1. Click STOP Length Control ❶

NOTE 1: CONTROL-DIMENSION

RULE: The CONTROL-DIMENSION MUST be.

DimPtoP#	the distance between two POINTS
DimL#	the length of a LINE

Or, the CONTROL-DIMENSION MUST NOT be:

DimPtoL#	the perpendicular distance form a POINT to a LINE, or a POINT to the **X-axis**, or a POINT to the **Y-axis**
DimLtoL#	the distance between two parallel LINES
AnglePPP# **AngleLtoL#**	an angle
A dimension that is gray before you select it.	

For example, a Design-Set already controls the dimension.

PARAMETERS

CONTROL-DIMENSION LENGTH - **read-only**❸

The value of the CONTROL-DIMENSION.

ACTUAL PATH LENGTH - **read-only**❹

The length of the **sketch-loop** associated with the MOTION-PATH FB.

TARGET PATH LENGTH❺

We recommend you use the Spin-Box tool to edit the TARGET-PATH LENGTH with a small **Spin- Increment**.- e.g. 10mm

If the SPIN-BOX TOOL does not show, double-click and double-click again in the data-box.

Round and then edit the length of the **sketch-loop** associated with the MOTION-PATH FB **- see** NOTE **2**

CONTROL-DIMENSION MIN❻ / MAX❼ **- see Note 3 below**

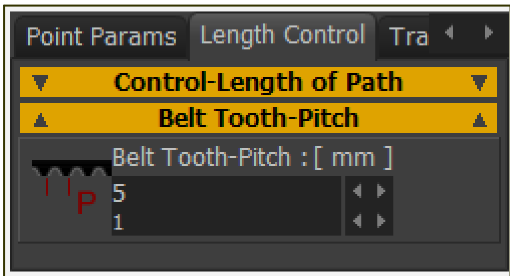
When you select the CONTROL-DIMENSION:

- CONTROL-DIMENSIONS MINIMUM❻ is estimated as 0.5 × CONTROL-DIMENSION - **see** NOTE **3.**
- CONTROL-DIMENSIONS MAXIMUM❼ is estimated as 2.0 × CONTROL-DIMENSION - **see** NOTE **3.**

If required:

Edit the CONTROL-DIMENSION MINIMUM❻ and MAXIMUM❼ limits **- see** NOTE **2.**

BELT TOOTH PITCH



BELT-TOOTH-PITCH

The BELT-TOOTH-PITCH does not change the belt length.

The diameter of a PULLEY is a function of the NUMBER OF TEETH AND BELT TOOTH-PITCH.

See Pulley dialog 582

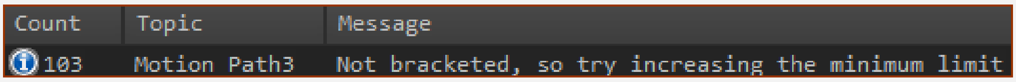
Notes 2 and 3

NOTE 2: TARGET PATH-LENGTH

Edit the TARGET PATH-LENGTH with small increments. If the ACTUAL PATH LENGTH does not change, **see** NOTE **3**

NOTE 3: CONTROL-DIMENSION MINIMUM and/or CONTROL-DIMENSION MAXIMUM

If the Actual Path Length does not change, you may see the message in **FEEDBACK-AREA** (below the graphics-area)



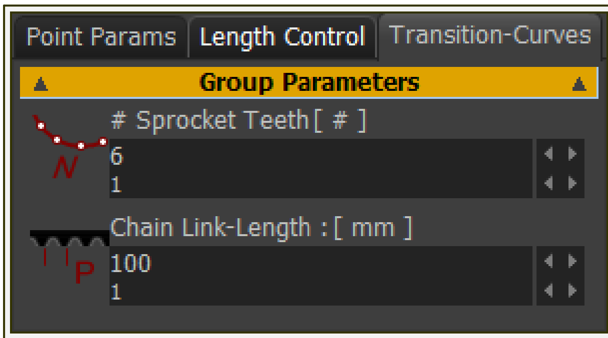
The default values for the CONTROL-DIMENSION MIN or CONTROL-DIMENSION MAX are such that the ACTUAL-PATH LENGTH can be equal to the TARGET PATH LENGTH.

However, it is possible that the **Root-Finding Math** to calculate the Control-Dimension to find the ACTUAL-PATH LENGTH from the TARGET PATH LENGTH is confused!

To reset the **Root-finding Math**:

- Increase or decrease the CONTROL-DIMENSION MIN/MAX, then try to edit the TARGET-PATH-LENGTH again.
- You may need to edit these values to be almost equal to the actual length of the CONTROL-DIMENSION.

Transition Curve tab



This tab will show If there is a TRANSITION-CURVE in the sketch-loop.

SPROCKET TEETH

Maximum = 11 ; Minimum = 3

CHAIN LINK-LENGTH

When the TARGET PATH LENGTH is set, you can enter the CHAIN-LINK LENGTH to give an integer number of teeth.

MOTION-PATH AND DATA TYPES

DATA-TYPE AND MOTION-POINTS

The position and motion of **MOTION-POINTS** along the **sketch-loop** is a function of the **Data-Type** at the input-connector to the **MOTION-PATH FB**.

The **Data-Type** at the input-connector **must** be LINEAR or ROTARY.

DATA-TYPE = LINEAR

The position of the **MOTION-POINT #1** along the **sketch-loop** has a scale of: **1mm at input = 1mm along sketch-loop**

∴ the position of the **MOTION-POINT #1** along the **sketch-loop** = motion-value at input-connector(mm)

DATA-TYPE = ROTARY

The position of **MOTION-POINT #1** along the **sketch-loop** has a scale of:
1deg at input = Length of sketch-loop / 360

∴ the position of the **MOTION-POINT #1** along the **sketch-loop =** motion-value at input-connector(degrees) × **(Length of the sketch-loop /360)**

The **Motion-Point** moves along the total length of the sketch-loop when the input is 360.

1.5.11.29 Dialog: Function-Block: Graph

Graph FB

see **Add Graph FB** 202

Use a **GRAPH FB** to plot **Kinematic Motion-Data**, **Kinetostatic Force-Data** and **Cam-Data**.

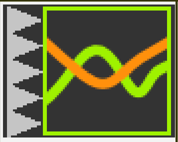
There are:

➔ **4 × Y-axis input**: the top four(4) input-connectors.

➔ **1 × X-axis input:** the bottom input-connector controls the **X-axis** for all of the graphs.

If you do not connect a wire to the X-axis input-connector, the **X-axis** is one machine-cycle, 0 – 360.

How to open the Graph Interface



To open the **GRAPH FB DIALOG**

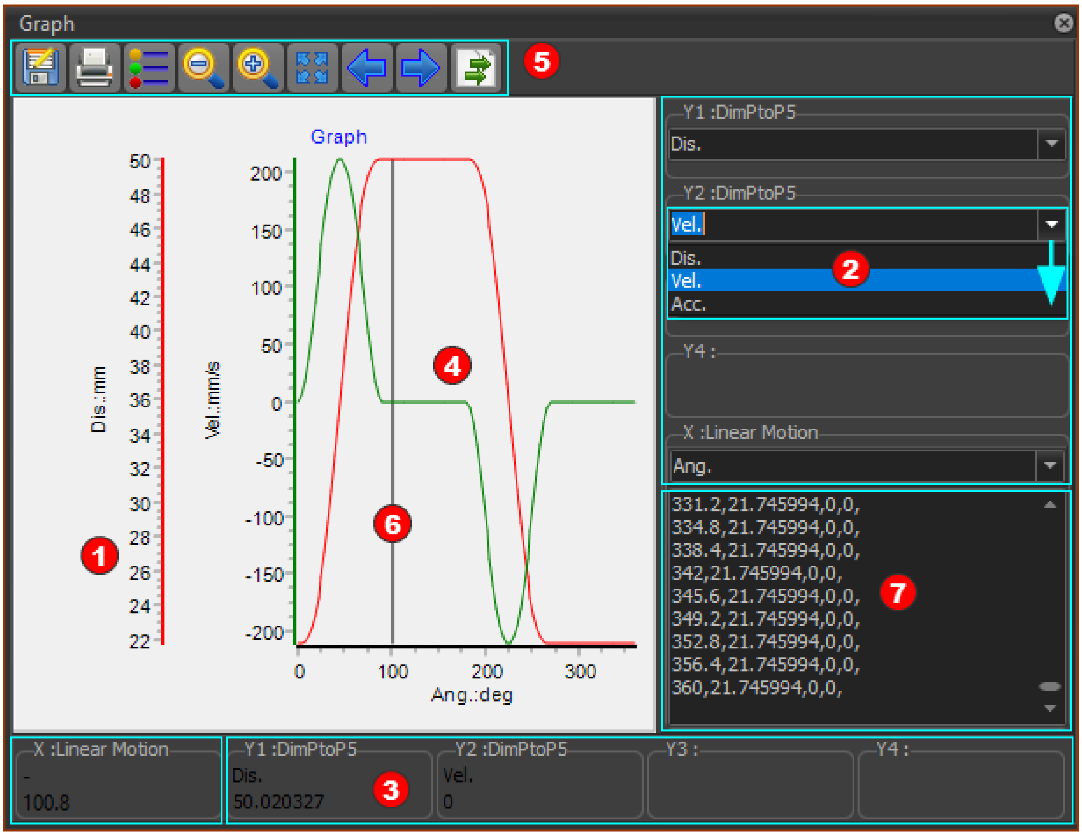
1. Double-click the **GRAPH FB** in the graphics-area.

OR

1. **See** **How to Open a dialog** 627 **.**

The **GRAPH INTERFACE** is now open.

Graph Interface



Grap dialog/interface

1 Y–axes: Colors and Scales

There is one Y-axis scale for each wire that you connect to an Y-axis input-connector. Maximum = 4

Y-axis scales | Left >> Right >>> Wires at Y-axis input-connector | Top >> Bottom.

- The color of each Y–axis scale is the same as the graph.

  Edit axis colors in Graph Setting dialog[480] .
- Default: the Y-axes auto-scale to the data at the input-connector.

  Edit Minimum / Maximum values with Graph Setting dialog[480] .

2 Y–axis: Data-Channels (Drop-Down): See also Y–axis Data-Channel Display Options[479]

Each wire that you connect to an input-connector has up to 3 Data-Channels.

1. Click the drop-down arrow to select which Data-Channel to plot for each wire that you connect to an input-connector.

3 Digital Readout (D.R.O.):

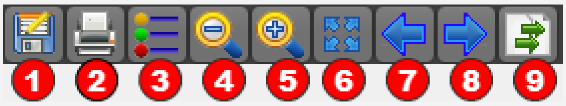
The **X–axis** value and the **Y1-axis** to **Y4-axis** values in the Digital Readout are those values of the graph at the position of the vertical cursor 6

The Number-Format for the **X–axis** and **Y–axis** values are configured in Edit menu > Application Settings | Number Format tab.[343]

4 Graph Area:

There is a graph for each wire you connect to a Y-axis input-connector.

5 Graph toolbar:



1 Save data as

2 Print graphs

3 Graph Settings dialog[480]

4 Zoom-Out

5 Zoom-In

6 Zoom-Extents

7 Pan Left

8 Pan Right

9 Copy Graph Data to Clipboard – see below

6 Vertical-Cursor

When you click or drag your pointer in the graph-area 4:

- the Vertical-Cursor moves with your pointer
- the Digital-Readouts❸ are equal to the X-axis and Y-axis values of the Vertical-Cursor
- the **MASTER MACHINE ANGLE** continuously updates to equal the X-axis value of the Vertical-Cursor
- the kinematic-chains that are **kinematically-defined** move to agree with the **MASTER MACHINE ANGLE**.

❼ **Graph Data in Clipboard**

To list the graph data-values ❼,

1. Click the right-most icon in the **Graph toolbar**❾.

There is one data-point for each Machine Step - see Machine-Settings dialog > Number-of-Steps 351.

You can Paste the data:

- to Excel, or Notepad, ...
- to the **MotionDesigner Data-Transfer Table**

From the **Data-Transfer Table**, you can paste the data:

- as a dumb Overlay-Trace to compare it with a motion
- to a Position List, Acceleration List, or Z Raw Data segment-type, and link it to a **MOTION-PART** or **MOTION-POINT**.

Y-Axis Data-Channels:

Each wire that you connect to a **GRAPH FB** has three(3) data-channels.

Use the drop-down arrow to select which **Y-Axis Data-Channel**❷ to plot for each **Y-axis.**

The Data-Channels that are available are a function of the Function-Block and wire you connect at the input to the Graph FB.

DATA-CHANNELS:

Kinematic Function-Blocks 169 (Linear-Motion, Gearing, Motion, Motion-Dimension) you can plot:

- **Linear or angular position**
- **Linear or angular velocity**
- **Linear or angular acceleration**

Measurement FB 193 or **Point-Data FB** 197 you can plot:

- **Linear or angular position**
- **Linear or angular velocity**
- **Linear or angular acceleration**

Cam-Data FB 199

- **Pressure Angle.**
  You can plot three Pressure Angles – See **Pressure Angle**

- **Radius-of-Curvature.**
  You can plot the Radii-of-Curvature of the Inner and the Outer Cam.
- **Contact Cam Force**
- **Maximum Contact Shear Stress.**
- **Sliding-Velocity**
  Plot the Sliding-Velocity between the Cam-Profile and Follower-Profile for the INNER Cam and the OUTER Cam.

Force-Data FB [230]

The output form a FORCE-DATA FB is a function of the element with which it is linked. **See Force-Data FB dialog** [541]

If you link a FORCE-DATA FB to a:

- PIN-JOINT with a Motor, you can plot the **Application Load**.
- SLIDE-JOINT with a Motor, you can plot the **Application Load**
- Joint that does not have a Motor, you can plot:
  - ☑ **Total Force** ($F_T = \sqrt{(F_X^2 + F_Y^2)}$)
  - ☑ **Force along the X-coordinate of a Point: F_X**
  - ☑ **Force along the Y-coordinate of a Point: F_Y**
- 2D-CAM: you can plot the **Cam Contact Force**
- SPRING FB: you can plot the **Total Force, X Force, Y Force** acting on the Anchor-Point.

Why are the Y–axis values in the DRO❸ different to the vector-values in the main graphics-area?

The values may be slightly different because, in the graph, the X–axis and Y–axis values at the D.R.O. must jump from 'machine -step' to 'machine-step'. See Machine Settings dialog > Number-of-Steps [351].

In the graphics-area, the vector values are calculated for the value of the Master Machine Angle, which may not coincide with a machine step.

1.5.11.30 - > Graph Settings

Graph FB > Settings

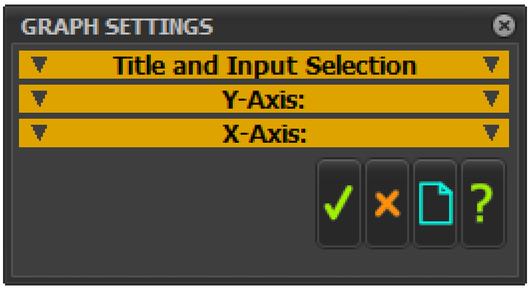
How to open the Graph-Settings

1. Click Graph toolbar > Graph Settings icon [478] in the Graph toolbar to open the **Graph Settings dialog.**

The settings are:

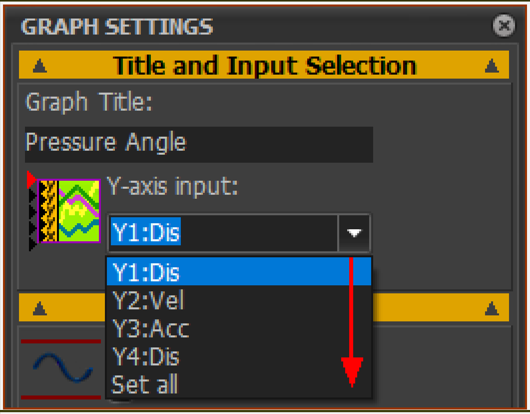
- Graph Title / Name
- Color of each graph line
- Maximum and Minimum scale for each **Y-axis**
- Maximum and Minimum scale for the **X-axis**

Graph-Settings dialog



Graph-Settings dialog

TITLE AND Y-AXIS INPUT SELECTION



GRAPH TITLE

The **GRAPH TITLE** - for example, **Pressure Angle**, shows above the graph plots.

Y–AXIS INPUT

Click the drop-down to select for which **Y-AXIS INPUT** you want to edit

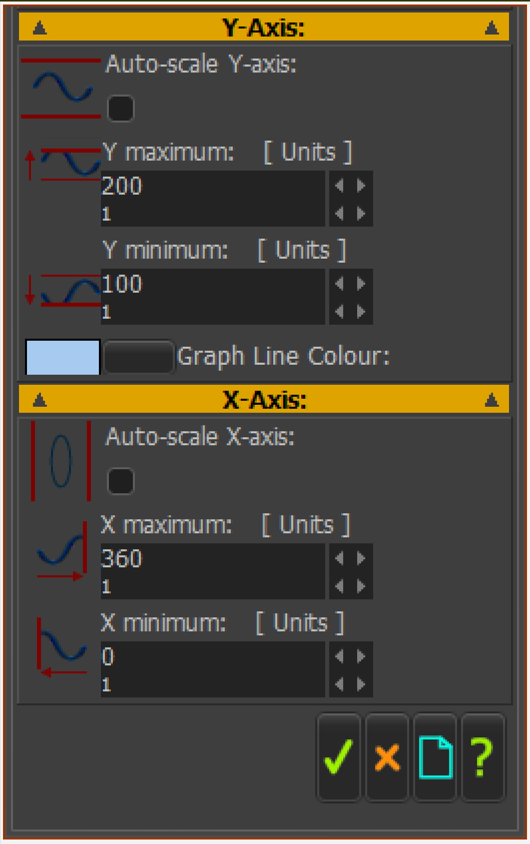
You can select:

- **Y1** to **Y4**

or

- **Set all** : to apply the same **Y-AXIS** and **X-AXIS** settings to **ALL** Y-axis inputs.

Y-AXIS & X-AXIS



The Y-axis parameters apply one the Y-AXIS INPUT or **ALL** Y-AXIS INPUTS (if you select SET ALL)- **see** Title and Input Selection 481

Y-AXIS:

AUTO-SCALE Y-AXIS: **check-box**

☑ **Auto-scale Y-minimum / Y-minimum** values for a Y-AXIS INPUT

❑ **Enter the** Y-MAXIMUM **and** Y-MINIMUM values for a Y-AXIS INPUT

Enter values for Y MAXIMUM and Y MINIMUM when the AUTO-SCALE Y-AXIS check box is **Clear**

GRAPH LINE COLOR:

Click the button and use the Windows® pop-up color picker to select a different color.

Top Tip 1:

Select Set all in the Y-AXIS INPUT drop-box, and set the MAXIMUM and MINIMUM for the all of the Y-axes to be equal for all graphs.

For example: the wire to all of the input-connectors is PRESSURE-ANGLE from different 2D-CAMs. Then, it is easy to see on the graph which 2D-CAM exceeds the limits for PRESSURE-ANGLE.

Top-Tip 2:

The RADIUS-OF-CURVATURE of a 2D-CAM can be a very large value. The large values are not important. The small values are more important.

Set the MAXIMUM and MINIMUM values at approximately 3 × the radius of a **Follower-Roller**.

X–AXIS:

The **X-axis values** apply to **ALL** graph plots.

AUTO-SCALE X-AXIS:

☑ Auto-scale the X-MAXIMUM and X-MINIMUM values for the X-AXIS.

❑ Enter the X-MAXIMUM and X-MINIMUM values for the X-AXIS

1.5.11.31 Dialog: Function-Block: Point-Data

Point-Data FB

see Add Point-Data FB 197

The **POINT-DATA FB** measures the kinematic motion-values of a **POINT*** with respect to the **Mechanism Plane**.

The **POINT-DATA FB** has three output-connectors. The data at the output-connectors, from top to bottom, are:

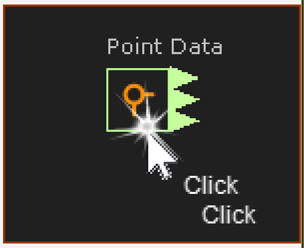
- ➔ motion-values parallel to the X-axis
- ➔ motion-values parallel to the Y-axis
- ➔ Magnitude of the motion-values equal to:
  - o $\sqrt{(X^2 + Y^2)}$

Note: Kinematic Motion-Values are the **Position**, **Velocity**, and **Acceleration** of the **POINT***.

* The **POINT** should be a child to a **PART** that is **kinematically-defined**.

* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**, or **MOTION-POINT**.

How to open the Point-Data FB dialog



To open the **POINT-DATA DIALOG**

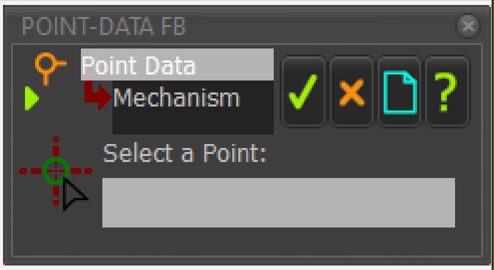
1. Double-click the **POINT-DATA FB** in the graphics-area

OR

1. **See** How to Open a dialog 627

The **POINT-DATA DIALOG** is now open.

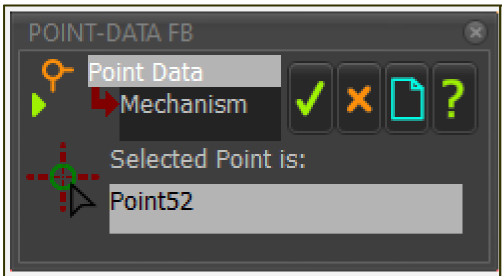
Point-Data dialog



Point-Data dialog; without Point

SELECT A POINT:

1. Click the **POINT** in the graphics-area whose motion you want to measure.

 **Point-Data dialog; with Point**	When the **POINT** in the selection-box: 2. Click ✅ to close the **POINT-DATA DIALOG**

Different ways to use the Point-Data FB

The data at the output-connectors includes the Position, Velocity, and Acceleration values. **Connect wires from the output-connectors to the input-connector of:**	
1:	a **GRAPH FB**[202] : to plot the Position, Velocity, and Acceleration of the **POINT** in the X and Y–axis directions (**see: Top-Tip**)
2:	a **MOTION FB** : to use the motion-values as the independent (X-axis) of a **Motion**.
3:	a **MOTION-DIMENSION FB** or a **MOTION-PATH FB** : to use the motion-values as a motion of a **MOTION-PART** or **MOTION-POINT**.
4:	**a:** a **MATH FB** : to use the motion-values to calculate another function that is not available directly to you. **b:** a **MATH FB** : to convert the data-type from motion-values to a different data-type. E.g. **Force(N)**.
Top-Tip :	To plot **Position**, **Velocity**, **AND Acceleration** of a **POINT** in one **GRAPH FB**: 1. Drag **three wires** from one of the output-connectors of the **POINT-DATA FB** to **three different input-connectors** of a **GRAPH FB**. 2. In the **GRAPH FB** interface, use the Y–axis display options[479] to plot a different motion-derivative for each input.
See also :	Connecting FBs[166]

1.5.11.32 Dialog: Function-Block: CAD Control

CAD Control FB

see Add CAD-Control FB 219 .

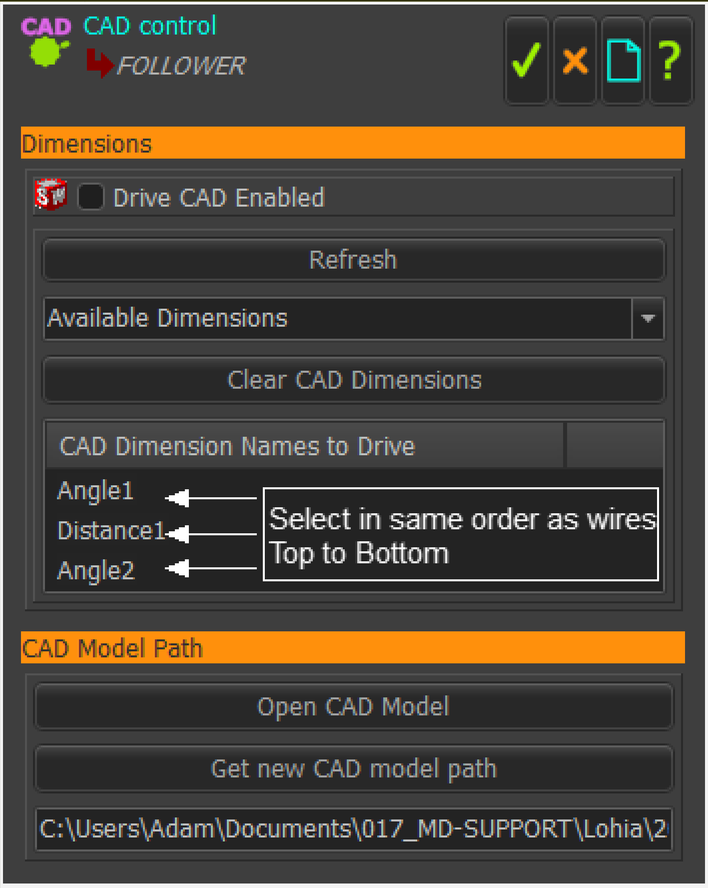
Use a **CAD CONTROL FB** to synchronize **Distance** or **Angle** mates in a **SOLIDWORKS®** assembly document with the motion of **PARTS** in a **MechDesigner** model.

You can control up to four(4) SOLIDWORKS® mates with one **CAD-CONTROL FB**.

Why use a **CAD-CONTROL FB**? You can use the powerful Evaluation / Validation Tools in SOLIDWORKS® to check the clearance between a Follower-Roller and the flanks of a 3D-Cam, for example.

Note the SOLIDWORKS® mates respond very slowly. Increment the model very slowly when you using the **CAD-CONTROL FB**.

See Getting Started Tutorial 6C3: Examine 3D-Cam Clearances



CAD-Control dialog

STEP 1: Connect wires to the input-connectors of the CAD-Control FB from other FBs in your model.

The motion-values at the output of a FB you connect should control a **Motion-Dimension** and be equivalent to a **Distance** or **Angle** Mate in SOLIDWORKS that you want to control.

To control a Distance (or Angle) Mate, set the **OUTPUT DATA TYPE** in each Motion FB dialog 462 to Linear (or Rotary).

STEP 2: Open the SolidWorks Assembly.

STEP 3: Double-Click a CAD-Control FB in the graphics-area, to open this dialog

If necessary, click **DIMENSION** and **CAD MODEL PATH** to expand the dialog.

STEP 4: Click the Refresh button.

When you click the **REFRESH** button, we find for you all of the **Dimension** and **Angle** mates in your SOLIDWORKS® Assembly model.

STEP 5: Click the Available Dimensions down-arrow button to see the mates that have been found in the SolidWorks® Assembly model.

STEP 6: Click, in the Available Dimension list, each Dimension or Angle mate you want to control.

Repeat to select and control a maximum of 4 mates.

Note: Select the mates in the same order (sequence) as the wires

Mate1 = Wire 1(top); Mate 2 = Wire 2; Mate 3 = Wire 3; Mate 4 = Wire 4(bottom).

The mates show in the **CAD-DIMENSION NAMES TO DRIVE** box.

If the mates are not in the same sequence as the wires you can click the **Clear CAD Dimensions** button.

You can select the mates again.

STEP 7: Click the Drive CAD Enabled check-box at the top of the dialog.

DO NOT CLOSE THE DIALOG

You can only control the mates with this dialog open.

The position of the parts in the SOLIDWORKS® Assembly model move* when you move your model in **MechDesigner**.

STEP 8: Click ✅ at the top of the dialog when you have finished using the evaluation and analysis tools in SOLIDWORKS®.

* Only use the **Home, Step Back** or **Step-Forward** buttons in the **Run toolbar**.
Do not use the Cycle button.

1.5.11.33 Dialog: Function-Block: Statistics

Statistics FB

See Add Statistics FB 209

If you can connect a wire to a **GRAPH FB** to plot the data over a complete machine-cycle ...

... then you can also connect a wire to a **STATISTICS FB** to show the statistical data for the complete machine-cycle.

Compare with **Element Properties dialog** 609, which displays the data-values at the MASTER MACHINE ANGLE only.

After you add the **STATS FB** to the graphic-area, there are three more steps you need to do to get Statistics for a Data-Channel on a wire.

STEP 0: Connect a wire to the input of the Statistics FB.

A wire that you connect from the output-connector of a FB to the input-connector of the **STATISTICS FB** has three Data-Channels.

For example, the three Data-Channels at the output-connector of a **MOTION-DIMENSION FB** are the three linear or angular motion-derivatives of the **MOTION-DIMENSION**

STEP 1: Select the Data-Channel

STEP 1. Open the Statistics dialog

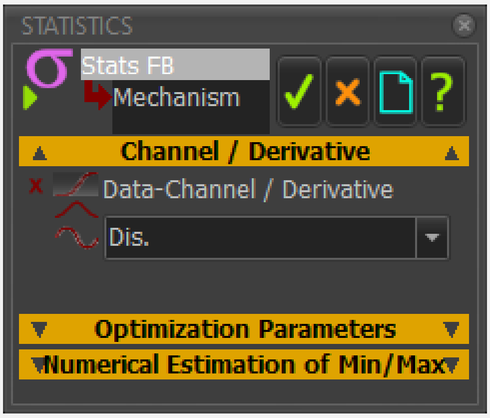
To open the **STATISTICS FB DIALOG**

1. Double-click the **STATISTICS FB** in the graphics-area

OR

1. **See How to Open a dialog** 627

The **STATISTICS FB DIALOG** is now open.



Statistics FB dialog

CHANNEL / DERIVATIVE

STEP 2. Click the Derivative drop-down and select the derivative for which you want Statistics

Derivative	≡ Data-Channel
Dis.	Linear Displacement or Angular Displacement; or Torque
Vel.	Linear Velocity or Angular Velocity; or Force X
Acc.	Linear Acceleration or Angular Acceleration; or Force Y

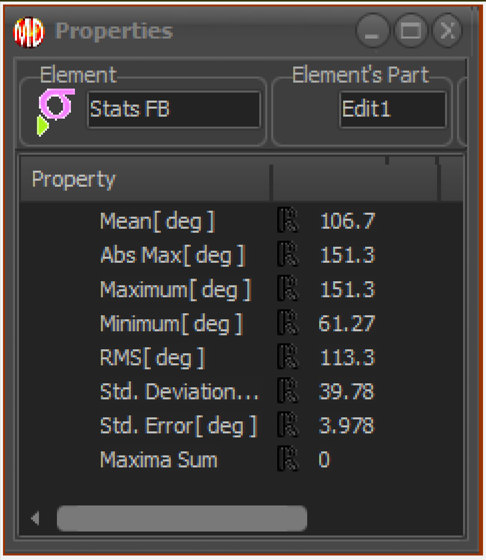
* The **Data-Channels** in the drop-down box are **always**: Dis, Vel, and Acc , even if the actual units are different. The actual units:

- For a KINEMATIC-FB are **three(3) motion-derivatives**
- For a FORCE-DATA FB are **Total Force/Torque, Force X, Force Y.**

Ignore the other SEPARATORS in the dialog.

STEP 3. Click ✅ to close the STATISTICS DIALOG

STEP 2: Show the Statistics Properties



Statistic Properties dialog

STEP 1. Open the Properties box

1. CTRL + Click the STATISTICS FB in the graphics-area

The STATISTICAL PROPERTIES form is now open.

Read the **Statistical Properties** for the **Data-Channel** of the wire that is connected to its input-connector.

Mean

Ans Max

Maximum

Minimum

RMS

Standard Deviation

Standard Error

Maximum Sum

Note: to edit the NUMBER-FORMAT for the **Statistics Properties**, use:

APPLICATION-SETTINGS > NUMBER-FORMAT > DATA-OUTPUT FORMAT > DIGITS and PRECISION

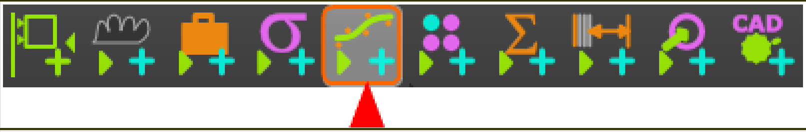
1.5.11.34 Dialog: Function-Block: Polynomial-Fit

Polynomial-Fit FB

See also: Add Polynomial Fit FB 211

Before you use this tool, I recommend you save your work.
Then save it again with a new model file-name.

About Polynomial FB

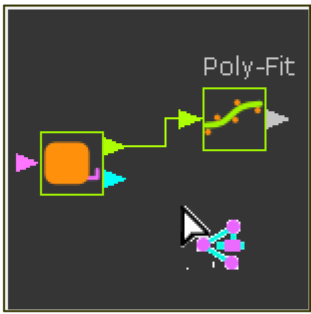


The **POLYNOMIAL FIT FB** finds a concatenated series of Polynomials (5th order) that are approximately equal to the data at its input-connector.

After you do a Polynomial-Fit, you can:

- Transfer Polynomials directly to **MotionDesigner** as a new **Motion name-tab**.
- Connect a wire from the output-connector of the **POLYNOMIAL-FIT FB** to the input-connector of a different **FB**.
- Export the motion-values that you calculate as a text-file.
- Export the values for position, velocity, and acceleration at the beginning and end of each polynomial segment as a CSV file.
- Export the polynomials segments in a format suitable for the Schneider-Electric EPAS4 servo-controller.

How to open the Polynomial-Fit dialog



After you add a **POLYNOMIAL-FIT FB** to the graphics-area:

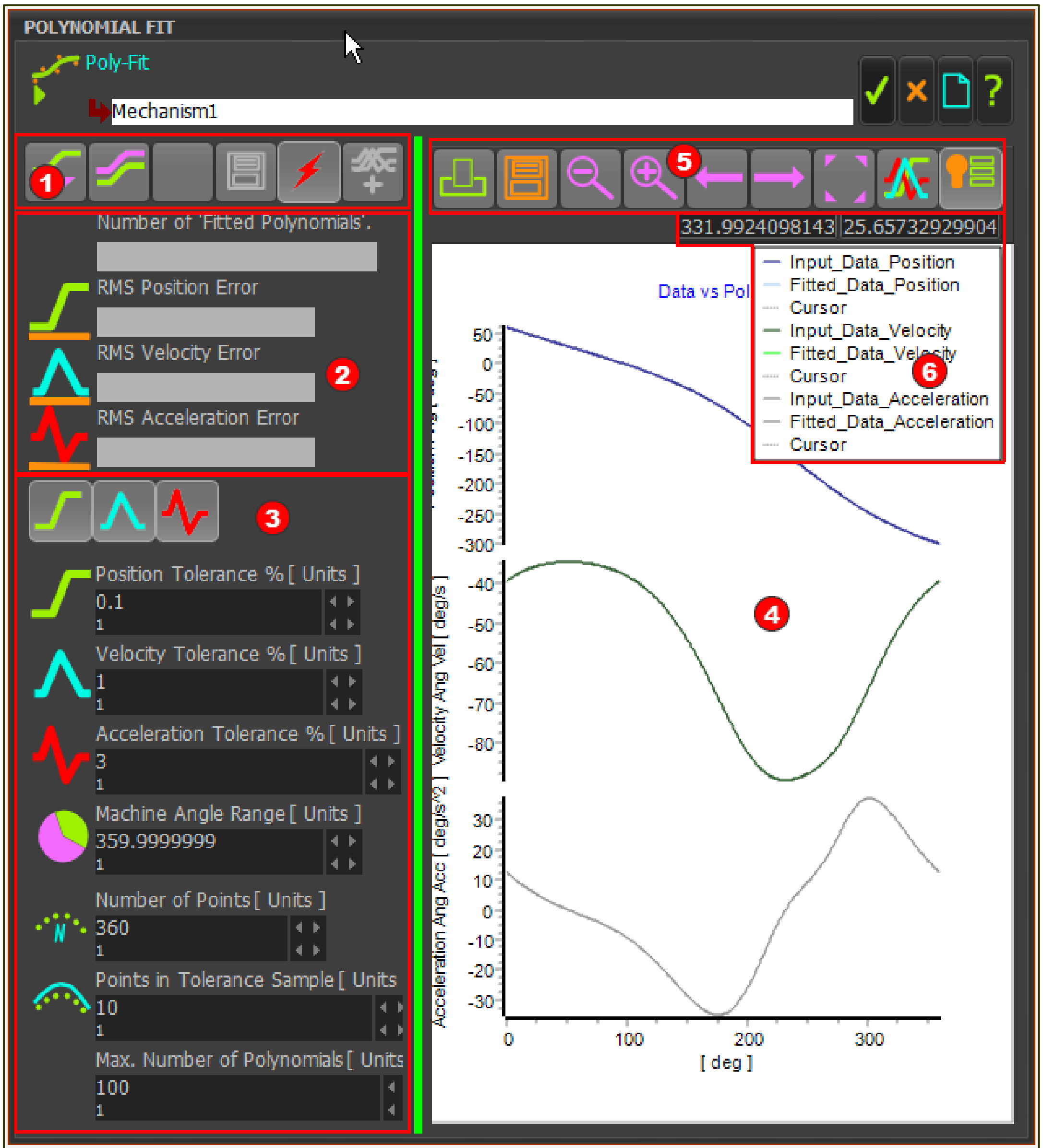
1. Double-click the **POLYNOMIAL-FIT FB** in the graphics-area

OR

1. **See** How to Open a dialog 627

The **POLYNOMIAL-FIT DIALOG** is now open.

Polynomial-Fit dialog



Polynomial-Fit FB dialog/interface.

The Polynomial-Fit dialog:

❶ **Acquire and Save Toolbar** - acquire and save results.

❷ **Analysis of Results** - RMS errors and the number of Polynomials.

❸ **Settings for Polynomial Fitting Algorithms** - tolerances, limits, and range for polynomial fitting.

❹ **Graph Plots**: for the input-data and the calculated data from the Polynomials.

❺ **Graph toolbar** - view and save the graph-data in different ways.

❻ **Graph Legend**. - graph plot color scheme for original data and fitted Polynomials, for each motion-derivative

❶Acquire and Save toolbar

Acquire and Save Results toolbar

The toolbar buttons are:

❶ **Acquire** (Capture, Get One Cycle) :

Click this button to acquire data at the input-connector for one machine-cycle - this is the **Raw-Data**.

❷ **Fit Polynomials to Data** :

Click to **Fit Polynomials** to the **Raw-Data** - see Settings for Polynomial Fitting Algorithms[494] .

❸ **Stop Algorithms : (see also Auto-Run)**

The algorithms usually fit polynomials within a few seconds. If you do not see the results after a few seconds, then click this button to stop the algorithms.

❹ **Save Coefficients** :

Click to save the results to a CSV file, or a EPAS4 file that is suitable for a Schneider Electric servo-controller.

❺ **Auto-Run** :

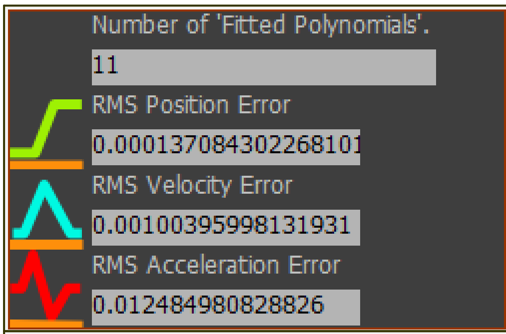
Immediately allow the algorithms to find the polynomials that fit the data to the accuracy as specified, and with less or equal to the maximum number of polynomials.

❻ **Send Polynomials to MotionDesigner** :

Send the Polynomials to **MotionDesigner** as a new motion. Add a new Motion name-tab.

Note on **Blend-Point Control-Buttons**: After you send the Polynomials to **MotionDesigner**, none of the **Match Control Buttons** are active. Instead, the Start motion-value of a segment, is equal to the End motion-value of the previous-segment. Obviously, you can choose to Match the motion-values as part of your motion-design process.

2 2 Analysis of Results



Number of Fitted Polynomials in Fit (read-only)

The actual number of Polynomials in the numerical solution.

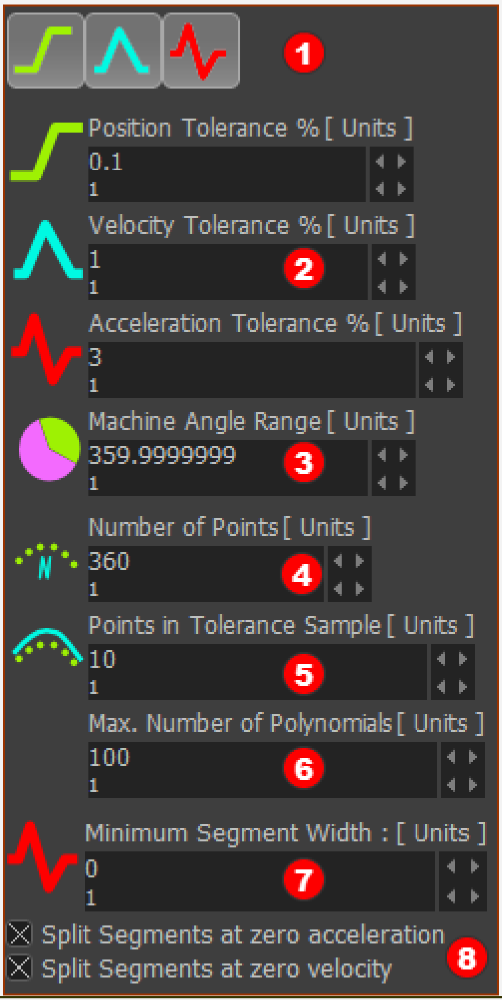
See also: **Maximum Polynomial Count** in the Settings for Polynomial Fitting Algorithms.

494

RMS Position Error, RMS Velocity Error, RMS Acceleration Error (read-only).

They give the RMS (Root of the Mean of the Square) error as a percentage for each motion-derivative between the Polynomial that we fit to the data, and the raw-data at the input-connector.

3 Settings for Polynomial Fitting Algorithms



Parameters to enter before you click **Fit Polynomials to Data** (button 2 in the Acquire and Save toolbar 492, above)

1 Position, Velocity, Acceleration buttons.

Click each button to identify the motion-derivatives to which you want to **Fit Polynomials**.

2 Position, Velocity, Acceleration Tolerance %

Enter the tolerance, as a %, for each motion-derivative, within which the **Fitted Polynomials** should represent the data at the input-connector.

3 Machine Angle Range

Optionally, reduce the range for which you want to calculate Polynomials

❹ **Number of Points**

The number of data points that are calculated from the Polynomials, to plot the graphs.

❺ **Point in Tolerance Sample of Points**

The number of points that the algorithm uses to fit each polynomial to the data at the input-connector.

❻ **Maximum number of Polynomials.**

Upper limit of the number of **Fitted-Polynomials** in the data.

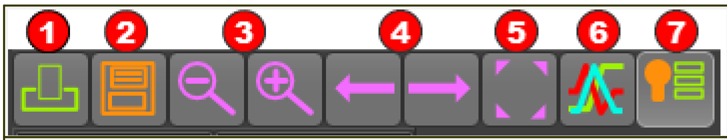
❼ **Minimum Segment Width.**

Lower Limit for the width of a Segment

❽ **Split Segment at Zero Acceleration / Velocity check-boxes**

Force the solutions to split the motion (add a new Segment) at which the Acceleration / Velocity crosses zero - positive to negative and vice versa.

❺ Graph toolbar



The toolbar buttons are:

❶ **Print Graphs** : Print the graphs immediately to the default printer

❷ **Save Graph Data:** Save the Data to a text file.

❸ **Zoom Out** and **Zoom In** to the Graph Details

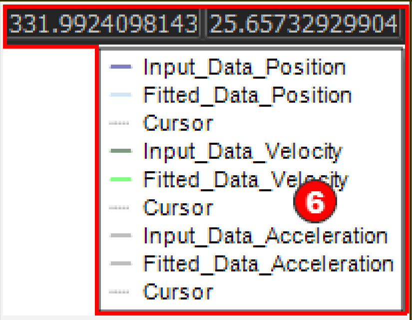
❹ **Pan Left and Pan Right** : Click to save the results to a CSV file, or a EPAS4 file that is suitable for a Schneider-Electric servo-controller.

❺ **Zoom Extents**

❻ **Toggle display: Plot three separate graphs** OR **Plot three stacked on-top of each other**

❼ **Toggle display: Do show Graph Legend** OR **Do NOT show Graph Legend**

❻ Graph Legend

	Graph plot color scheme for • original, or input, data • fitted data calculated from the fitted polynomials • each motion-derivative • Cursor - you can click ON a graph of each motion-derivative to show a cursor. The X-Y data-values of the active cursor is above the graphs.

1.5.11.35 Dialog: Function-Block: Parameter-Control

Parameter-Control FB

See: Add Parameter-Control FB 216

The **PARAMETER-CONTROL FB** has one input-connector.

The motion-values at the input-connector can control:

- a DIMENSION when the **Driven Parameter** is a DIMENSION
- an EXTRUSION DEPTH when the **Driven Parameter** is a PROFILE
- an EXTRUSION-OFFSET when the **Driven Parameter** is an EXTRUSION.

How to open the Parameter-Control dialog

To open the PARAMETER-CONTROL DIALOG

1. Click the PARAMETER-CONTROL FB in the graphics-area or the **ASSEMBLY-TREE**.

The PARAMETER-CONTROL FB is now in the **SELECTION-WINDOW**

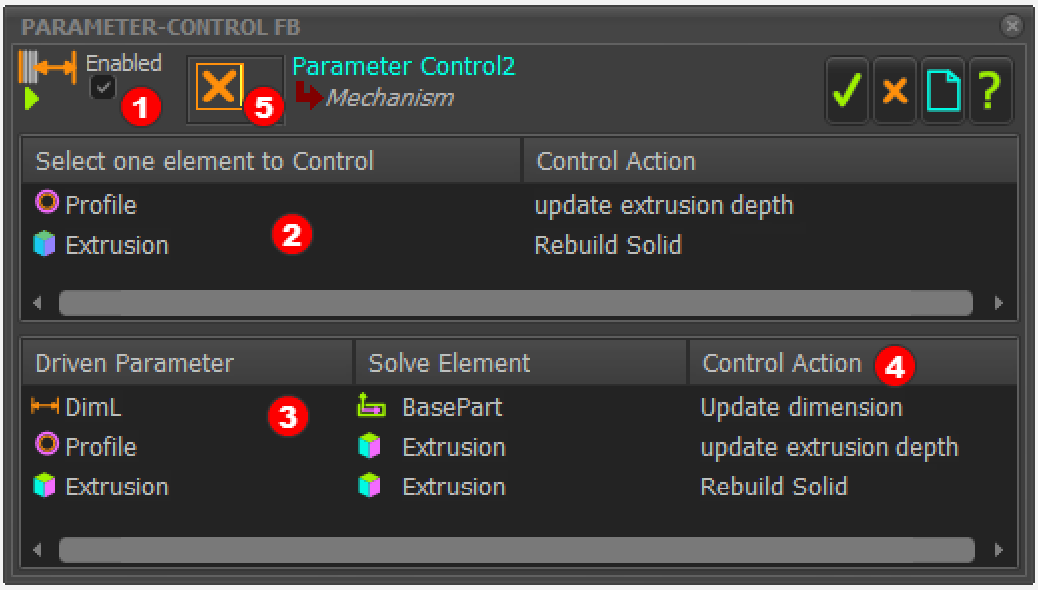
2. Right-click the PARAMETER-CONTROL FB element in the **SELECTION-WINDOW**
3. Click **Edit element** in the shortcut menu

OR

See How to Open a dialog 627.

The PARAMETER-CONTROL DIALOG is now open.

Parameter-Control dialog



Parameter-Control dialog
Three parameters are controlled by the motion-values at the input-connector

The sections in the PARAMETER CONTROL DIALOG are the

❶ **ENABLE / DISABLE** check-box

❷ **TOP-BOX** - we add the **PROFILES** and **EXTRUSIONS** that you select in the **ASSEMBLY-TREE** and/or graphics-area to the **TOP-BOX**.

Then, you must select (click) which of those elements that are in the **TOP-BOX** you want to control. When you select an element in the **TOP-BOX**, we add it to the **BOTTOM-BOX** as a **Driven Parameter**.

❸ **BOTTOM-BOX** - A list of the **Driven Parameters**, **Solve Element**, and **Control Actions** that we control with the motion-values at the input-connector to the **PARAMETER CONTROL FB**.

❹ **CONTROL ACTIONS** - the actions that the **PARAMETER-CONTROL FB** control with the motion-values at the input-connector to the **PARAMETER-CONTROL FB**.

❺ **DELETE** - to remove an element from the dialog - select the element, then click the **DELETE X** icon.

How to use Parameter-Control dialog

To enable the FB

☑ Enabled

1. Click the check-box to enable the **PARAMETER-CONTROL DIALOG**.

To control a Dimension

1. **MECHANISM-EDITOR**: Click the sketch-element that has a **DIMENSION** (that you have added with the **PART-EDITOR**)

OR

2. **PART-EDITOR**: Click the **DIMENSION**, or the sketch-element with a **DIMENSION**.

In the BOTTOM-BOX

- The **DIMENSION** is the **Driven-Parameter**
- The **PART** is the **Solve-Element**
- **Update Dimension** is as the **Control-Action**

To control the Extrusion-Depth of a Profile/Extrusion:

1. **MECHANISM-EDITOR**: Click a **PROFILE**.
   The **PROFILE** and **EXTRUSION** show in the **Top-Box**.
2. Click the **PROFILE** in the **Top-Box**.

In the Bottom-Box:

- The **PROFILE** shows as the **Driven-Parameter**
- The **Extrusion** shows as the **Solve-Element**
- **Update Extrusion-Depth** shows as the **Control-Action**

To control the Extrusion-Offset of a Profile/Extrusion:

1. **MECHANISM-EDITOR**: Click the **PROFILE**.
   The **PROFILE** and **EXTRUSION** show in the **Top-Box**.

2. Click the EXTRUSION in the **Top-Box**.

   In the Bottom-Box:

   - The EXTRUSION shows as the **Driven-Parameter**
   - The **Extrusion** shows as the **Solve-Element**
   - **Rebuild Solid** shows as the **Control-Action** - this is actually the EXTRUSION-OFFSET.

To delete an element:

1. Click an element in the Top-Box or the Bottom-Box.
2. Click 

We remove for you the ELEMENT and PARAMETER from the PARAMETER-CONTROL DIALOG.

1.5.11.36 Dialog: Function-Block: Pattern

Pattern FB

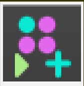
See Add Pattern FB 213

Use a **PATTERN FB** to make **Copies** of **PROFILE**/**EXTRUSIONS** (**MD-SOLIDS**) and/or **CAD-SOLIDS** at different phases of the machine-cycle - see **SOLIDS**,

- The **PATTERN FB** anticipates the motion of each **Copy** and puts each **Copy** at a position that corresponds to its phase of the machine-cycle.
- The **PATTERN FB** can show or hide a **Copy** for a machine-cycle.
- The **PATTERN FB** can use a timing-chart to show or hide **Copies** as they pass through different phases of the machine-cycle.

Use **Visibility toolbar** > Show Solids in Mechanisms 66 to see the **Copies** that we generate for you with the **PATTERN FB**.

How to open the Pattern FB dialog



Open the **PATTERN FB DIALOG**:

1. Click the **PATTERN FB** in the **ASSEMBLY-TREE**.

The **PATTERN FB** is now in the **SELECTION-WINDOW**

2. Right-click the **PATTERN FB** element in the **SELECTION-WINDOW**

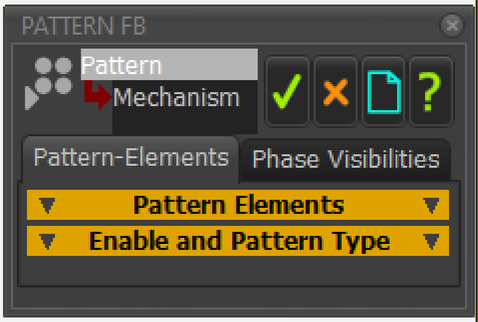
3. Click **Edit element** in the shortcut menu

OR

1. **See How to Open a dialog** 627 .

The **PATTERN FB DIALOG** is now open.

Pattern dialog



Pattern FB dialog

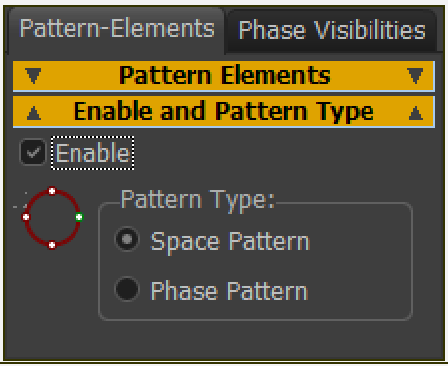
There are two tabs in the **PATTERN FB DIALOG**:

Pattern Elements

Phase Visibilities

Pattern Elements tab

ENABLE AND PATTERN TYPE



1. Click **ENABLE** check-box to make the **PATTERN** dialog active

PATTERN TYPE:

2. Click **SPACE PATTERN** or **PHASE PATTERN**.

   These two options take a **snap-shot** of the path of a **SOLID**. The Pattern shows copies of the **SOLID** at equal increments of its path in the machine-cycle.

   ⦿ **SPACE PATTERN** (**Note:** I rarely use this option!)

   When you cycle the model:

   a) Each copy of the **SOLID** moves locked to the **PART**

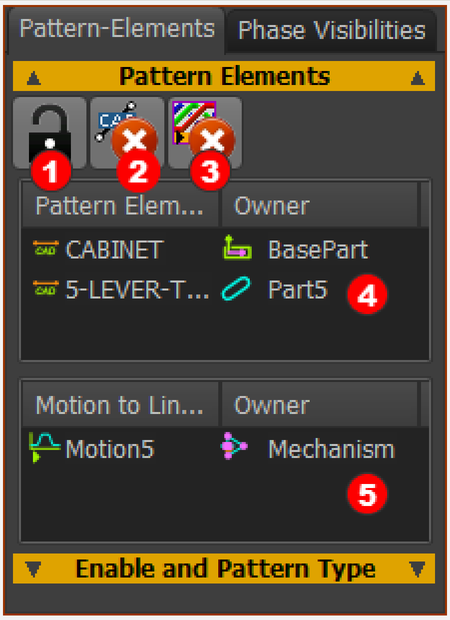
OR

   ⦿ **PHASE PATTERN**

   a) Each copy of the **SOLID** moves along the path of the **SOLID**.

   b) Each copy of the **SOLID** is at a different advanced position in the machine-cycle.

PATTERN ELEMENTS



Pattern-Elements

PATTERN-ELEMENTS❹

SOLID elements from which we make for you **copies** for the **Space Pattern** or **Phase Pattern**.

There are two categories of **SOLID** elements you can add as **PATTERN ELEMENTS**:

- **MD-SOLIDS** - **PROFILE/EXTRUSIONS** - you **MUST** select the **EXTRUSION**
- **CAD-SOLIDS** - **SOLIDS** you import onto a **CAD-LINE** - you can select the **CAD-SOLID** or the **CAD-LINE**.

MOTION TO LINEARIZE❺

A **MOTION FB❺** can linearize the motion of the **SOLIDS** in **PATTERN-ELEMENTS❹**. **EXPERIMENT!**

- If the **SOLIDS** in the **PATTERN-ELEMENTS❹** move as you expect, **do not add** a **MOTION FB**.
- If the **SOLIDS** in the **PATTERN-ELEMENTS❹** do **not** move as you expect, **do add** a **MOTION FB** - but this may not solve the problem!

Add SOLIDS to the **PATTERN-ELEMENTS** box❹

Pattern-Elements toolbar

1. **Pattern-Elements toolbar**: Click the **Padlock❶** to unlock the **toolbar**
2. **Graphics-area**: **SHIFT + Click PROFILE** elements to add **EXTRUSION** elements that **you cannot see**

OR

2. **Graphics-area**: **CLICK EXTRUSION** elements that **you can see** to add **EXTRUSION** elements

OR

2. **Graphics-area** or **ASSEMBLY-TREE**: Click **CAD-LINES** onto which a **CAD-SOLID** has been imported.
3. **Pattern-Elements toolbar**: Click the **Padlock❶** to lock the **toolbar** and box.

SOLID elements are now in the **PATTERN ELEMENTS** box as **EXTRUSIONS** and/or **CAD-LINES**.

To add a MOTION FB to the MOTION TO LINEARIZE box❺

Pattern-Elements toolbar

1. **Pattern-Elements toolbar**: Click the **Padlock❶** to unlock the **Pattern-Elements toolbar**.

2. Graphics-area or **ASSEMBLY-TREE:** Click a MOTION FB
3. **Pattern-Elements toolbar**: Click the **Padlock**❶ to lock the **Pattern-Elements toolbar** and box.

A MOTION FB is now in the MOTIONS TO LINEARIZE box

To remove a SOLID❹ or MOTION FB❺

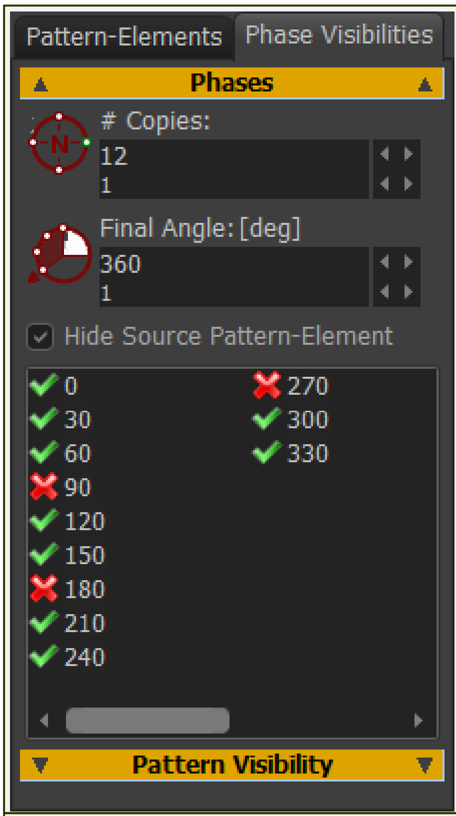
Pattern-Elements toolbar

1. **Pattern-Elements toolbar**: Click the **Padlock**❶ to unlock the **Pattern-Elements toolbar**.
2. Click to select a PATTERN-ELEMENT or a MOTION FB in the boxes
3. Click the REMOVE SOLID❷ or the REMOVE MOTION FB❸ button in the **Pattern-Elements toolbar**
4. **Pattern-Elements toolbar**: Click the **Padlock**❶ to lock the **Pattern-Elements toolbar** and box.

Phase Visibilities tab

PHASES are the number of copies of the PATTERN-ELEMENTS and the machine-angles to show or hide them.

PHASES



COPIES: from 1 to 100 :

The number of copies of the PATTERN-ELEMENTS in the **Pattern**.

The format of the PHASES separator is slightly different for the SPACE PATTERN and the PHASE PATTERN.

IF SPACE PATTERN

START ANGLE, FINAL ANGLE:

- The COPIES show at equal intervals from the START ANGLE to the FINAL ANGLE.

IF PHASE PATTERN

FINAL ANGLE = ?- default =360.

The concept of a **Motion-Period** is important.

If FINAL ANGLE is 360, then the **Motion-Period** is equal to **1 Machine-Cycle**

If FINAL ANGLE is, for example, 20º, the **Motion-Period** is 20º.

- The # COPIES show at regular intervals within one **Motion-Period**, from **MMA=0** to FINAL ANGLE.
- The PHASE PATTERN repeats one time for each **Motion-Period** or 36/20 = 18 times in 1 Machine-Cycle.
- You can show or hide each PATTERN ELEMENT within each **Motion-Period** - see PHASE VISIBILITY separator.

HIDE SOURCE PATTERN ELEMENT:

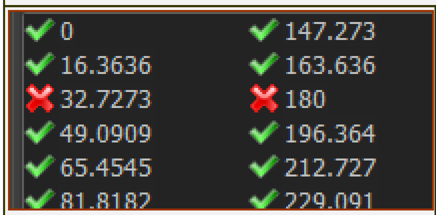
SOURCE PATTERN ELEMENTS are the **SOLIDS** (CAD-Solids and/or MD-Solids) that you select in the model as PATTERN-ELEMENTS, and show in the PATTERN ELEMENTS separator of the Pattern-Elements tab[501].

Nearly always, enable HIDE SOURCE PATTERN-ELEMENT. This is because the COPY #1 and the SOURCE PATTERN-ELEMENT are at the same position

1. Click a PATTERN-ELEMENT in the PATTERN ELEMENTS[501] separator and Pattern-Elements tab[501].

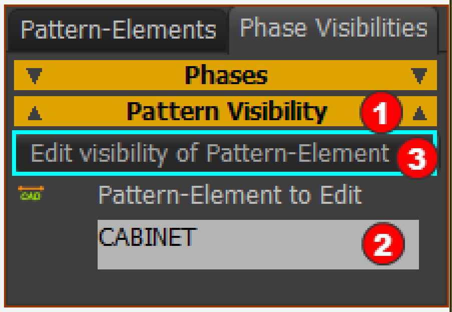
   It should show in the PHASE-VISIBILITIES[504] separator (to see you have selected it).
2. Click the HIDE SOURCE PATTERN ELEMENT check-box.

COPIES BOX



- To hide a **Copy** for the total **Motion-Period**, click a ✓ next to the phase angle of a **Copy** to show a ✗.
- To show a **Copy** for the total **Motion-Period**, click a ✗ next to the phase angle of a **Copy** to show a ✓.

PATTERN VISIBILITY



Phase-Visibilities > Pattern-Visvibility

Note: PATTERN VISIBILITY ❶ shows only if you select PHASE PATTERN - **see** Enable and Type. 500

Use PATTERN VISIBILITY to show or hide a PATTERN-ELEMENT for different periods within the **Motion-Period.**

To edit the **Visibility** of a PATTERN-ELEMENT:

1. Click an EXTRUSION or CAD-LINE in the PATTERN ELEMENTS box - **see** Pattern-Elements tab 500

The element - EXTRUSION or CAD-LINE - must show in the PATTERN-ELEMENT TO EDIT❷ box.

2. Click the EDIT VISIBILITY OF PATTERN-ELEMENT... button❸.

The **Pattern Visibility** interface is now open.

You can now edit the Visibility of the element that is in the PATTERN-ELEMENT TO EDIT❷ box.

How to use the Pattern Visibility interface

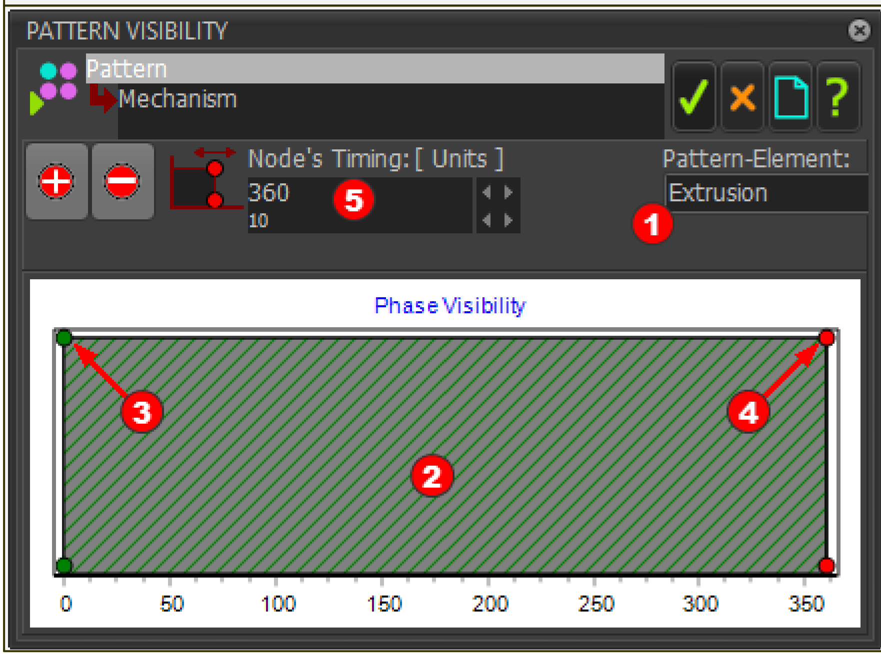
Refer to the image below:

❶ **Pattern-Element box (top-left)-** is the name of the PATTERN-ELEMENT 500 you are editing.

❷ **Phase Visibility Timing Chart -** the chart controls the **Visible-Period(s)** of the PATTERN-ELEMENTS.

As an example:

In the image below, there is one **Visible-Period** of the PATTERN-ELEMENT "EXTRUSION", from 0º to 360º.



There are two(2) **NODES** that control the timing of each **Visible-Period**.

❸ Node at the Start of Visible-Period - **Start-Node**

❹ Node at the End of Visible-Period - **End-Node**

To edit a **Visible-Period** for the PATTERN-ELEMENT you must edit the timing of the **Start-Node** and/or **End-Node.**

STEP 1. (Example) Edit the Start-Node and End-Node to define a Visible-Period.

1. Click the **Start-Node** ❸.

When the **Start-Node** is Red ...

2. Edit the NODE'S TIMING ❺ to control the start of the **Visible-Period** for the PATTERN-ELEMENT ❶.

Then

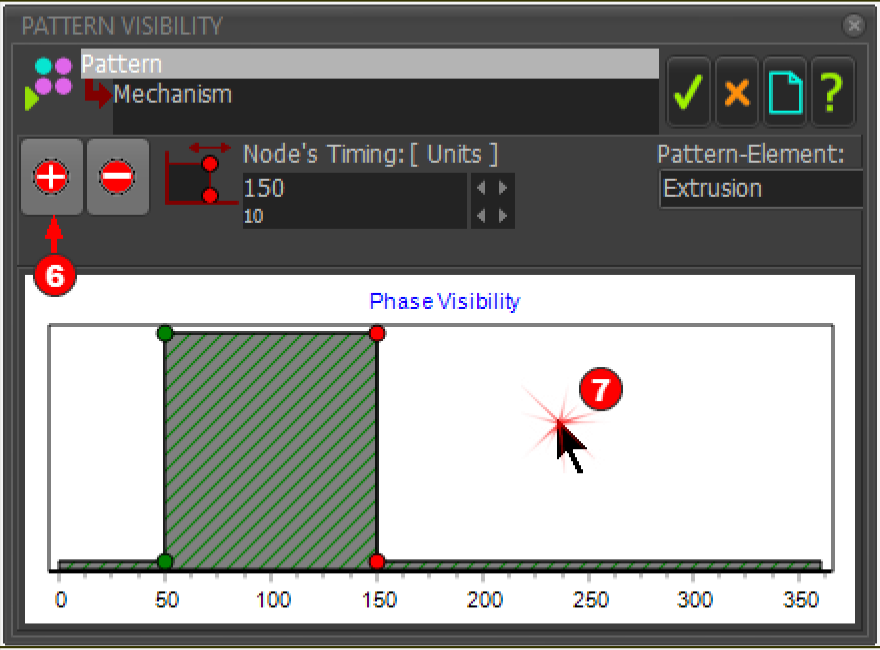
3. Click the **End-Node** ❸

When the **End-Node** is Red ...

3. Edit the NODE'S TIMING ❺ to control the end of the **Visible-Period** for the PATTERN-ELEMENT ❶.

The image below shows the new timing of the **Visible-Period** for the PATTERN-ELEMENT (EXTRUSION).

It starts at 50 and end at 150 in the Machine-Cycle.



STEP 2. (Example continued...) Add a new Visible-Period

- see image above.

1. Click ⊕ ADD NODE button ❻

2. Click the PHASE VISIBILITY CHART in a free area❼ which is not in the **Visible-Period** (e.g. between 150 and 360) - see cursor in the image above.

There is now a new **Visible-Period** in the PHASE-VISIBILITY CHART - see image below.

STEP 3. (Example continued...) Edit the Start-Node and End-Node to define the timing of the new Visible-Period.

1. Click the **Start-Node**3 or **End-Node**4 of the new **Visible-Period**

When a **Node** is Red ...

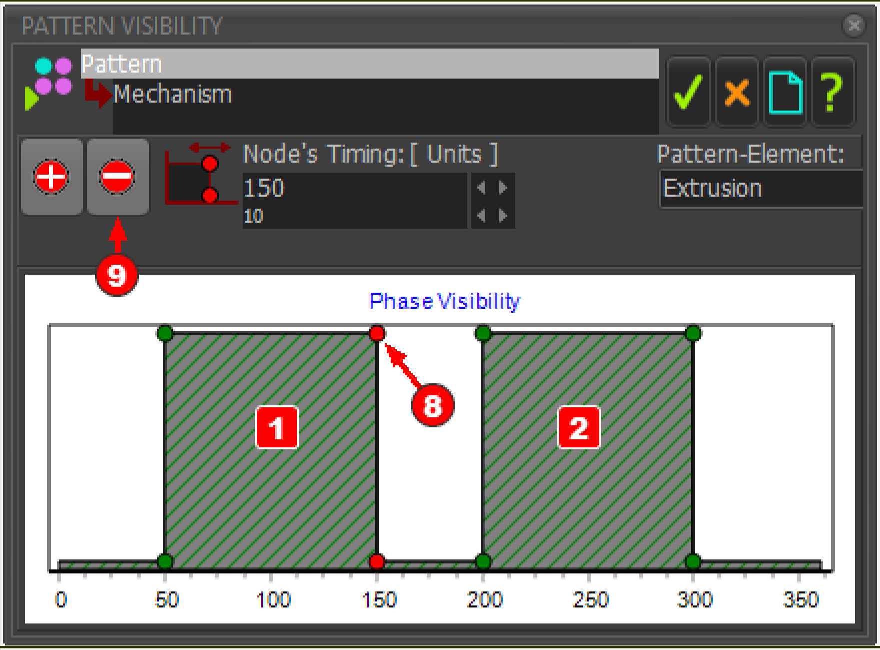
2. Edit the NODE'S TIMING5

Do **1** and **2** again to define the new **Visible-Period** for the PATTERN-ELEMENT

The image below shows the two **Visible-Periods** in the PHASE-VISIBILITY CHART for the PATTERN-ELEMENT (EXTRUSION)

Visible Period 1 - starts at 50 and ends at 150

Visible-Period 2 - starts at 200 and ends at 300



STEP 4. (Example continued...) Delete a Visible-Period

1. Click the **Start-Node** or **End-Node** of the **Visible Period** you want to **delete**.

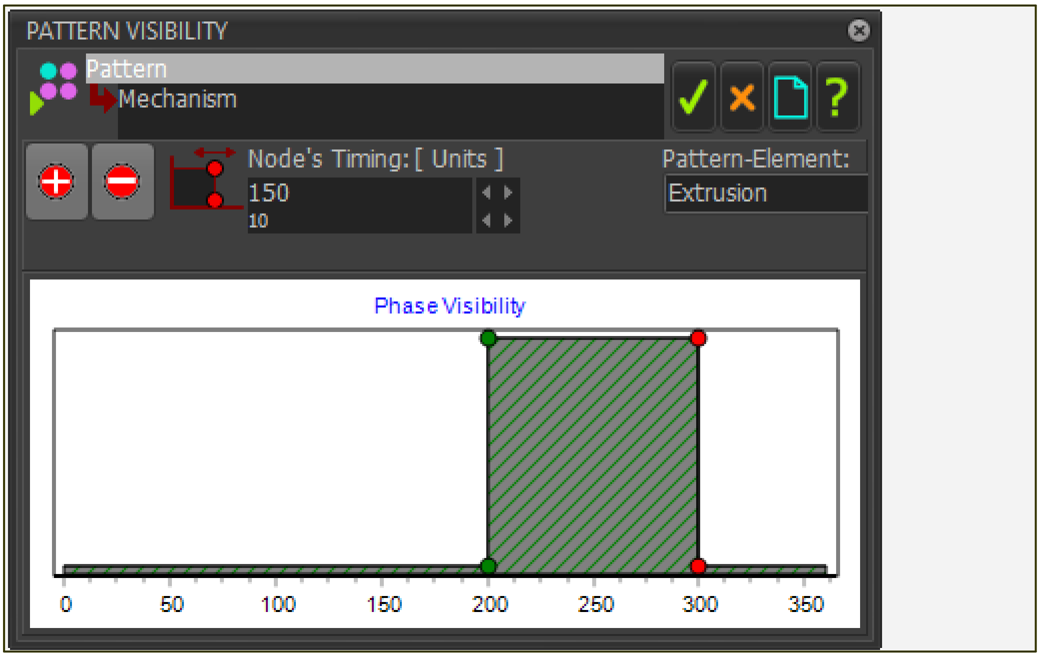
In the image above the **End-Node**8 of **Visible-Period** 1 is Red ...

2. Click **DELETE-NODE** 9

We delete **Visible-Period** 1 from the PHASE-VISIBILITY CHART

The image below shows one **Visible-Period** in the the PHASE-VISIBILITY CHART for the PATTERN-ELEMENT (EXTRUSION)

You can now Click to close the **Pattern Visibility interface**.



Pattern Visibilities - example

Imagine a chain wrapped around a circular, 12-hour, analog, clock. There are 12 hours and 12 chain-links in the chain.

The chain moves continuously around the circular clock.

To add the 12 copies of the Pattern-Element (see Pattern-Elements tab chain-links is the SOURCE PATTERN-ELEMENT (**SOLID**).

- Edit Phase Visibilities tab > **PHASES** separator > # COPIES to edit the number of chain-links on the chain - in this example, 12 copies to give 12 chain-links.

You will see in the box below the angle of the 12 Copies, when the **MMA=0**.

- Click a copy in the table.

The changes to a for each copy you click.

A next to the copy means you can see the copy move around the clock - however, see also **PATTERN VISIBILITIES**

A next to the copy means you can not see the copy, as it moves ALL the way around the clock.

- Nearly always, enable HIDE SOURCE PATTERN-ELEMENT.
- Use **PATTERN VISIBILITY** to hide each chain-link, one link after the next link, as it moves between hours, for example, between 6 and 9 o'clock.

1.5.11.37 Dialog: Function-Block: Math (with Calculator)

Math FB (with Calculator)

See Add Math FB [215] **See also : *Tutorial 18: Math FB***

Use a **MATH FB** to add new math functions.

Use a **MATH FB** to change units of a Data-Type. For example, change units from motion (P, V, A) to Force (Newtons) units, and connect a **MATH FB** to a SPRING FB [234].

A **CALCULATOR** interface can help you select different functions.

How to open the Math FB dialog

To open the **MATH FB DIALOG**:

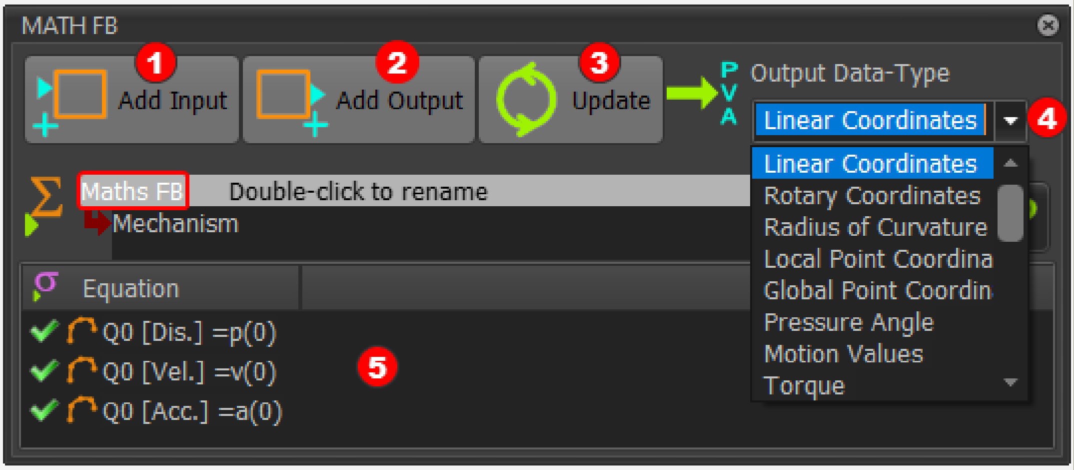
1. Double-click the **MATH FB** in the graphics-area

OR

1. **See How to Open a dialog** [627]

The **MATH FB DIALOG** is now open.

Math FB dialog



Math FB dialog

Math FB Interface

ADD INPUT button❶

1. Click the Add Input button to add an input-connector to the **MATH FB**.

   You need one input-connector for each variable or parameter in your equation.

Note:

If you connect a wire from a **MOTION FB** to the input-connector of a **MATH FB**, then select **LINEAR** or **ROTARY** as the **OUTPUT DATA-TYPE** in the **MOTION FB**.

ADD OUTPUT button❷

1. Click the [Add Output] button to add an output-connector from the MATH FB.

   You need one output-connector for each output.

UPDATE button❸

1. Click the [Update] button when you:
   - Change the OUTPUT DATA-TYPE
   - Edit an Equation

OUTPUT DATA-TYPE❹

The units of the OUTPUT DATA-TYPE apply to ALL of **output-connectors** from the MATH FB.

To select a different OUTPUT DATA-TYPE

1. Click the drop-down box❹
2. Select the OUTPUT DATA-TYPE

Note:

Inside the MATH FB, all units are **SI units**.

A change to the OUTPUT DATA-TYPE may change the values at the output-connector of the MATH FB.

Equations❺

Output Data-Type, Output-Connectors, Data-Channels

The OUTPUT DATA-TYPE controls the units of **ALL** output-connectors.

Each **output-connector** has **three(3) Data-Channels**.

You can write one equation for each **Data-Channel**.

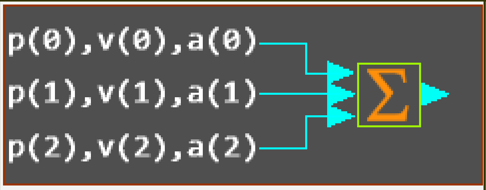
For example:

If you select LINEAR COORDINATES as the OUTPUT DATA-TYPE, then the output of ALL equations have **Linear Units**

If you have two(2) **output-connectors**, there are 6 equations.

- The units for **Data-Channels** Q0[Dis.] and Q1[Dis.] are Displacement, with units of m
- The units for **Data-Channels** Q0[Vel.] and Q1[Vel.] are Velocity, with units of $m.s^{-1}$
- The units for **Data-Channel**s Q0[Acc.] and Q1[Acc.] are Acc, with units of $m.s^{-2}$
- Data-Channels/Equations 0, 1, 2 are for the Output-Connector #1
- Data-Channels/Equations 3, 4, 5 are for Output-Connector #2

Wire Numbers / input-connectors and Data-Channels

<table>
<tr><td colspan="2">The image below shows three Wires connected to three Input-Connectors.</td></tr>
<tr><td>
3 Wires, 3 Input-Connectors
Each wire has 3 Data-Channels</td><td>WIRE NUMBERS - refer to the image.
Wire numbers start at 0
• Input-Connector 1 is for Wire 0 - connected to the TOP input-connector
• Input-Connector 2 is for Wire 1
• Input-Connector 3 is for Wire 2 - connected to the BOTTOM input-connector</td></tr>
<tr><td colspan="2">DATA-CHANNELS
Each wire has 3 data-channels.
Each DATA-CHANNEL is designated a letter:
• p = Data-Channel 1
• v = Data-Channel 2
• a = Data-Channel 3
The format of an Equation references a WIRE-NUMBER and a DATA-CHANNEL:
DATA-CHANNEL (WIRE-NUMBER)
EXAMPLE - Entries in an Equation:
p(0) : p refers to DATA-CHANNEL 1 ; and (0) refers to INPUT-CONNECTOR 1
a(2) : a refers to DATA-CHANNEL 3 ; and (2) refers to INPUT-CONNECTOR 3
v(1) : v refers to DATA-CHANNEL 2 ; and (1) refers to INPUT-CONNECTOR 2</td></tr>
</table>

How many input and output-connectors?

As an example, to calculate **Power** :

P = Ʈ . ω

Power (N.m./sec) = Torque(N.m.) × Angular Velocity (rad/sec)

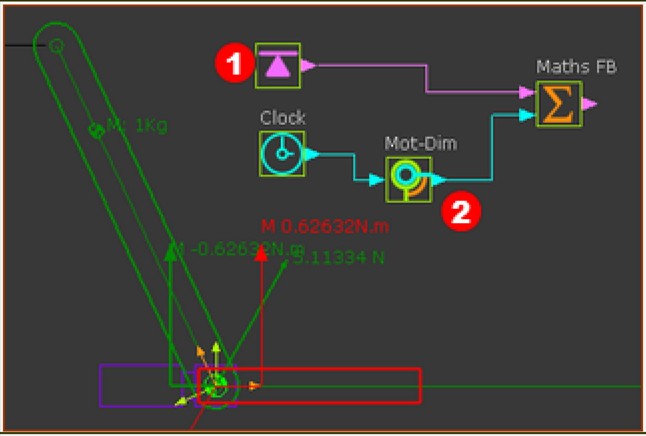
Torque and **Angular-Velocity** are inputs to the equation.

Power is the output.

You need **two input-connectors** and **one output-connector**.

Edit the MATH FB **to open the** MATH FB DIALOG.

1. Add two Input-Connectors with the ADD-INPUT button
2. Select **Power** as the OUTPUT DATA-TYPE
3. Click the UPDATE button



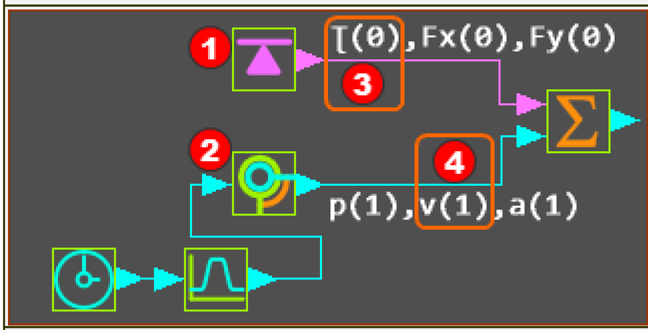
Prepare the model (see above)

1. Add a **ROCKER - see Tutorial 1**
2. Edit the **CAD-LINE** of the **ROCKER**, to open the **CAD-LINE DIALOG.**

In **CAD-Line dialog** > Mass Properties tab 367 > **USER MASS PROPERTIES** : Enter a value for the **Mass.**

Enter X and Y values to move the **Center-of-Mass** away from the **START-POINT** (origin) of the **CAD-LINE**.

3. Add a **FORCE-DATA FB** to the model ; open the **FORCE-DATA DIALOG** ; select the **PIN-JOINT**, and select the **POINT** in the **BASE-PART** to find the **Torque** that acts-on the **BASE-PART**.



See image above - the **DATA-CHANNELS** on the **WIRE** of the **FORCE-DATA FB**❸ and the **MOTION-DIMENSION FB**❹

The **MATH FB** uses SI units for all data 'inside'.

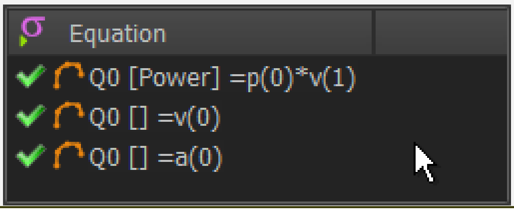
Enter the Equation

Click the first equation in the **MATH FB**

The **EQUATION-EDITOR** opens - see below.

You need to enter this equation:

Q0 [Power] = p(0)*v(1)



p(0) = Channel 1 (p = Torque), Wire-Number 0 (top input-connector)

×

v(1) = Channel 2 (v = Angular Velocity), Wire-Number 1 (input-connector below top)

SYNTAX and VALID Equations

Click **UPDATE** button to confirm that the syntax of the equation correct.

For example, it may not have correct number of parentheses. The reason is given as a message in the Feedback-Area[326] .

The ✅ at the left of each equation shows that the syntax is correct.

IMPORTANT

Data from Motion FBs

If you connect a wire from a **MOTION FB** to the input of a **MATH FB**, Set the **OUTPUT DATA-TYPE** in the **MOTION FB** to **LINEAR** or **ROTARY**.

MORE ABOUT UNITS 'inside' the Math FB

The data-values at the output connector of a **MATH FB** an be confusing for these reasons:

A: SI Units

Inside the **MATH FB**, the units are **SI**.

B: SI Units are converted to the ENGINEERING UNITS of the OUTPUT-DATA-TYPE.

The **SI units** and values that are internal to the **MATH FB** are converted back to Engineering Units[351] for the **OUTPUT DATA-TYPE** that you select.

Example:

- If a **MOTION FB** is set to **Rotary**, and the output from it is 90º, then the value internal to the **MATH FB** is 1.57radians.
- If the **MOTION FB** is set to **Linear**, and the output from it is 100mm, the value internal to the **MATH FB** is 0.1m.

Example continued...

If you multiply these values in the **MATH FB** dialog, the internal result is 0.157.

- If the **OUTPUT DATA-TYPE** is set to **ROTARY COORDINATES**, the output is 9º.
- If the **OUTPUT DATA-TYPE** is set to **LINEAR COORDINATES**, the output is 157mm

The reason? **0.157rads (inside the Math FB) = 9º (outside the Math FB).**

C: If you connect an output with ROTARY-COORDINATES to a Slider:

Rotary units to move a Linear Slider!

In the **MATH FB**, if you set the **OUTPUT DATA TYPE** to **ROTARY COORDINATES**, then **0.157** is **0.157rads** internally to the Math FB. It is **9º** at the output, when the Engineering-Units are **degrees**.

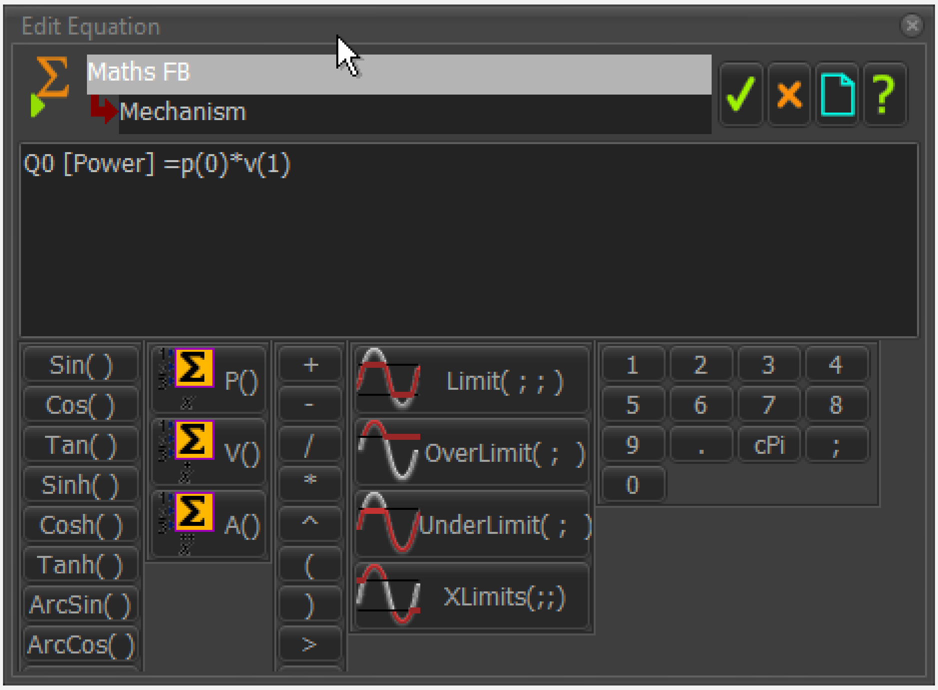
If you connect the **MATH FB** to a **MOTION-DIMENSION FB** to move a **Slider**, then the 9º is 9mm.

D: If you connect an output with LINEAR-COORDINATES to a Rocker:

Linear Units to move a Rotary Rocker!

In the **MATH FB**, if you set the **OUTPUT DATA TYPE** to **LINEAR COORDINATES**, then **0.157** is **0.157m** internally. It is **157mm** at the output when the Engineering-Units are **mm**.
If you connect the **MATH FB** to a **MOTION-DIMENSION FB** to move a **Rocker**, then 157mm is 157º.

Equation-Editor with Calculator



Equation-Editor with Calculator

The **EQUATION-EDITOR** provides a few of the common mathematical functions you can add to each equation.

When **open and close brackets** show within a function button, you should enter a value that is constant or a value that changes over a machine-cycle. For Example:

Sin( )

You can enter a constant. E.g. **Sin(3.14)**

You can also enter a variable. E.g. **Sin(p(1))**

p(1) is data-channel #1 of input-connector **#2**.

Calculator Functions

1. Position, Velocity, and Acceleration Values for a linear or angular input
   - P( ) ; V( ) ; A( )
2. Standard Algebra
   - Arithmetic: +, −, /, *
   - Power: ^
   - Brackets: ( )
3. Boolean
   - **>** : <output> = 1 if <value 1> **>** <value 2>, else 0
   - **<** : <output> = 1 if <value 1> **>** <value 2>, else 0
4. Trigonometry (all inputs in radians)
   - Standard: Sin( ), Cosine( ), Tangent( )
   - Hyperbolic: Sinh( ), Cosh( ), Tansh( )
   - Inverse: ArcSin( ), ArcCos( ) , ArcTan2(;)
5. Limit (input ; maximum value ; minimum value) :

   <output> = <input> if <input> is less than maximum value AND more than minimum value.

   <output> = <maximum-value> if <input> is greater than maximum

   <output> = <minimum-value> if <input> is less than minimum
6. OverLimit (input ; limit-value) :

   <output> = <input> if <input> is 'greater than limit-value'

   <output> = <limit-value> if <input> is 'less than limit-value'
7. UnderLimit (input ; limit value) :

   <output> = <input> if <input> is 'less than limit-value'

   <output> = <limit-value> if <input> is 'greater than limit-value'
8. Limits (input ; maximum value ; minimum value) :

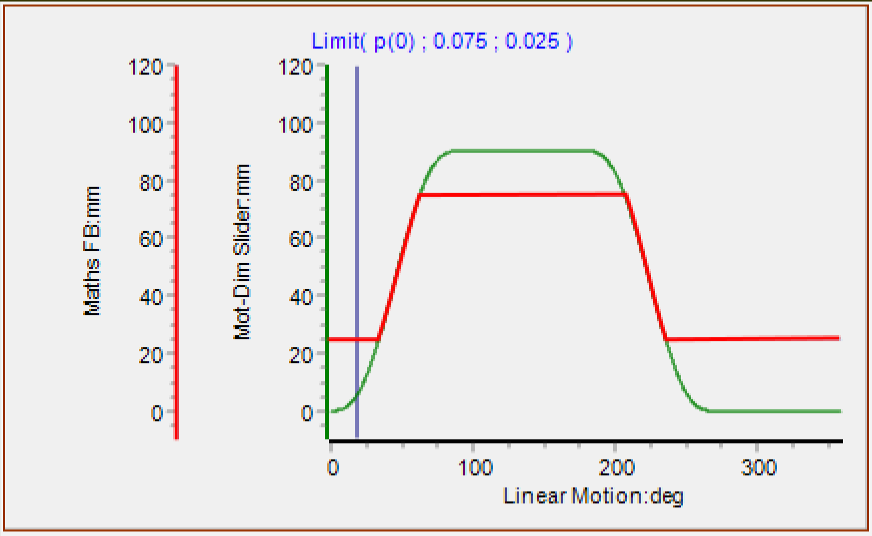
   <output> = <input> if <input> is 'greater than maximum value' OR less than minimum value'.

   <output> = <maximum-value> if <input> is 'less than maximum' AND 'more than minimum-value

   <output> = <minimum-value> if <input> is 'greater than minimum-value AND 'less than maximum-value'
9. Numerical Keypad
10. 1...9, 0, Π.
11. Abs( )

12. Mag(;) (assumes the two values are 'orthogonal' and uses Pythagoras to find the 'resultant')
13. Sqrt( );
14. DegToRad( )
15. RadToDeg( )

Limit Functions:



LIMIT Function

Limit (input ; maximum value ; minimum value) :

<output> = <input> if <input> is less than maximum value AND greater than minimum value.

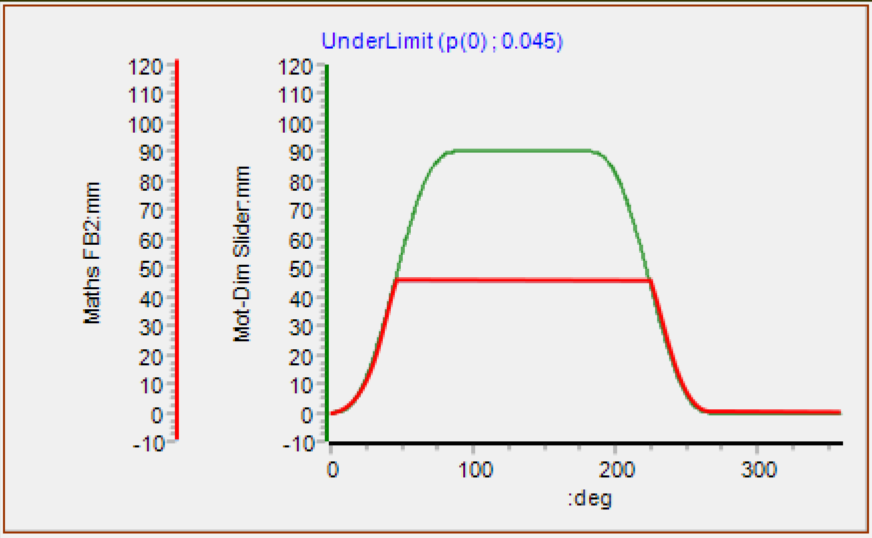
<output> = <maximum-value> if <input> is greater than maximum

<output> = <minimum-value> if <input> is greater than minimum

---

Note that the arguments in the Limit Function are SI units for the units in the model.

For example, **75 millimeters** in the model is **0.075 meters** in the function.

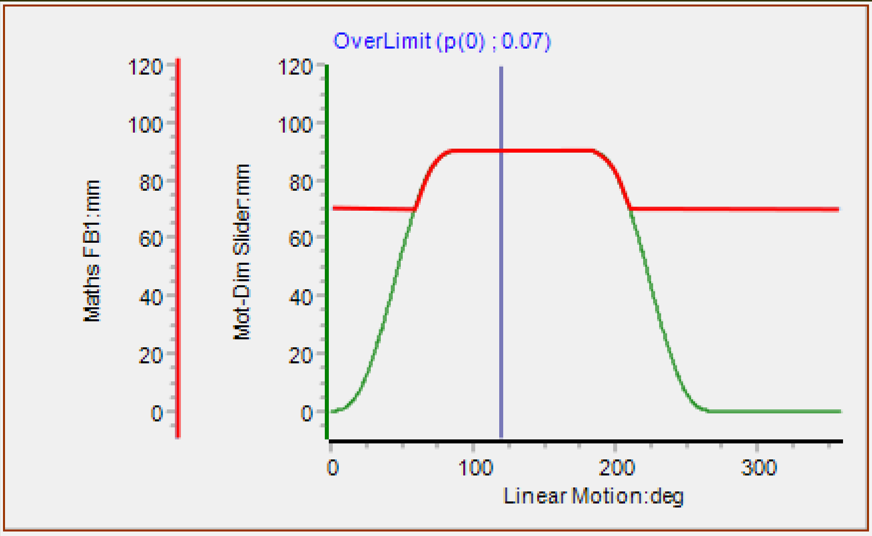


UNDER-LIMIT Function

UnderLimit (input ; limit value) :

<output> = <input> if <input> is 'less than limit-value'

<output> = <limit-value> if <input> is 'greater than limit-value'



OVER-LIMIT Function

OverLimit (input ; limit-value) :

<output> = <input> if <input> is 'greater than limit-value'

<output> = <limit-value> if <input> is 'less than limit-value'

1.5.11.38 Dialog: Function-Block: Briefcase

Briefcase FB

See: Add Briefcase 208

Use a **BRIEFCASE FB** to hide other **Function-Blocks** from the graphics-area.

You can use one **BRIEFCASE FB** to hide all of the **Function-Blocks**. However, I usually add one **BRIEFCASE FB** for each machine function.

You can also hide a **BRIEFCASE FB** inside a different **BRIEFCASE FB**.

How to open the Briefcase FB dialog

Open the **BRIEFCASE FB** dialog:

1. Double-click a **BRIEFCASE FB** in the graphics-area

OR

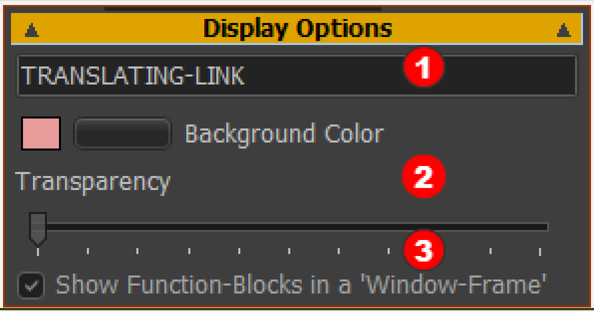
1. **See** How to Open a dialog 627

The **BRIEFCASE DIALOG** is now open.

Briefcase FB dialog

Briefcase FB dialog

DISPLAY OPTIONS



❶ **<< WRITE A LABEL >>** (For example: TRANSLATING-LINK)

Enter a **name** to remind you of what the Function-Blocks in the Briefcase do in your model.

The label you enter shows above the **BRIEFCASE FB** in the graphics-area after you add **Function-Blocks** to the **BRIEFCASE FB**.

❷ **BACKGROUND COLOR** and **TRANSPARENCY**

Use the **BACKGROUND COLOR** button to edit the color of the **BRIEFCASE WINDOW-FRAME** **-see example below.**

Use the TRANSPARENCY slider to edit the transparency/opacity of the BRIEFCASE WINDOW-.

❸ SHOW-FUNCTION-BLOCKS IN A WINDOW-FRAME

☑ Select SHOW FUNCTION-BLOCKS IN A WINDOW-FRAME to show the BRIEFCASE WINDOW-FRAME

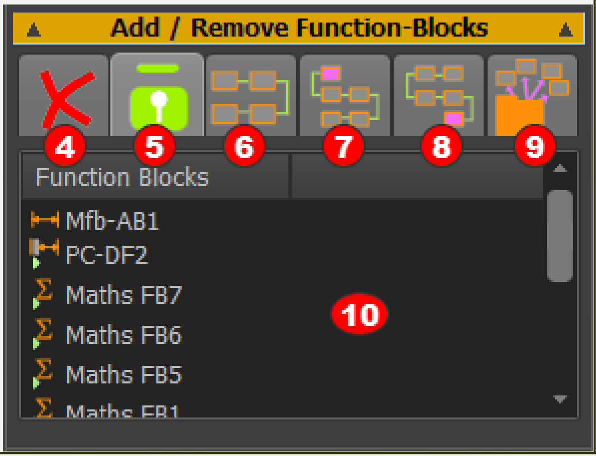
❑ Clear SHOW FUNCTION-BLOCKS IN A WINDOW-FRAME to hide the BRIEFCASE WINDOW-FRAME

New Functionality

SHORT-CUT - to toggle “”SHOW FB IN A WINDOW FRAME

1. Press your SHIFT key on your keyboard
2. Move your mouse above a BRIEFCASE FB
3. Click your mouse

ADD / REMOVE FUNCTION-BLOCKS



Add FBs to the Briefcase

1. Click the PADLOCK❺ to unlock the BRIEFCASE FB

The PADLOCK❺ icon is now unlocked - see image.

2. Click FBs in the graphics-area

   We move each FB you click from the graphics-area to the FUNCTION-BLOCKS❿ box in the BRIEFCASE FB.

3. Click the PADLOCK❺ to lock the BRIEFCASE FB

Remove FBs from the Briefcase:

1. Click a FB in the FUNCTION-BLOCKS❿ box
2. Click the CROSS❹ button.

   The FB returns to the graphics-area, outside of the BRIEFCASE WINDOW-FRAME.

3. Do **1 - 3** again to remove different FBS.

Arrange FBs in the Briefcase Display Window.

1. Click SHOW FUNCTION-BLOCKS IN A 'WINDOW-FRAME' check-box❸ - see above.
2. Click the ARRANGE FBS❻ button

The FBS are now arranged in a **linear array** in the graphics-area.

You may need to drag FBS to arrange the FBS in the **linear array.**

Add all those FBs that are connected with wires 'upstream' of a FB

1. Click a FB in the FUNCTION-BLOCKS box ❿
2. Click the ADD ALL UPSTREAM icon ❼

The FBs that are connected to the input-connector of the FB you select are now in the FUNCTION-BLOCK box.

Add all those FBs that are connected with wires 'downstream' of a FB

1. Click a FB in the FUNCTION-BLOCKS box ❿ in the BRIEFCASE
2. Click the ADD ALL DOWNSTREAM icon ❽

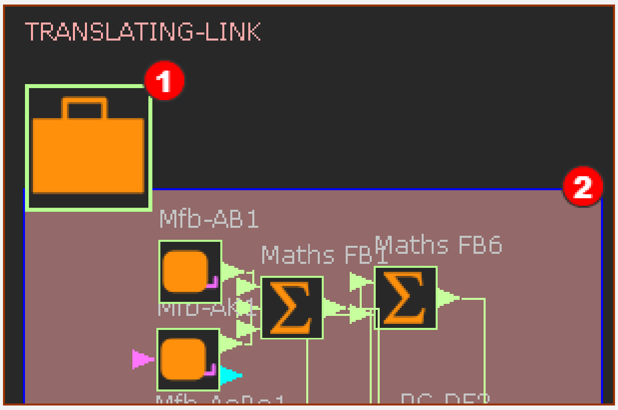
The FBs that are connected to its output-connector are now in the FUNCTION-BLOCK box.

Remove all FBs from the Briefcase

1. Click the REMOVE ALL icon❽ .

The FBs are now in the graphics-area again.

EXAMPLE:



Function-Blocks in the "Briefcase Window-Frame"

❶ BRIEFCASE FB and label: TRANSLATING-LINK.

❷ BRIEFCASE WINDOW-FRAME is a colored box, with a **blue** border.

- The window re-sizes as you drag, add, or remove FUNCTION-BLOCKS.
- Drag the BRIEFCASE FB❶ to move the BRIEFCASE WINDOW-FRAME❷

1.5.11.39 Dialog: Function-Block: Point-Cloud

Point-Cloud FB

See Add Point-Cloud 206

Do two steps in the POINT-CLOUD DIALOG:

STEP 1: IMPORT-DATA (TXT file-type).

For example, import the X,Y coordinates of a cam-profile, which you have measured with a Coordinate Measurement Machine (CMM).

STEP 2: FIT-A-CURVE TO THE DATA

We fit for you a smooth **Curve** to the data that you import, with a Fourier Harmonic-Series.

How to open the Point-Cloud dialog

Open the POINT-CLOUD DIALOG:

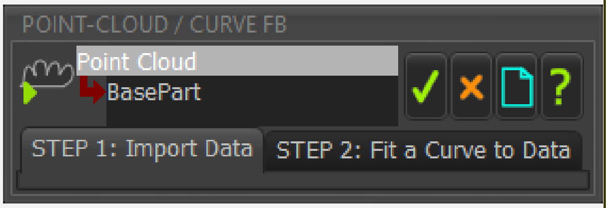
1. Double-click a POINT-CLOUD FB in the graphics-area

OR

See How to open a dialog 627

The POINT-CLOUD DIALOG is now open.

Point-Cloud dialog



Point-Cloud dialog

STEP 1: Import Data

STEP 2: Fit Curve to Data

STEP 1: Import Data

Do A, B, and C.

Import and Browse buttons

A. BROWSE...

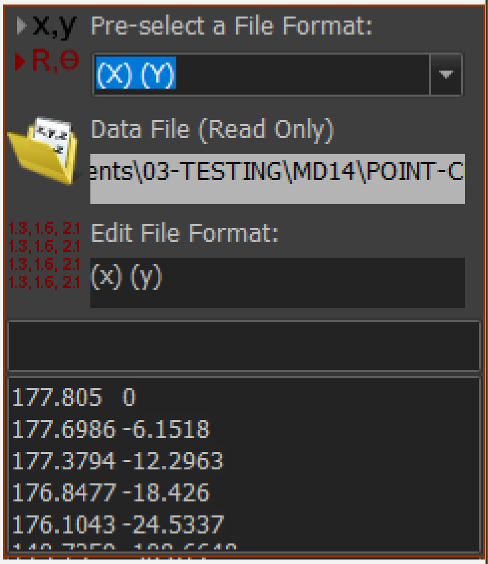
Click the BROWSE... button to find a data-file.

The data-file must by an ASCII, or TXT file-type.

The file-name you select shows in the DATA-FILE (READ-ONLY) box.

A preview of the data in the file is in the box below.

B. EDIT FILE-FORMAT



Example File Format

Any **Header** in the data-file is not imported.

The data should be rows of data-points - see **Data-Points** below

You can remove extra **data** from columns/rows with the EDIT FILE-FORMAT box. See File Formats[523] below.

C: IMPORT BUTTON

When the File Format is correct (see below), click the IMPORT button to import the POINT-CLOUD data-file.

We plot for you the POINT-CLOUD on the PART to which the POINT-CLOUD FB is a child.

The Point-Cloud plot is a continuous line in the graphics-area.

See also: Messages[524]

Data-Points

The **File Format** must include at least these terms:

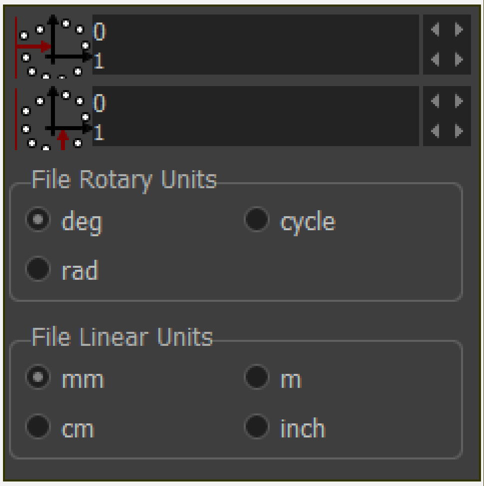
- **(x) (y)** : if each data-point is an **X** and **Y** coordinate

OR

- **(Radius) (Angle)** : if each data-point is a **Radius** and **Angle** coordinate.

Characters that are ignored in the data-file:

- Header lines, when entered as text.
- ASCII characters that are NOT : **. , -, 0–9,** in all lines.



Optional: Data Offset and Scale option

Options:

X , Y

When you add a POINT-CLOUD, you select a PART. The PART has an origin - its START-POINT - where its XY coordinates are (0,0)

If the origin of the POINT-CLOUD has an offset relative to the origin of the PART, you can remove the offset. Enter -X, -Y, the negative of the offset.

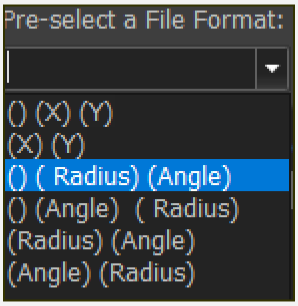
Or, to offset the POINT-CLOUD, by (X,Y), enter (X,Y) values.

	FILE ROTARY UNITS ; FILE LINEAR UNITS Select the units that match those of the original **POINT-CLOUD** data-file.

File Formats:

PRE-SELECT A FILE FORMAT

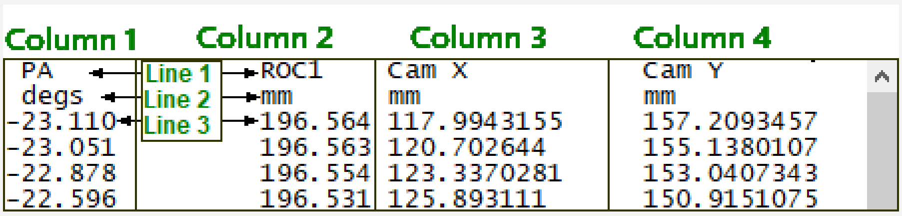
To help you with the formatting, you can use the **PRE-SELECT A FILE FORMAT** from the drop-down list-box.



When any of these formats do not represent the format of the data in your data-file, then edit the format in the Edit File Format box directly.

Example: Data-Files and File-Formats and Enter File Format.

EXAMPLE 1: Data-File:



Enter File Format: () () (x) (y)

Why?

Line 1	Is Not imported - text only (A, B, C, ... Z)
Line 2	Is Not imported - text only (A, B, C, ... Z)
Line 3: Column 1 and Column 2:	Are Not imported because of () () in the File Format () () (x) (y) removes these two Columns
Line 3: Column 3 and Column 4	**Are Imported** because the (x) (y) in the File Format () () (x) (y) identify that these Columns as x, y data
Lines 4, 5, 6, ...	Equal to Line 3

EXAMPLE 2: Data-File

Data Format: N100 G00 X10 Y25 Z27

Enter File Format: () () (x) (y) ()

Why?

~~N~~100 ~~G~~00 ~~X~~10 ~~Y~~25 ~~Z~~27	**Letters** - not imported **(A, B, C, ... Z)**
~~N100~~ ~~G00~~ ~~X~~10 ~~Y~~25 ~~Z27~~	**Column 1, Column 2**, and **Column 5** - not imported - the () in the **File Format** () () (x) (y) ()
10 25	Imported - the (X) and (Y) in the **File Format** () () (x) (y) ()

Feedback Messages:

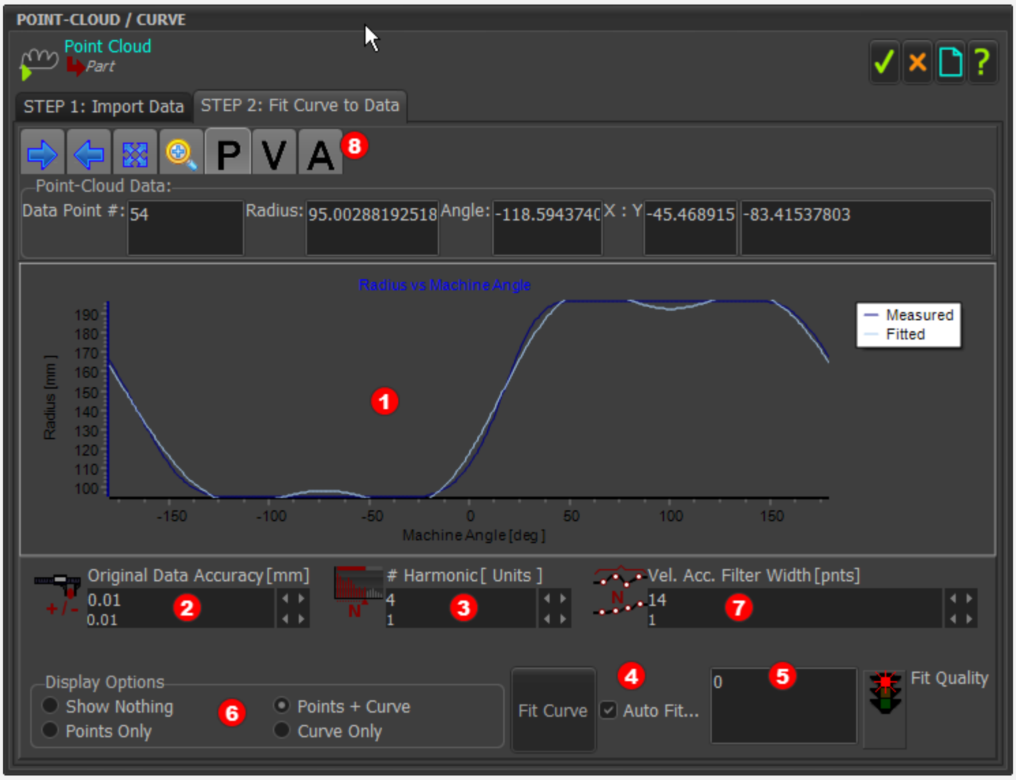
Topic	Message
Point Cloud Import	*XXX* total points have been imported
Point Cloud Import	*XXX* number of unique angles

STEP 2: Fit Curve to Data

When you import **Point-Cloud data**, the chart❶ shows the **Points**, the **Curve**, **Nothing**, or **Points** + **Curve**❻

In the chart below, the **Continuous Curve** does **not** follow the **Point-Cloud data** - it is planned and to see the different charts ONLY.

The two charts show as one chart after you successfully **Fit the Continuous Curve** to the **Point-Cloud data** when you increase the number of Harmonics.



Point-Cloud dialog > Fit Curve to Data tab

Parameters

❷ ORIGINAL DATA ACCURACY

This is a judgment you must make. Start with 0.1 then reduce it to approximately 0.001 - but see Original Data Accuracy 526 for more thoughts.

❹ AUTO-FIT check-box and FIT CURVE button

Usually, click the AUTO-FIT button to make it active - see options

❸ Increase the # HARMONICS

Edit the # HARMONICS❸

The difference between the **Continuous-Curve** and the **Imported Data** decreases as you increase the **# Harmonic**❸.

❺ FIT-QUALITY =0 >> 1

When FIT QUALITY TRAFFIC LIGHT is Green, ...

or

When the number in the FIT-QUALITY NUMBER BOX❺ is near to, or equal to, one(1), ...

... STOP - do not increase the number of Harmonics.

❻ DISPLAY OPTIONS

Click one of the four radio-buttons

- SHOW NOTHING
- POINTS ONLY

- ○ POINTS AND CURVE
- ○ CURVE ONLY

The view of the **Continuous-Curve** and the POINT-CLOUD in the graphics-area match the P, V, or A❽ button.

Steps to do in Fit Curve

A. Edit the # Harmonics

☑ AUTO-FIT Check-box

The CURVE updates immediately each time you edit the # HARMONICS

❏ AUTO-FIT check-box is clear.

The CURVE only updates when you click FIT CURVE❹

B. Repeat A

Increase the # Harmonics until the FIT-QUALITY =~1, and the TRAFFIC-LIGHT is **Green** or Orange.

We recommend the Maximum # Harmonics < # Data-Points in the Point-Cloud / 3.

VELOCITY and ACCELERATION GRAPHS and FILTER WIDTH❼

The default plot is Position. If you want to plot the Point-Cloud and the Curve as Velocity or Acceleration (❽), then click the **V** or the **A** icon.

Even if the Fit Quality = 1, you can continue to increase the number of # Harmonics to improve the fit of the Velocity and/or Acceleration Curve to the Point-Cloud.

However, we recommend the Maximum # Harmonics = # Points in the Point-Cloud/3.

If the plot of the Velocity or Acceleration data is noisy you can smooth the noise (remove the noise) with the Filter-Width❼. This may help you identify the original Motion-Law.

Original Data Accuracy❷

Thoughts:

- Consider an **Original Data Accuracy** of 0.1, then reduce it to approximately 0.001.
- Do not enter a value that is more accurate than the original accuracy of the data. For example, if the data has 2 d.p. , then 0.05 OK, and 0.001 is not a sensible value. However, experiment, as you find that more accuracy gives you better results.
- Is the skill of the person that measured the Cam-Profile a factor?
- Is the Cam-Profile clean? Is the Cam-Profile worn? Is the Cam-Profile damaged?

Machine Measurement Accuracy Approximations: per 100mm Diameter of Cam Diameter:

- Temperature-Controlled (18-22ºC) CMM approximately 0.2 - 2µm
- Non-temperature-controlled CMM approximately 2 - 10µm (~h4 for a Ø100mm shaft)
- Portable CMM approximately 5 - 20µm (~h5-h6 for a Ø100mm shaft)
- Test Rigs are variable, but you should aim for approximately 20 - 100µm (~h8-h9 for a Ø100mm shaft)

1.5.11.40 Dialog: Function-Block: Design-Set

Design-Set FB

See Add Design-Set 217

Use **DESIGN-SETS** to edit a number of dimensions and parameters in one place - with the **DESIGN-SET DIALOG**.

Add to a **DESIGN-SET** those dimensions and parameters that you believe to be important to the outcome of a design-objective.

You can add more than one **DESIGN-SET**.

Question:

Why use a **DESIGN-SET?**

Answers: Three good reasons:

A. Frequently, you edit the same dimensions and parameters in a model many times to improve a design objective. You can add and edit them directly with a **DESIGN-SET**.

B. If you need to open the model after a period of time, a **DESIGN-SET** reminds you of which dimensions and parameters are important to your design. Also, you can give your model to a different engineer, and tell him to ONLY edit the dimensions and parameters in the **DESIGN-SET**.

C. When dimensions are in a **DESIGN-SET**, you cannot only edit them with the **DESIGN-SET**.

IMPORTANT

After you add a **DIMENSION** to a **DESIGN-SET**, you **CAN ONLY** use the **DESIGN-SET** to edit that **DIMENSION**.

To edit a **DIMENSION** in the **PART-EDITOR** again, you must delete the **DIMENSION** from the **DESIGN-SET**.

A **DIMENSION** that is in the **DESIGN-SET** is **gray** in the **PART-EDITOR** - to indicate you cannot edit it.

TOP-TIPS:

1. Rename each dimension to a name that will help you know its function in the **DESIGN-SET**.
2. Rename each **DESIGN-SET** to remind of its design-objective.

See SHOW DIMENSION-NAMES 343 , and SHOW FUNCTION-BLOCK NAMES 345

How to open the Design-Set FB dialog

Edit the DESIGN-SET FB

1. Double-click the DESIGN-SET FB in the graphics-area

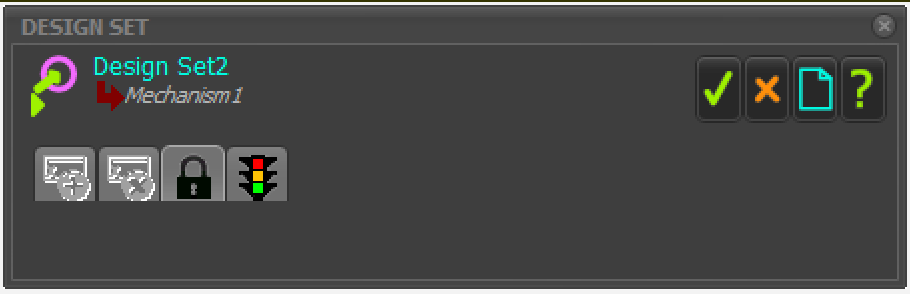
OR

1. **See** How to Open a dialog 627

The DESIGN-SET DIALOG is now open.

Design-Set dialog

Design-Set toolbar



Design-Set dialog - LOCKED

Design-Set dialog - UNLOCKED

When you open the DESIGN-SET DIALOG, the toolbar is locked. It is NOT active.

The Design-Set toolbar icons - when active - are:

❶ : ADD ELEMENT-ROW

❷ : DELETE ELEMENT-ROW

❸ : PADLOCK : LOCK / UNLOCK TOGGLE

❹ : REBUILD MODEL

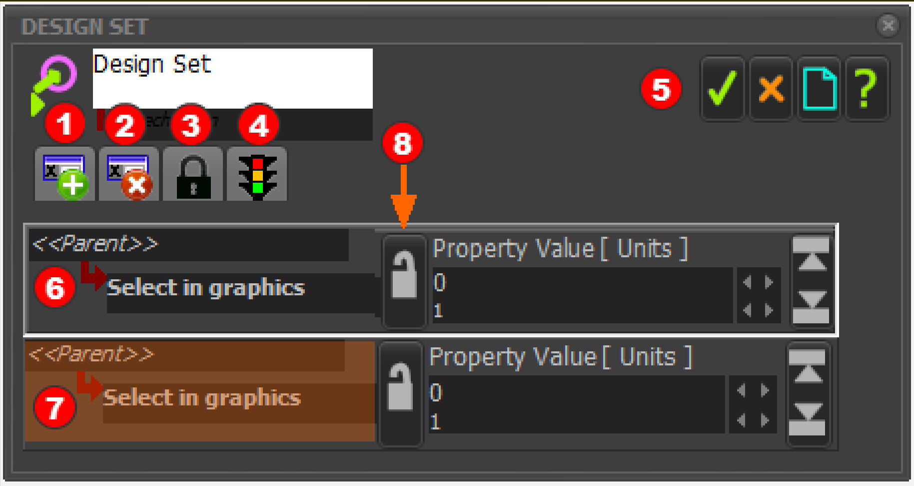
❺ : ✓ ✗ 🗋 ? OK, CLOSE, UNDO EDITS, HELP

To enable the Design-Set toolbar icons

1. Click the PADLOCK icon ❸.

The icons in the toolbar are **colorized** and the DESIGN-SET interface is **active**.

Add or Delete Element-Rows



Design-Set - 2 Element Rows

To add Element-Rows

1. Click the PADLOCK❸ - the toolbar is now colorized.
2. Click ADD ELEMENT-ROW❶ one time for each dimension or parameter you want to add to the DESIGN-SET.

   In the image above, there are two **Element-Rows**❻❼.

The active Element-Row.

The **active Element-row**❻ has a white box around its perimeter.

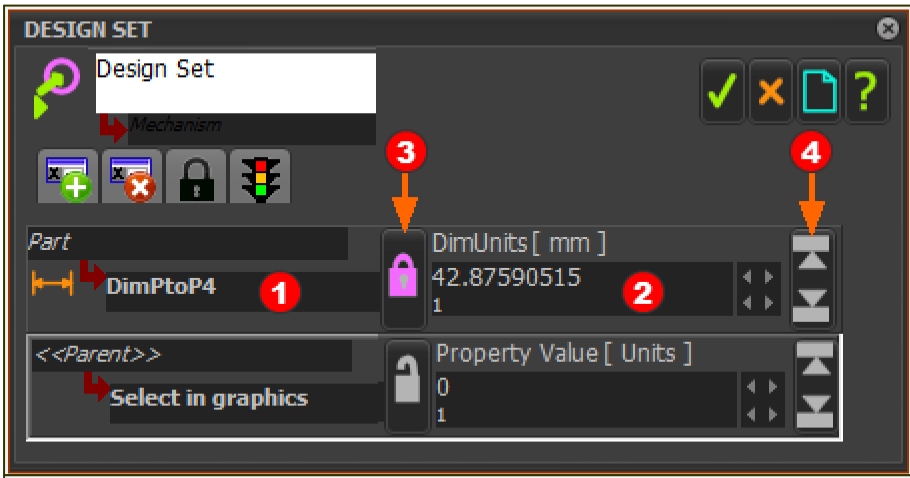
To make a different **Element Row** the **active Element-Row**:

1. Click in the **Select in graphics**❼ label - or the parameter name

To delete an Element-Row

1. Click the **Select in Graphics** label to make it the **active Element-Row**
2. Click DELETE ELEMENT-ROW❷

Link a Dimension to an Element-Row



1. If necessary, open the DESIGN-SET DIALOG
2. Click the **Select in graphics** label of an **Element-Row**, so that it is the **active Element-Row**.

3. Edit a PART
4. Click the arrowhead of a DIMENSION in the **PART-EDITOR**

Result:

The **Dimension name**❶ replaces the **Select in graphics** (DimPtoP4)

The **Dimension Units** name replace the **Property Value** (DimUnits)

The **Dimension value**❷ replaces the **Property Value** (42.87580515)

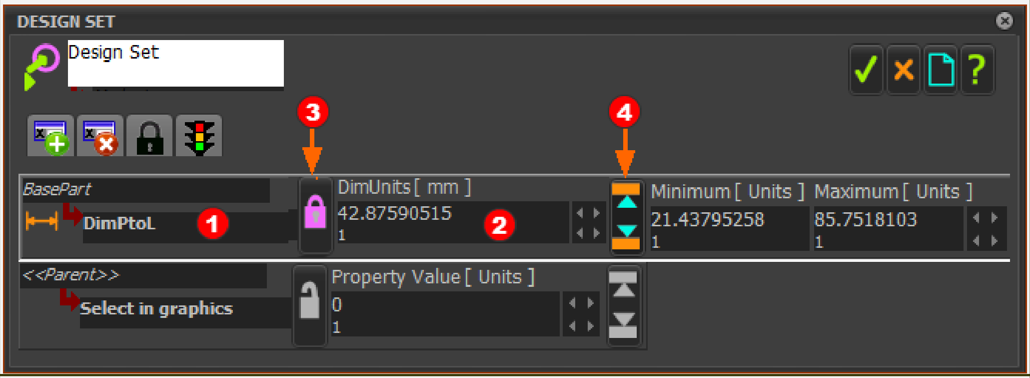
The Locked Padlock❸ is colorized. In this state, you **cannot overwrite** this **Element-Row.**

The next **Element-Row** is the **Active Element-Row** (a white box is around the **Element-Row**)

Maximum and Minimum 'Hard-Limits'

Maximum and Minimum 'Hard-Limits'

It is frequently useful to set maximum and minimum limits for each dimension or parameter in the **Design-Set.**



To edit the Maximum and Minimum limits:

1. Click the up/down arrow **Min-Max button**❹ **- see image above**

   The **Minimum** and **Maximum** data-boxes are now active.
2. Edit the **Minimum** and **Maximum** values.
3. Continue to edit the Dimension❷ - but now it cannot be less-than the **Minimum** or more-than the **Maximum** values.

Replace a Dimension or Parameter

To replace a Dimension or Parameter in an **Element-Row** with a different Dimension or Parameter.

1. Click the **Dimension name** to make it the **Active Element-Row**.
2. Click a Locked Pink Padlock❸ it changes to an Unlocked Grey Padlock.
3. Click a different Dimension or Parameter in your model and graphics-area.
4. Click the Unlocked Grey Padlock❸ so it is a Locked Pink Padlock.

Parameter Lists in different Element-Types:

In addition to dimensions, you can link parameters from dialogs for different element types with a Design-Set.

For example: Parameters of FBs, Parameters of a Gear-Pair, Parameters of a CAD-Line, and other elements.

Link a Parameter (from a dialog-box) with an Element-Row

Select the Element-Type:

1. Open the DESIGN-SET DIALOG
2. Click the **Element-Row** to make it the **Active Element-Row**
3. Click the PADLOCK icon in the Design-Set toolbar, to unlock the DESIGN-SET.
4. Click the ELEMENT-TYPE in the graphics-area or the ASSEMBLY-TREE

If the **Element-Type** has only one(1) PARAMETER

The PARAMETER passes immediately into the **Element Row**.

If the **Element-Type** has two(2) or more PARAMETERS:

A list of PARAMETERS that you can select show in a box.

See below: 'Parameter Lists in different-elements' below**.** If you cannot identify the PARAMETER from its name, then experiment.

---

1. Click the PARAMETER in the list
2. Click the ✅ button to close the PARAMETER box

   The PARAMETER name and its value shows in the **Element-Row** in the DESIGN-SET.

Available Element-Types and their Parameters

Linear-Motion Function-Block

When you click a LINEAR MOTION FB, you add:

- LINEAR MOTION as the **Element Name**
- OUTPUTSTART_UNITS as the parameter.

OUTPUTSTART_UNITS ≡ START-ANGLE parameter in the LINEAR-MOTION DIALOG.

Motion-Dimension Function-Block

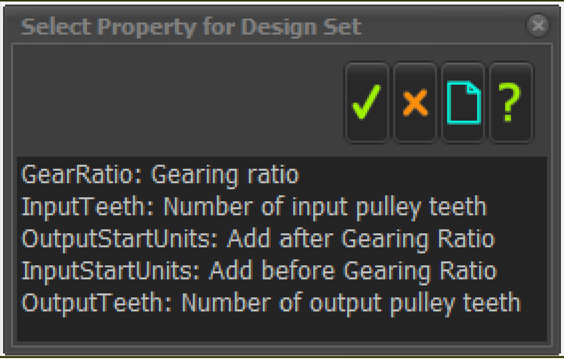
When you click a MOTION-DIMENSION FB, you add:

MOT-DIM ROCKER (or SLIDER) as the **Element Name**

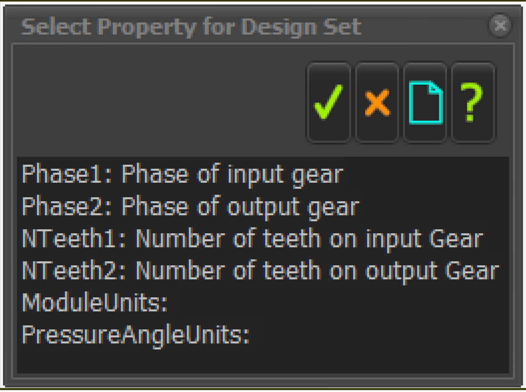
BASEUNITS as the parameter.

BASEUNITS ≡ BASE-VALUE in the MOTION-DIMENSION DIALOG.

Gearing Function-Block

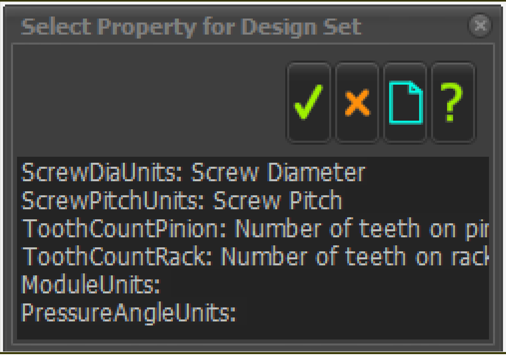


Gear-Pair

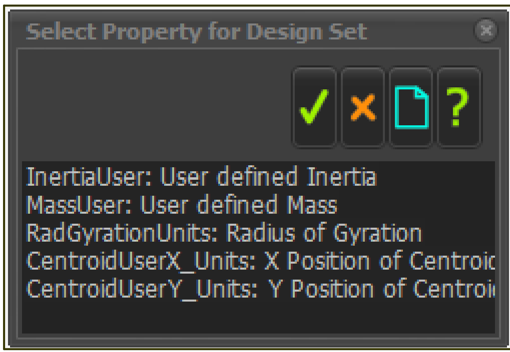


Do not select Phase1 or Phase2 for the Design-Set.

Rack-Pinion / Ball-Screw



CAD-Line



Pulley

When you click a **PULLEY**, you add

- PATH JOINT as the **Element Name**
- TOOTH-COUNT as the parameter.

TOOTH-COUNT ≡ NUMBER OF PULLEY TEETH parameter in the PULLEY DIALOG.

1.5.11.41 Dialog: Function-Block: Continuous-Crank

Continuous-Crank

See also **Add Continuous-Crank** 221

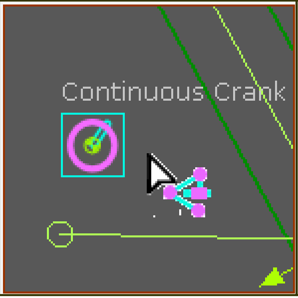
Usually, in a multi-part mechanism, you design the motion for a Tool-Part (the Part with the tooling), and MechDesigner applies Inverse-Kinematics to calculate the motion of a follower or a servomotor.

The follower usually oscillates or reciprocates.

A servomotor may also oscillate. However, there is also the case in which the servomotor rotates completely, but with a non-uniform rotating speed. This is a special-case. To enable this special-case, the rotating part must be the correct length, and its motion, also derived by inverse-kinematics from the motion of the Tooling, is more complex.

This is one application of the CONTINUOUS-CRANK FB.

How to open the Continuous-Crank FB dialog



Edit the CONTINUOUS-CRANK FB:

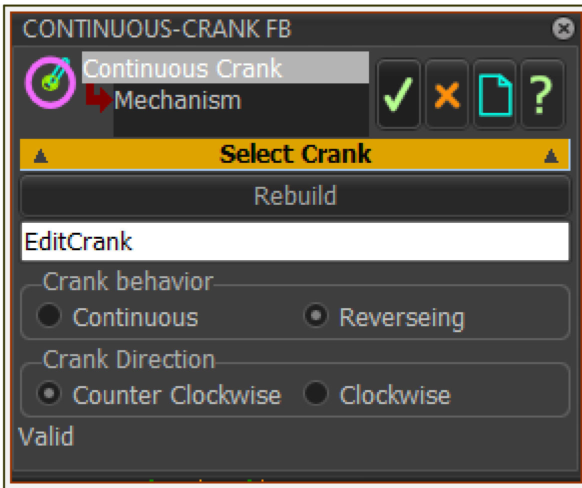
1. Double-click the CONTINUOUS-CRANK FB in the graphics-area

OR

1. **See** **How to Open a dialog** 627

The CONTINUOUS-CRANK DIALOG is now open.

Continuous-Crank dialog



Continuous-Crank dialog - not enabled

STEP 1: Select Crank Behavior and Direction

CRANK BEHAVIOR

CONTINUOUS - the PART rotates continuously.

REVERSING - the PART rotates to ~180º, and then return back to ~0º.

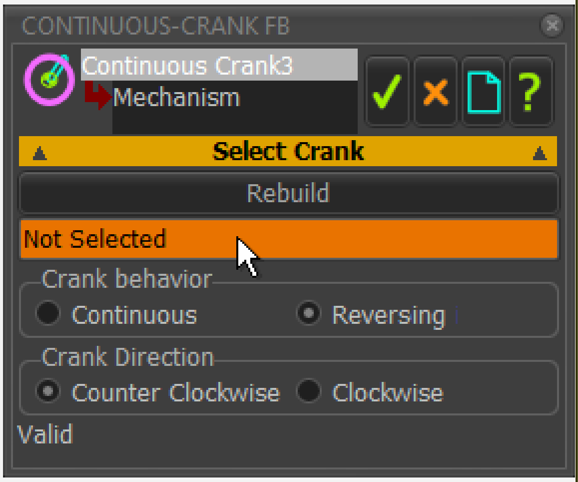
CRANK DIRECTION

If CRANK BEHAVIOR is CONTINUOUS, then:

COUNTER-CLOCKWISE - the PART rotates in the Counter-Clockwise direction

CLOCKWISE - the **PART** rotates in a Clockwise direction

If **CRANK BEHAVIOR** is **REVERSING**, to change Crank closure, see Change-Dyad Closure[119] .



Continuous-Crank dialog- enabled

STEP 2: Activate the Not Selected box

1. Click in the box labeled **Not Selected**

THE BOX IS NOW ORANGE. You can now select a **PART**.

STEP 3: Click a Part that you want to be the Continuous-Crank

1. Click a **PART** in the graphics-area or **ASSEMBLY-TREE.**

The **Continuous-Crank PART** must have a **PIN-JOINT** that joins it to the **BASE-PART**.

The **PART** immediately changes its length so that it can rotate continuously or oscillate by 180º. If there is a problem, see **Messages at the bottom of the dialog**.

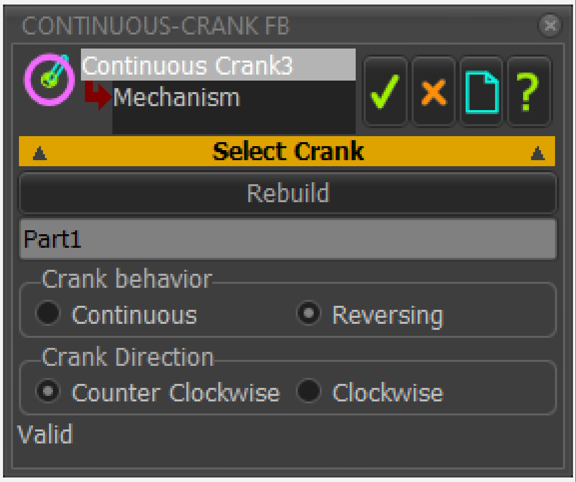
STEP 4: Confirm the behavior is as expected

1. Do **Run toolbar > Cycle Continuously** (**ALT+C**)

STEP 5: Click ✓ to close the dialog.

Messages at the bottom of the dialog:

When you select a **PART** as the Continuous Crank, there is be a message at the bottom of the dialog.



Continous-Crank dialog

Message	Meaning
Valid	The **PART** can be a Continuous Crank
Failed assign pivot-Point	We could not find for you the rotating-axis.
Impossible crank length: Geometry is inconsistent	For example, the **MOTION-PART** does not move, and thus the length of the Crank must zero(0).

1.5.11.42 Dialog: Function-Block: Spring

Spring FB

See Add Spring FB[234]

Use a **SPRING FB** to apply a force between two **POINTS**. The name that we use for the two **POINTS** is **ANCHOR-POINTS**.

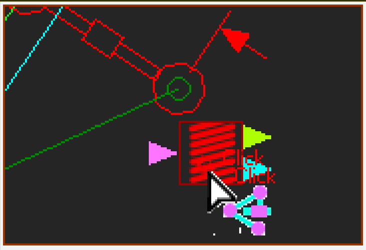
Force units are defined in the **Machine-Settings dialog > Engineering Units**[352] - default Force units are Newtons (N).

See also:

Machine Settings > Engineering Units[352]

Configure Power Source[589]

How to open the Spring FB dialog



In Mechanism-Editor:

1. Double-click the **SPRING-FB** in the graphics-area

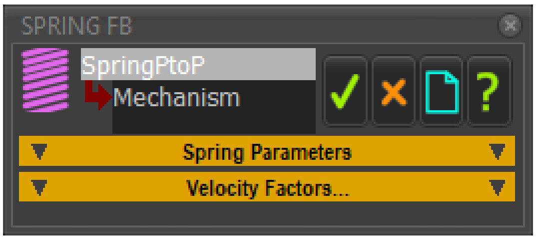
OR

1. **See How to Open a dialog**[627]

Note: It is **not** necessary to connect a wire to the input-connector or from the output-connectors of the **SPRING FB**. The input and output-connectors provide extra functionality - see Here[540]

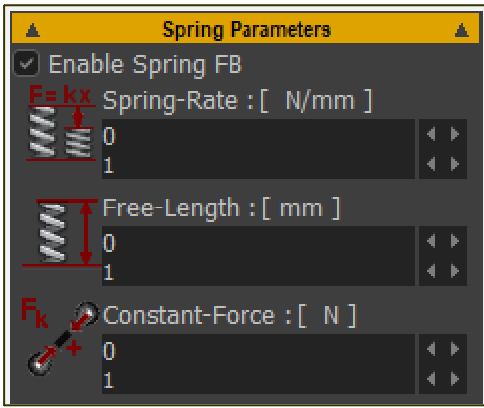
The **SPRING DIALOG** is now open.

Spring dialog



Spring FB dialog

SPRING PARAMETERS



☑ Check-box to enable the SPRING FB.

SPRING-RATE:

Force Contribution:

$$= \text{SPRING-RATE} \times abs \left| \text{SPRING-LENGTH} - \text{FREE-LENGTH} \right|$$

SPRING-LENGTH is the distance between the two anchor-points.

The Force always tries to move the anchor-point to the FREE-LENGTH (They cannot, of course).

FREE-LENGTH:

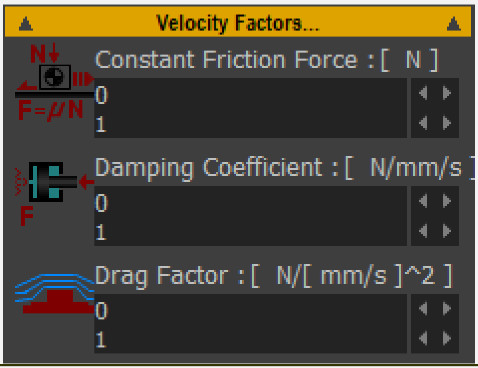
The natural length of the **Spring**, when it is not joined to the ANCHOR-POINTS.

CONSTANT-FORCE:

A positive force PULLS the ANCHOR-POINTS together (**o>>> + <<<o**)

A negative force PUSHES the ANCHOR-POINTS apart (**o<<< — >>>o**)

VELOCITY PARAMETERS



COULOMB (CONSTANT) FRICTION FORCE (Ff = µ.Fn)

A CONSTANT FORCE that is opposite to the direction of the motion.

You can use it to approximate a Friction-Force.

Note: Friction Force is NOT constant in general. Friction-Force is proportional to the Contact-Force between two bodies, and the Contact-Force is not generally constant.

VISCOUS COEFFICIENT (Fv α V (N/(mm/s))

A Force that is proportional to the relative velocity between the POINTS.

The Force is opposite to the direction of motion.

For example, if the DAMPING COEFFICIENT = 4 and the VELOCITY IS +100MM/S, (anchor points moving away from each other), the force pulling the points together is a force of 400N.

DRAG FACTOR (Fd α V2) (N/((mm/s)^2))

A Force that is proportional to square of the relative velocity between the POINTS. For example, air resistance.

The Force is opposite to the direction of motion.

For example, if the DRAG FACTOR = 4, and the VELOCITY = +100MM/S (anchor-points are moving apart), then the force pulling the anchor-points together is a force of 40000N.

INPUT AND OUTPUT-CONNECTORS

OUTPUT-CONNECTORS

The SPRING-FB has two output-connectors.

TOP :	**Distance, Velocity, Acceleration** of the dimension between the ANCHOR-POINTS.
BOTTOM :	**Total Force, Force-X, Force-Y** acting on ANCHOR-POINTS. **OR** **Driving-Force** = **Linear Motive Force**, if you configure the SPRING FB as a LINEAR MOTOR - see Configure Power Source 589

INPUT-CONNECTOR - **see more at** Spring FB dialog 540

The SPRING-FB has one input-connector.

Connect a wire to the input-connector of a SPRING FB to add a **Force-Function** to the **Total-Force** that is exerted by the SPRING-FB.

The units of the data-values at the input-connector must be **Force**, for example, **Newtons**.

If necessary, use a MATH FB to convert values and units to **Force units.**

For example: To convert **100mm** at the input to a MATH FB to **100N**, you must:

1. **Change the Output Data Type to Force (N) - see** Math FB dialog > Output data-type 510

AND

2. **Multiply the input-value by 1000 to convert 0.1m to 100N**

1.5.11.43 Dialog: Function-Block: Force-Data

Force-Data FB

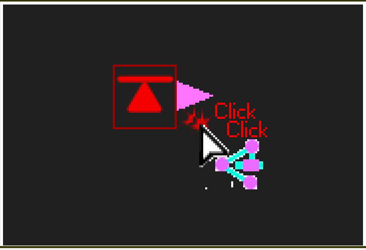
See: Add Force-Data FB[230] , Configure Power Source[232]

Use the **FORCE-DATA FB** to measure the Force that **acts ON** a **POINT** at a Joint, Spring, or the Contact-Point of a **2D-CAM**.

To use the **FORCE-DATA FB** correctly, you must also do CONFIGURE POWER SOURCE[589].

How to open a Force-Data dialog

To open a **FORCE-DATA DIALOG**:



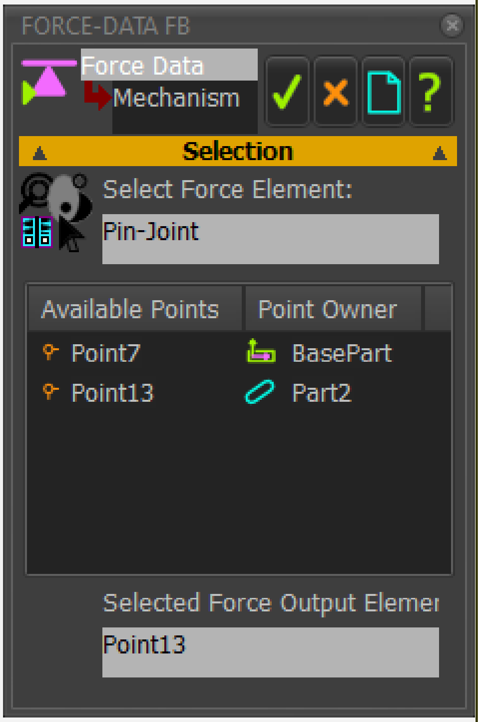
1. Double-click the **FORCE-DATA FB** in the graphics-area.

OR

2. **See** How to Open a dialog[627]

The **FORCE-DATA DIALOG** is now open.

Force-Data dialog



Force-Data dialog

SELECTION

STEP 1. Select a Force Element:

A Force-element is a: JOINT, CAM, GEAR, RACK, BALL-SCREW or a SPRING

1. Click a **Force element** in the graphics-area or the **ASSEMBLY-TREE**.

The **Force element** should now be in the **SELECT FORCE ELEMENT** box

<<< in the image: **Pin-Joint** is the **Force element**

In the box below:

A list of **AVAILABLE POINTS**, each with a **Point Owner**

Each **AVAILABLE POINT** is a child to the **Force element**

STEP 2. Select a Point:

	1. Click a **POINT** in the **AVAILABLE-POINTS** box, above A **POINT** should now be in the **SELECTED FORCE OUTPUT ELEMENTS** box The output from the **FORCE DATA FB** is the Force **ACTING ON** the selected **POINT**.
List of **AVAILABLE-POINTS** for each type of **Force element** • **PIN-JOINT** - there are 2 **AVAILABLE POINTS** Each **POINT** that makes the **PIN-JOINT**. • **SLIDE-JOINT** - there are 4 **AVAILABLE POINTS** Two **POINTS** on each **LINE** that make the **SLIDE-JOINT**. • 2D-CAM [128] - there are 0 **AVAILABLE POINTS** The **CONTACT POINT** is assumed. • SPRING FB [234] - there are 2 **AVAILABLE POINTS** The **POINT** that anchors each end of the **SPRING FB**.	

1.5.11.44 Dialog: Point Properties

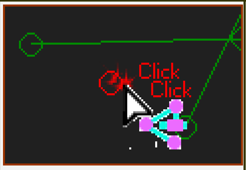
Point Properties

Use the **POINT-PROPERTIES DIALOG** to:

- Show the **Velocity Vectors** and **Acceleration Vectors** of a **POINT***.
- Show the magnitude of the Velocity Vector, or, the Velocity Vector with respect to the X, Y or Z axis.
- Find the X and Y coordinates of a **POINT*** on the XY-Plane of the **MECHANISM-EDITOR**.
- Find the x, y, and z coordinates of a **POINT*** on the xyz-axes of the **PART** to which the **POINT** is a child.
- Edit the x, y, and z coordinates of a **POINT*** in a **PART** - but ONLY if the position of the **POINT*** is not limited by ANY dimensions or ANY constraints.

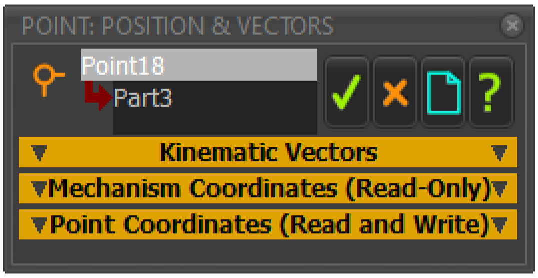
* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**.

How to open the Point Properties dialog

	To open the **POINT PROPERTIES DIALOG** 1. Double-click the **POINT** in the graphics-area OR 1. **See How to Open a dialog** 627

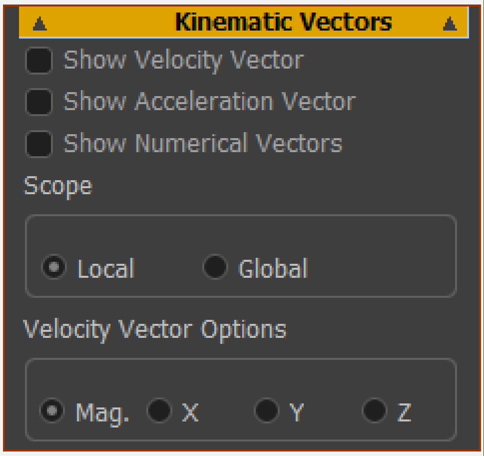
The **POINT PROPERTIES DIALOG** is now open.

Point Properties dialog



Point-Properties dialog

KINEMATIC VECTORS



VELOCITY and **ACCELERATION VECTOR** check-boxes

- **SHOW VELOCITY VECTOR** - evaluated at each machine step with closed-form algorithms
- **SHOW ACCELERATION VECTOR** - evaluated at each machine step with closed-form algorithms
- **SHOW NUMERICAL VECTORS** - calculated numerically with a simple difference algorithm.

NOTE:

Usually, do **not** show the **NUMERICAL VECTORS**. If you do show them, you will need use the Machine-Angle Indicator to jog the MMA backwards and forwards a small angle to calculate the values correctly.

If you show **VELOCITY** and **ACCELERATION VECTORS**, or both:

- The **length** of the **VECTOR** is proportional to the **POINT'S** instantaneous **Velocity** and **Acceleration**.
- The **direction** of the **VECTOR** is in the direction of the **Velocity** and **Acceleration**
- The **magnitude** of the **VECTOR** is at the arrowhead

See **Edit menu >Application-Settings > Graphics > Display Colors** to edit the **color** of the vectors.

SCOPE

Calculate and display the **Velocity and Acceleration Vectors** relative to the:

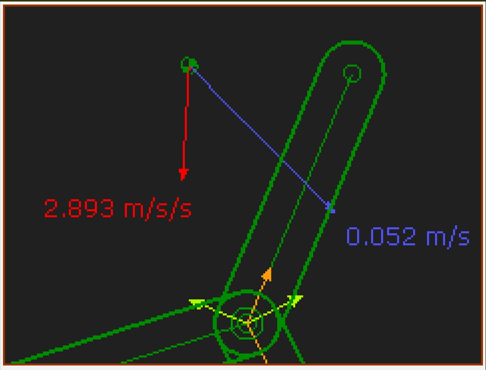
- **LOCAL xyz axes** - **MECHANISM AXES** (default)
- **GLOBAL XYZ axes** - **MODEL AXES.**

VELOCITY VECTOR OPTIONS

Display **Velocity Vectors** as:

- **MAGNITUDE** (default) of the **Velocity**, **or**
- **X COMPONENT** only of the **Velocity**, **or**
- **Y COMPONENT** only of the **Velocity**, **or**
- **Z COMPONENT** only of the **Velocity**

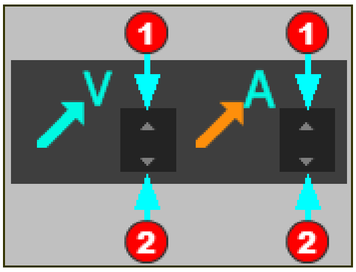
These can be useful to compare the X (or Y or Z) velocity components of a **POINT** with the velocity of a Conveyor, for example.



Velocity and Acceleration Vectors

Scale and Length of Vectors

Edit the length of the vectors, use the buttons in the Feedback-Area[326] :



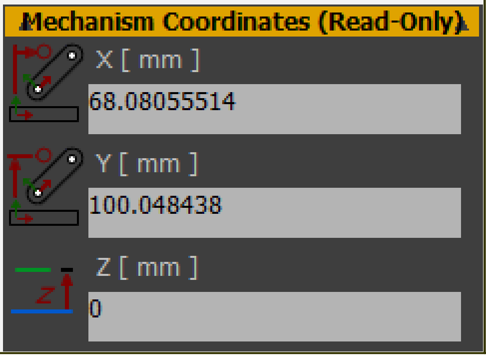
Velocity / Acceleration buttons

V Click ❶ to increase or ❷ **to** de-crease the length of the **Velocity Vector**

A Click ❶ to increase or ❷ to de-crease the length of the **Acceleration Vector**

See: App-Settings > Graphics tab[345] > DISPLAY COLORS | VEL/ACC VECTORS

MECHANISM COORDINATES (READ-ONLY)

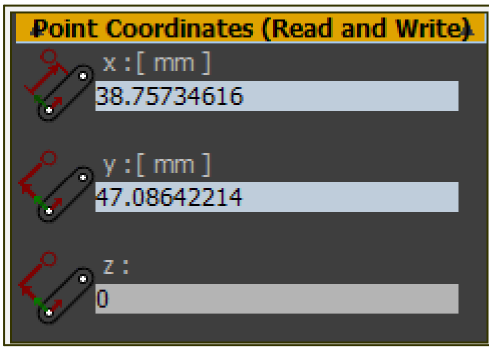


The POINT'S Mechanism Coordinates (X, Y, Z) are relative to the Origin of the MECHANISM-PLANE (XY-Plane of the MECHANISM-EDITOR), and also the BASE-PART.

The X, Y, Z dimensions are read-only.

POINT COORDINATES: READ-WRITE

Point with Constraints

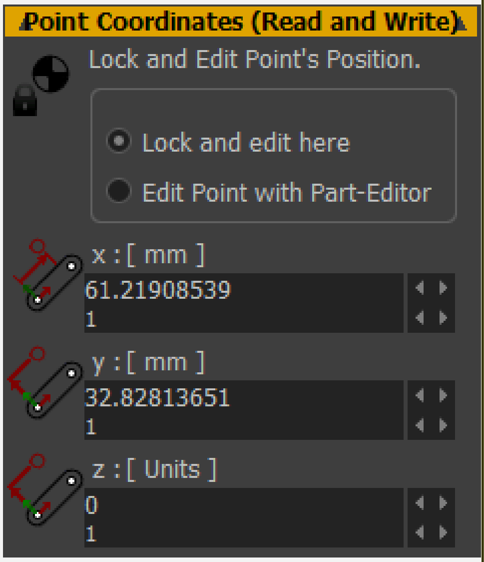


A POINT with Constraints

If you have used the PART-EDITOR to add one or more constraints or di-mensions to locate the POINT in the PART, ...

... you cannot edit the POINT'S x, y, or z coordinates in this dialog.

Point without Constraints



A POINT without Coordinates

If the POINT does not have a constraint or dimension to locate the POINT in the PART, ...

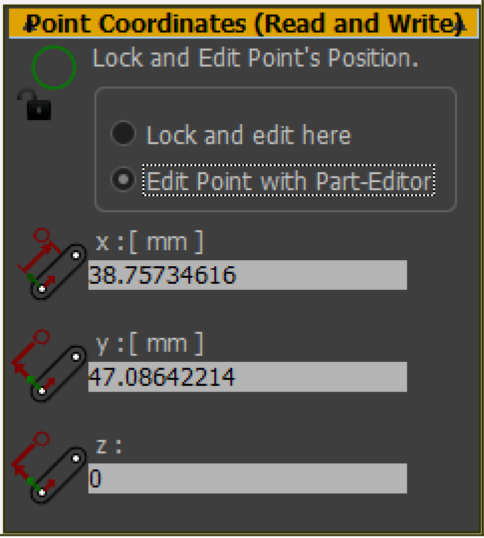
... you can edit the position of the POINT in this dialog.

LOCK AND EDIT POINT'S POSITION:

⦿ LOCK AND EDIT HERE

You can only edit the POINT'S X, Y and/or Z coordinates in this dialog.

You cannot add a constraint or dimension to the POINT in the PART-EDITOR.



⦿ EDIT IN PART-EDITOR

You cannot edit the POINT'S X, Y and/or Z coordinates in this dialog.

You can only use the PART-EDITOR to add constraints and dimensions to locate the POINT.

1.5.11.45 Dialog: Dimension

Dimension dialog

Use the DIMENSION DIALOG to edit a DIMENSION.

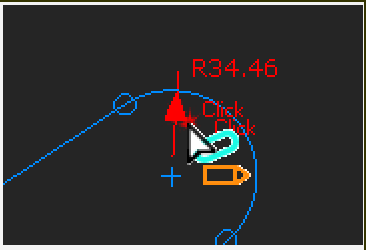
The DIMENSION DIALOG opens immediately when you add a DIMENSION to a sketch-element.

IMPORTANT:

You cannot open the DIMENSION DIALOG when a command is active - even if Add Dimension is the active command.

Deselect all commands to edit a DIMENSION. E.g. Right-click your mouse, or press the ESC key on your keyboard.

How to open the Dimension dialog (in the Part-Editor)



Edit a dimesnion

In the **PART-EDITOR**, to open the DIMENSION DIALOG:

1. Deselect ALL commands
2. Double-Click the arrowhead of a DIMENSION

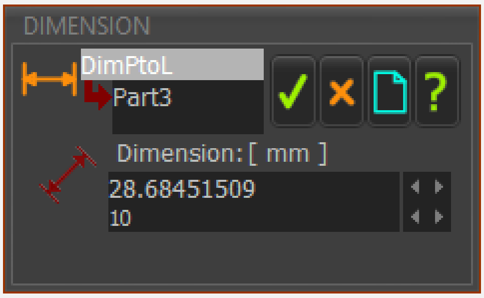
OR

1. **See** How to Open a dialog 627

Note: Nothing happens if you click the dimension number - **R34.46** in the image above.

The DIMENSION DIALOG is now open.

Dimension dialog



Dimension dialog

To edit the DIMENSION parameter-value in the DIMENSION DIALOG, do one or all of these:

- Enter a **value**, and press the enter key (↵) on your keyboard, **OR**
- Enter an **equation**, and press the enter key (↵) on your keyboard, **OR**
- Use the **Spin-Box tool**, OR

- Right-click the data-box, and use the **Zero / Round / Copy / Paste** shortcut menu

See also: How to edit a parameter in a dialog 631

1.5.11.46 Dialog: Blend-Curve

Blend-Curve

See also [Add Blend-Curve](286)

About the Blend-Curve

A **BLEND-CURVE** is a sketch-element that has a **START-POINT** and an **END-POINT**.

Use the **BLEND-CURVE DIALOG** to edit geometric-properties **AT** its **START-POINT** and **AT** its **END-POINT**. The properties you can edit are its:

- ANGLE
- CURVATURE
- CURVATURE RATE
- VELOCITY SCALING - a parameter that influences the overall shape between the **START-POINT** and **END-POINT**.

Typically, you merge the **START-POINT** and/or **END-POINT** of the **BLEND-CURVE** with other sketch-elements.

The default geometric-properties make sure that the **BLEND-CURVE** has [geometric continuity](553) with adjacent sketch-elements.

CASE 0 : You do NOT merge the **BLEND-CURVE** with another sketch-element. You can edit these geometric-properties at its **START-POINT** and **END-POINT**:

- ANGLE (default = 0)
- CURVATURE (default = 0)
- CURVATURE RATE (default = 0)

CASE 1 : You do merge the **START-POINT** and/or **END-POINT** of the **BLEND-CURVE** with a **LINE.**

- ANGLE is equal to the angle of the **LINE**
- CURVATURE is equal to zero
- CURVATURE RATE is equal to zero

CASE 2 : You do merge the **START-POINT** and/or **END-POINT** of the **BLEND-CURVE** with an **ARC.**

- ANGLE is equal to the tangent of the **ARC**
- CURVATURE is equal to 1 / Radius of the **ARC** (m)
- CURVATURE RATE is equal to zero

CASE 3 : You do merge the **START-POINT** and/or **END-POINT** of the **BLEND-CURVE** with a **BLEND-CURVE.**

Edit the **END-POINT** of a **BLEND-CURVE** that you merge with the **START-POINT** of an adjacent, or following, **BLEND-CURVE**.

In the **BLEND-CURVE DIALOG**, edit the:

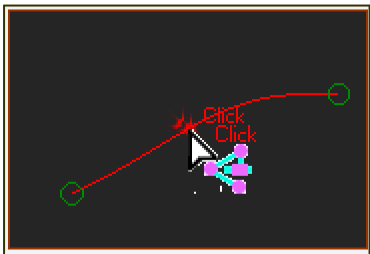
- **ANGLE** : Disable the **END-POINT ANGLE** check-box: edit the **ANGLE** - the angle of the adjacent **BLEND-CURVE** with equal the angle you enter.
- **CURVATURE** : Disable the **END-POINT CURVATURE** check-box: edit the **CURVATURE** - the curvature of the adjacent **BLEND-CURVE** with equal the curvature you enter.
- **CURVATURE-RATE** : Disable the **END-POINT CURVATURE-RATE** check-box: edit the **CURVATURE-RATE** - the curvature-rate of the adjacent **BLEND-CURVE** with equal the curvature-rate you enter.

You can edit the geometric-properties

- **Exactly** : with the Blend-Curve dialog[550]
- **Approximately** : with the Blend-Curve drag-handles[552] .

Edit Exactly

Open the Blend-Point dialog



In the **PART-EDITOR** or the **MECHANISM-EDITOR**:

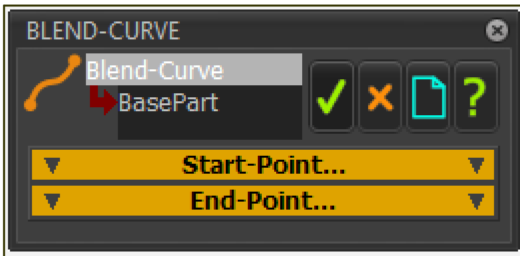
1. Double-click the **BLEND-CURVE** in the graphics-area

OR

1. **See** How to Open a dialog[627]

The **BLEND-CURVE DIALOG** is now open.

Blend-Curve dialog



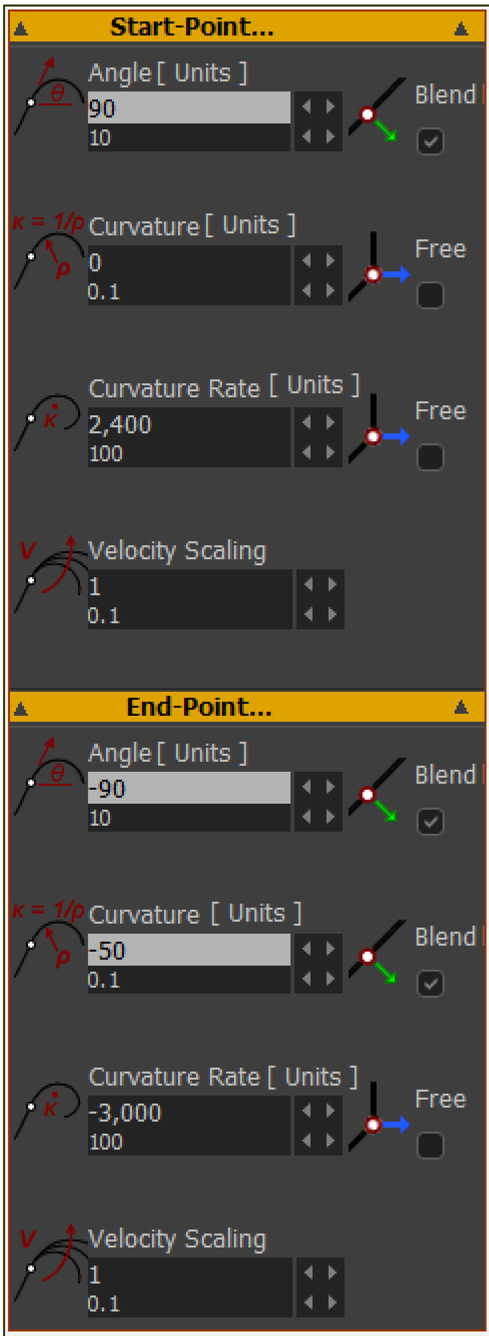
Blend-Curve dialog

There are two separators:

START-POINT...

END-POINT...

The parameters are the same for the two separators.



START POINT ... / **END POINT ...**

ANGLE (UNITS: °):

BLEND / FREE check-box:

☑ (DEFAULT) The ANGLE of the BLEND-CURVE (at its START-POINT / END-POINT) is equal to the ANGLE of the adjacent sketch-element

❑ Edit the ANGLE of the BLEND-CURVE (at its START-POINT / END-POINT).

CURVATURE K (UNITS:1/METER):

BLEND / FREE check-box:

☑(DEFAULT) The CURVATURE of the BLEND-CURVE (at its START-POINT / END-POINT) is equal to the CURVATURE of the adjacent sketch-element.

❑Edit the CURVATURE for the BLEND-CURVE (at its START-POINT / END-POINT).

CURVATURE-RATE DK/DS (UNITS: 1/M^2):

BLEND / FREE check-box:

☑ The CURVATURE-RATE of the BLEND-CURVE (at the START-OINT / END-POINT) is equal to the CURVATURE-RATE of the adjacent sketch-element

❑ (DEFAULT) Edit a CURVATURE-RATE for the BLEND-CURVE (at its START-POINT / END-POINT).

VELOCITY SCALING (NO UNITS)

Increase VELOCITY-SCALING to **in-flate** the balloon!

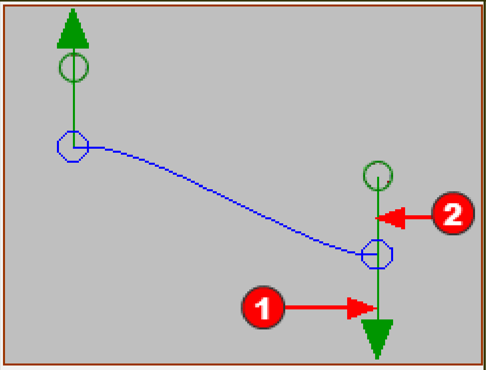
Decrease VELOCITY-SCALING to **de-flate** the balloon!

VELOCITY SCALING does not have units.

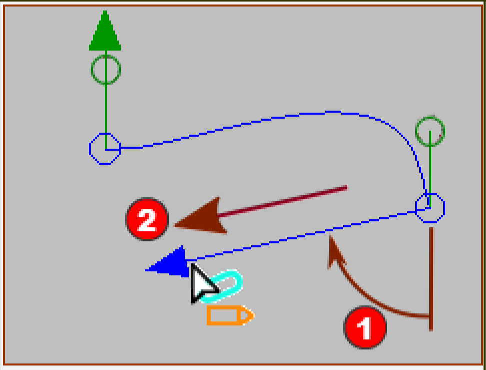
	Default = 1 ; Maximum = 10 ; Minimum 0.01

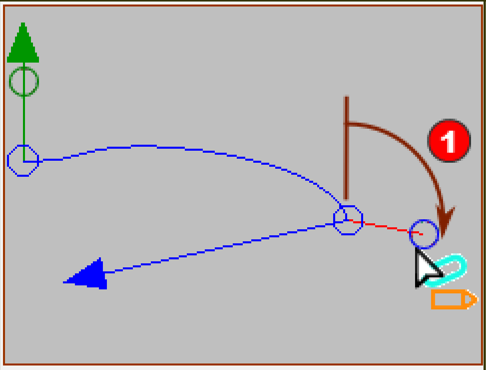
Edit Approximately

Enable / disable Blend-Curve drag-handles

 Drag handles in the Graphic-Area	**To show the Drag-Handles** 1. Click the BLEND-CURVE one time Now, you can see the **Drag-Handles** at the **START-POINT** and the **END-POINT** **There are two(2) Drag-Handle types:** ❶ **Arrowhead Drag-Handle** ❷ **Circle Drag-Handle** (difficult to see)

Blend-Curve drag-handles

 Arrowhead Drag-Handle	**Arrowhead Drag-Handles** - this controls the ANGLE and the VELOCITY-SCALING FACTOR 1. Double-click an **Arrowhead Drag-Handle** to enable it. When the **Drag-Handle** is blue, it is enabled. 2. Drag the blue arrowhead **relative to** the **START-POINT** (or **END-POINT**): ❶ **Rotate the arrowhead** about the **START-POINT** (or **END-POINT**) to control the ANGLE of the BLEND-CURVE. ❷ **Move the arrowhead away** from the **START-POINT** (or **END-POINT**) to increase the VELOCITY-SCALING FACTOR 3. Double-click the **Arrowhead Drag-Handles** again. When the **Drag-Handle** is green, it is disabled.

<table>
<tr>
<td>


Circle Drag-Handle
</td>
<td>

Circle Drag-Handle - this controls the CURVATURE

1. Double-click a **Circle Drag-Handle (difficult to see!)**

   When the **Drag-Handle** is blue **(difficult to see!),** it is enabled.

   At the default position (vertically-up), the CURVATURE = 0 (a straight-line).

2. **Drag the** blue circle around the START (OR END-)POINT:

❶ In a clockwise direction to increase the **+ve** CURVATURE

❶ In a counter-clockwise direction to increase the **-ve** CURVATURE

When the blue circle is vertically-down the CURVATURE is a large **+ve** or **–ve** value.

3. Double-click the **Circle Drag-Handle** again.

   The Drag-Handle is now green. You cannot drag the handle.
</td>
</tr>
</table>

Note on Curvature and Curvature-Rate

Curvature and Curvature-Rate

CURVATURE (k) ; **the inverse of RADIUS-OF-CURVATURE (R);**

The **Radius-of-Curvature** and **Curvature** of simple sketch-elements are constant. For example:

- **Radius-of-Curvature of a Line = ∞ ; Curvature of a Line = 0 ;**
- **Radius-of-Curvature of an Arc or Circle = Radius ; Curvature of a Circle = 1 / Radius**

To add numbers:

- A Circle of Radius = R20mm : **Radius-of-Curvature=20**mm, **Curvature =1/0.02m = 50/**m.

CURVATURE-RATE **= dk/ds**

Curvature-Rate : the rate-of-change of **curvature (k)** with respect to the **displacement (s)** along the curve.

The **Radius-of-Curvature** and **Curvature** of a simple sketch-elements (Lines and Circle/Arcs) are constant

The **Radius-of-Curvature** and **Curvature** of general sketch-elements, typically a named curve, e.g. **Splines**, **Bezier-Curves**, can continually change along their length.

Blend-Curve

The **Blend-Curve** is the only sketch-element you can add with which you can control its **Curvature** and **Curvature-Rate**.

1.5.11.47 Dialog: Import SOLIDWORKS Sketch FB

Import SOLIDWORKS Sketch FB

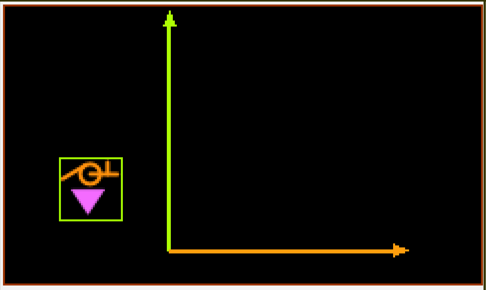
See also : Add Import SOLIDWORKS Sketch FB [289]
See also: CAD-Line > DXF tab [371]

Use the **IMPORT SOLIDWORKS SKETCH FB** to import sketches from a SOLIDWORKS document.

Limits:

- Imports Lines and Arcs
- Cannot import Blocks, Parabolas, Ellipses, ...
- Maximum of approximately 20 sketch-elements
- Construction and center-lines import as Lines
- Constraints do not import
- By default, all Points, Lines, and Arcs are Locked. To unlock, see Point Properties dialog [545].

How to open the Import SOLIDWORKS Sketch dialog



Import SOLIDWORKS Sketch FB in PART-EDITOR

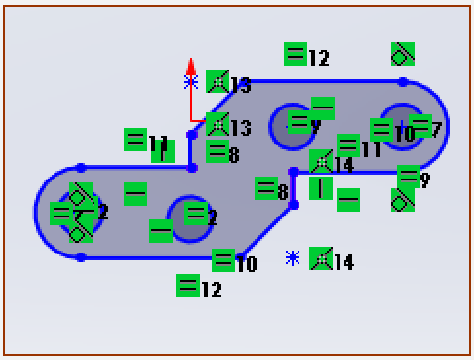
1. **MECHANISM-EDITOR**: Edit the **PART** to which you have added the **IMPORT SW SKETCH FB**
2. **PART-EDITOR**: Double-click the **IMPORT SW SKETCH FB**

OR

2. **See How to Open a dialog** [627]

The **IMPORT SOLIDWORKS SKETCH DIALOG** is now open.

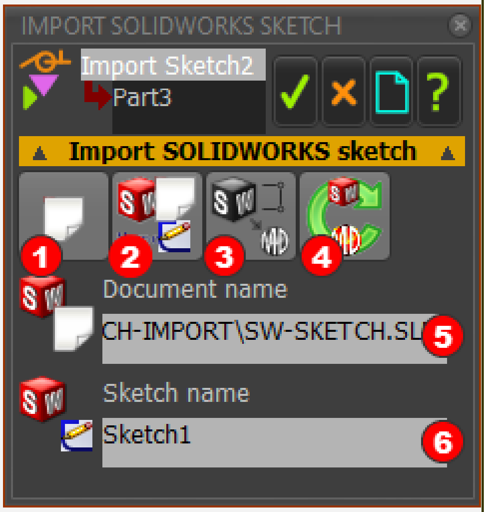
Import SolidWorks Sketch dialog



STEP 1: In SOLIDWORKS

1. Edit a SOLIDWORKS sketch to make it **active**

This image shows the active sketch in SOLIDWORKS.



Import SolidWorks sketch dialog

STEP 2. **Import the active in SOLIDWORKS**

IMPORTANT:

The sketch must be active in SOLIDWORKS.

In the IMPORT SOLIDWORKS SKETCH DIALOG:

1. Click button ❷

   Document name ❺ - a copy of the active SOLIDWORKS document (SLDPRT) file-name

   Sketch name ❻ a copy of the active sketch name, as it is in the SOLIDWORKS feature-tree

   Button ❸ is colorized.

2. Click button ❸

   WAIT until the SOLIDWORKS sketch shows in your **PART-EDITOR**.

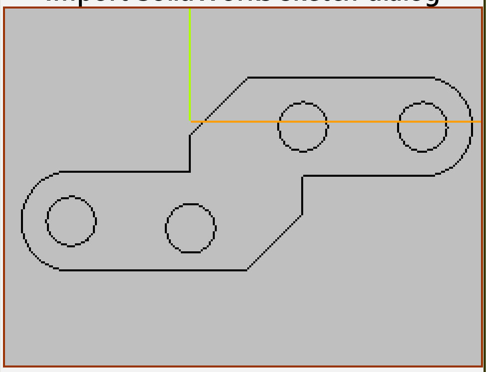
   Button ❹ is now colorized.

If you edit the sketch in **SOLIDWORKS** :

3. Click button ❹ to Refresh, or Update the sketch

Note: To use the same IMPORT SW SKETCH FB to import a different **SOLIDWORKS** sketch:

4. Click button ❶ to clear the Document name and the sketch-name from ❺ and ❻



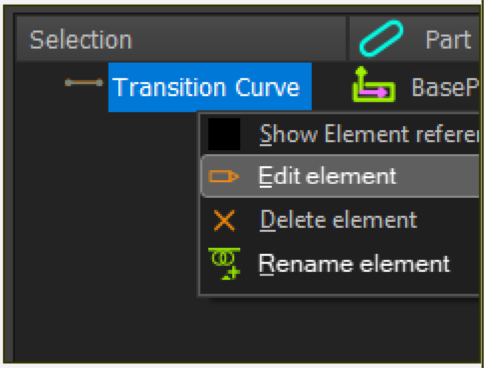
This image shows the active sketch in the **MechDesigner** graphics-area.

1.5.11.48 Dialog-Transition-Curve

Transition Curve

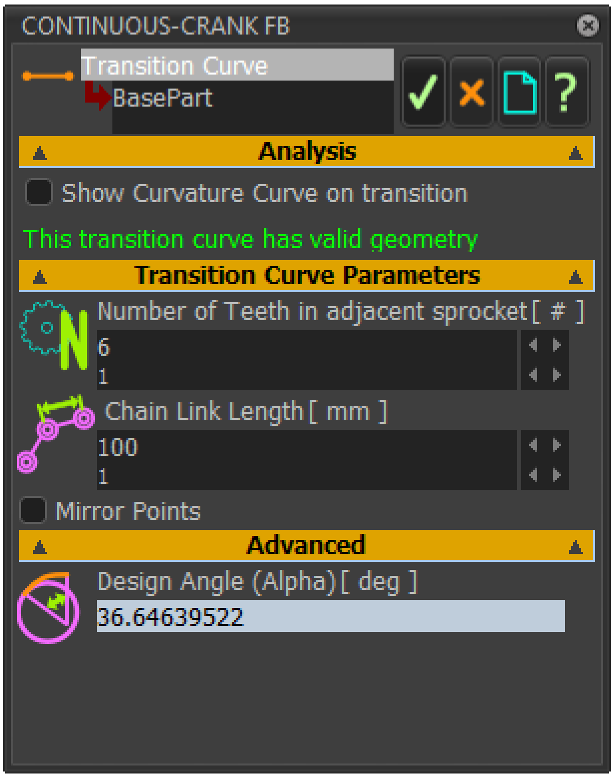
see Add Transition Curve 293

How to open the Transition-Curve dialog

 Edit Transition-Curve	Use the PART-EDITOR, to open the TRANSITION-CURVE DIALOG 1. Edit the PART that includes the TRANSITION-CURVE. 2. Click a TRANSITION-CURVE element (the curve or the Line at its 'center') in the graphics-area In the SELECTION-WINDOW: 3. Right-click the TRANSITION-CURVE 4. Click **Edit element**. in the shortcut menu **OR** 1. **See How to Open a dialog** 627

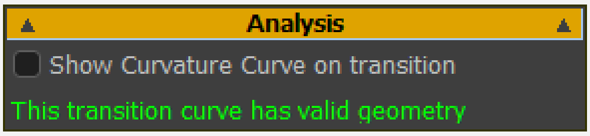
The TRANSITION-CURVE DIALOG is now open.

Transition-Curve dialog



Gearing FB dialog

ANALYSIS



Ratio and Phase

Curvature

❑ **SHOW CURVATURE CURVE ON TRANSITION**

Enable to show the Curvature as a curve that is offset from the TRANS-ITION-CURVE sketch-element.

We do not show the actual curvature value.

Messages:

- This Transition-Curve has valid geometry

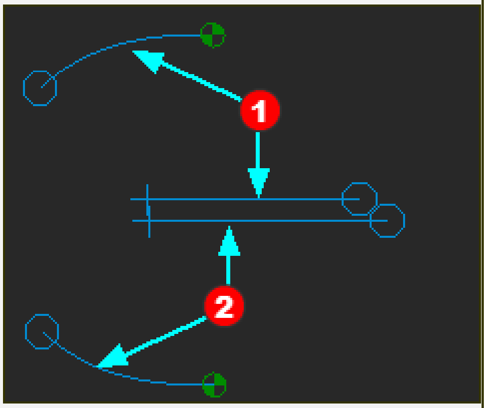
The Curve always has valid geometry.

Valid Geometry

TRANSITION CURVE PARAMETERDS

NUMBER OF TEETH IN ADJACENT SPROCKET (#)

CHAIN LINK LENGTH (mm)



1 - Transition-Curve
2 - Mirror Transiiton-Curve

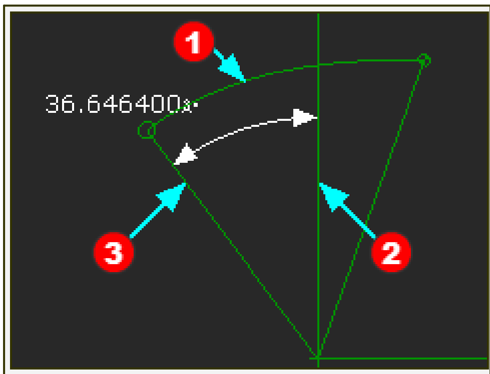
❑ **MIRROR POINTS**

Enable to mirror the TRANSITION CURVE to the other side of the LINE that you drag when you do Add Transition-Curve.

For example, in the image:

Curve ❷ is the TRANSITION-CURVE that is a mirror of TRANSITION-CURVE ❶

ADVANCED



Read-Only - **DESIGN-ANGLE**

The angle between:

❷ - a line perpendicular to the line you add when you do Add Transition-Curve

❸ - a line from the CENTER-POINT of the TRANSITION-CURVE to the END-POINT of the TRANSITION-CURVE.

1.5.11.49 Dialog: Ball-Joint

Ball-Joint

See: **Add Ball-Joint** 114 **. Tutorial 12: Design a Spatial Mechanism**

Use the BALL-JOINT for spatial mechanisms.

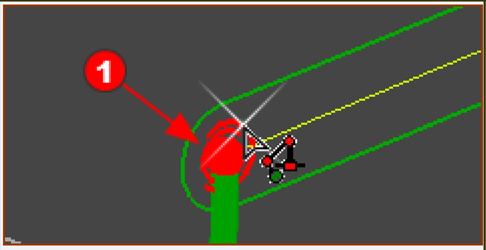
You must add a BALL-JOINT to each end of one PART.

Connecting-Part : the derived name of a PART that has a BALL-JOINT at each end.

One of the two BALL-JOINT joins the **Connecting-Part** to a PART (frequently, a **Motion-Part**) in a different MECHANISM-EDITOR.

The other BALL-JOINT, at the other end of the **Connecting-Part**, joins it to a PART in the active MECHANISM-EDITOR.

How to open the Ball-Joint dialog

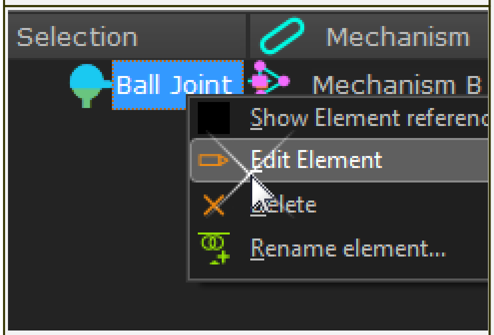


There are two BALL-JOINTS, with one at each end of a **Connecting-Part**.

The BALL-JOINT element symbol may be "inside" the symbol of the **Connecting-Part**.

1. Move your mouse-pointer above the end of the **Connecting-Part** until the symbol for the BALL-JOINT is red - see image.
2. Click the symbol for the BALL-JOINT ❶.

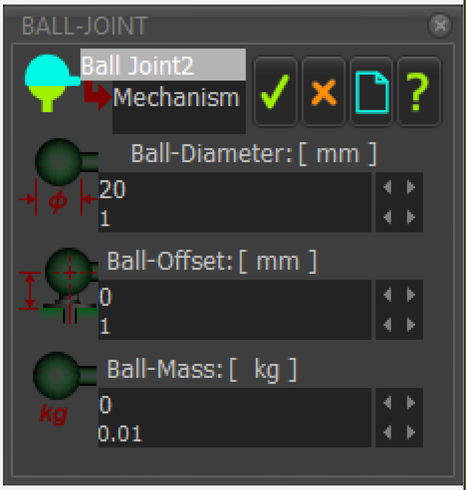
   The BALL-JOINT element should be in the SELECTION-WINDOW
3. Right-click the BALL-JOINT in the SELECTION-WINDOW
4. Click **Edit Element** in the shortcut menu.



Ball-Joint in the Selection-Window

The **BALL-JOINT DIALOG** is now open.

Ball-Joint dialog



Ball-Joint dialog

BALL DIAMETER

Diameter of the Ball symbol in graphics-area.

BALL-DIAMETER does NOT change the Kinematic-Analysis.

BALL OFFSET (±)

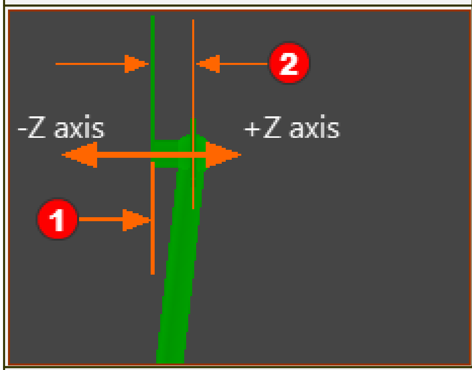
Perpendicular distance (±) from the MECHANISM PLANE to the center of the BALL-JOINT.

BALL-OFFSET does change the Kinematic-Analysis.

BALL MASS

Mass of the BALL-JOINT.

Its center-of-mass is coplanar with the **MECHANISM-PLANE**. even if the BALL-OFFSET ≠ 0.



Example of Ball-Offset : Z = 10mm

<<< the image shows the model from the left view - View toolbar > View Left (**Shortcut : F7**).

1. BALL-JOINT : on the **MECHANISM-PLANE** when BALL-OFFSET = 0mm.
2. In the image the BALL-OFFSET = +**10**mm in the +Z-axis direction.

When to use the BALL-OFFSET parameter?

The symbols of all other Kinematic elements are on the **MECHANISM-PLANE**. However, the center of a BALL-JOINT is frequently ***not*** on the **MECHANISM-PLANE**. The kinematic-analysis is correct only when the distance to the center of the BALL-JOINT from the **MECHANISM-PLANE** is also correct.

See also: Ball-Joint Configurations

1.5.11.50 Dialog: Magnetic-Joint

Magnetic-Joint

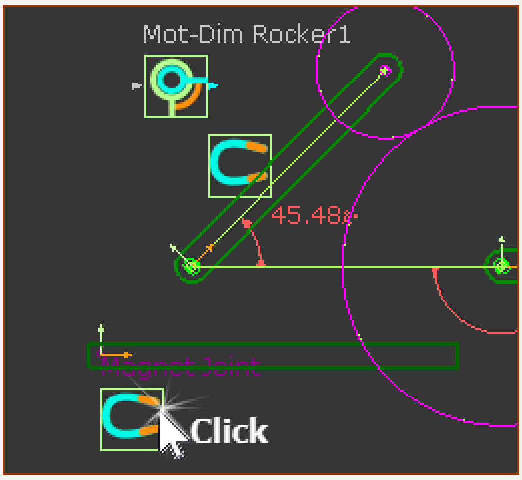
Terminology

MAGNETIC-JOINT :	A MAGNETIC-JOINT pulls a **circular** PROFILE to be in continuous contact with an **irregular** PROFILE (or CURVE). The **circular** PROFILE and **irregular** PROFILE (or CURVE) are in different kinematic-chains. After you

	add a MAGNETIC-JOINT, the motion of the two kinematic-chains are related by the contact between the **circular** and **irregular** PROFILES (or CURVE).
Irregular Shape :	The **Irregular Shape** can be PROFILE from a sketch-loop, or a CURVE that we calculate from a **Point-Cloud**.
Point-Cloud :	X-Y or R-Θ coordinates. Use a POINT-CLOUD FB to import the **Point-Cloud** coordinates.
CURVE :	The smooth shape that we calculate for you from the **Point-Cloud** coordinates - see POINT-CLOUD DIALOG 484 .

How to open the Magnetic-Joint dialog

See also: Add Magnetic-Joint 99 .



Before you edit a MAGNETIC-JOINT:

1. Click the **HOME** key on your keyboard to move the **MMA** to zero.
2. Click a **MAGNETIC-JOINT FB** in the graphics-area (see image to the left)

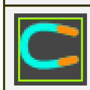
The **MAGNETIC-JOINT** element is in the **SELECTION-WINDOW**

3. Right-click the MAGNETIC-JOINT element in the SELECTION-WINDOW
4. Click **Edit element** in the shortcut menu.

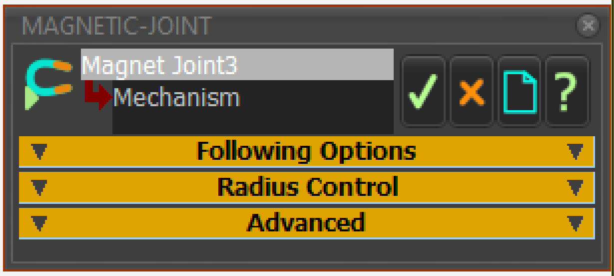
OR

1. **See How to Open a dialog** 627

Note: There are three states for the MAGNETIC-JOINT icon in the graphics-area.

	**Magnetic-Joint is enabled** and we find a solution.
	**Magnetic-Joint is enabled** but we do not find a solution.
	**Magnetic-Joint is disabled.**

Magnetic-Joint dialog

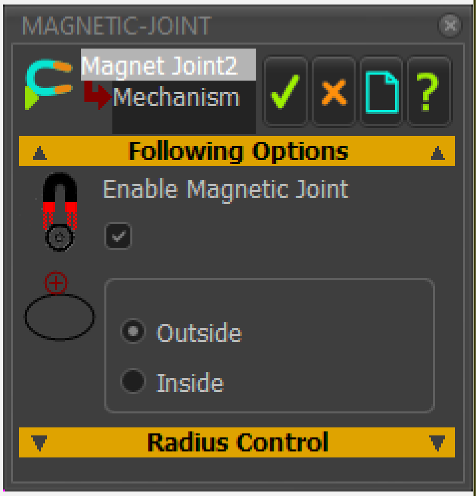


Magnetic-Joint dialog

The **Magnetic-Joint dialog** has three separators:

- FOLLOWING OPTIONS
- RADIUS CONTROL
- ADVANCED

FOLLOWING OPTIONS

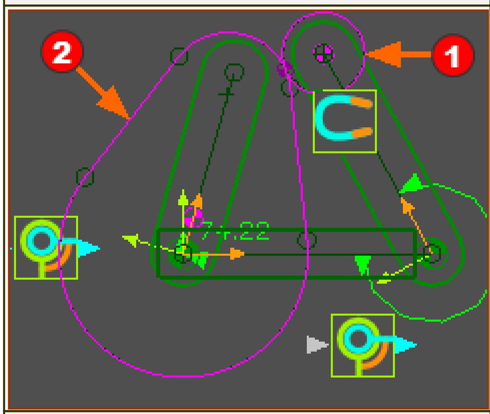


☑ **ENABLE MAGNETIC-JOINT** check-box

The circular PROFILE is in continuous contact with the irregular PROFILE or POINT-CLOUD 206.

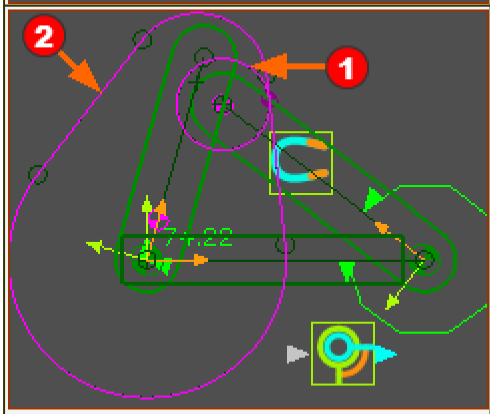
❑ **DISABLE MAGNETIC-JOINT** check-box

The circular PROFILE moves to the BASE-VALUE (Linear or Angular position) as specified by the MOTION-DIMENSION FB that was in continuous contact with the irregular PROFILE.



OUTSIDE

The circular PROFILE❶ moves to the external (outer) side of the irregular PROFILE❷.



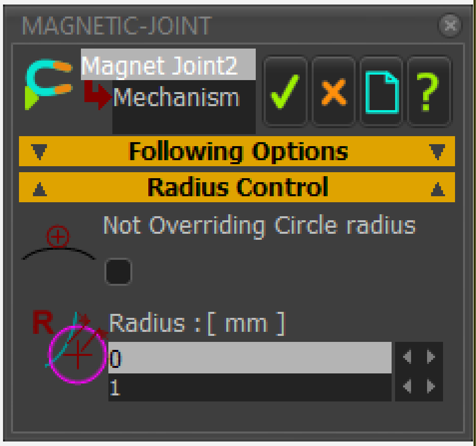
INSIDE

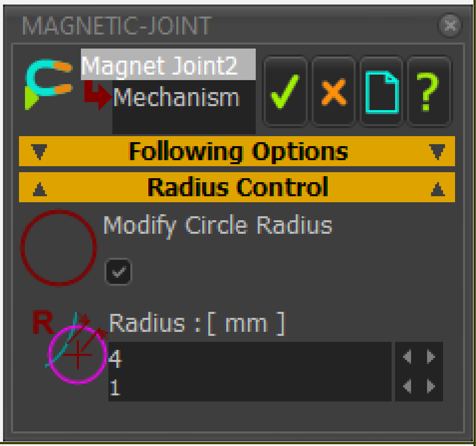
The circular PROFILE ❶ moves to the internal (inner) side of the irregular PROFILE❷.

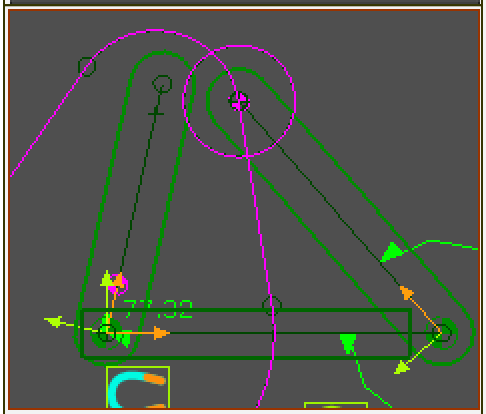
Note:

The INSIDE option does not find a solution as successfully as the OUTSIDE option.

RADIUS CONTROL







Optionally, edit the effective radius of the **Circular** PROFILE.

- ❑ NOT OVERRIDING CIRCLE RADIUS (default)
- ☑ MODIFY CIRCLE RADIUS

For example:

RADIUS = 0MM

When the RADIUS is 0mm, the center of the **Circular** PROFILE moves along the **Irregular Profile** as normal.

RADIUS = 3MM

When the RADIUS is 3mm (for example), the center of the **Circular Profile** is 3mm inside the **Irregular Profile**.

This is useful if you use a CMM machine with a probe diameter that is different to the Follower-Roller, and the CMM software does not have Probe Compensation.

When the CMM data does not compensate for the Probe Diameter, you would enable Modify Cycle Radius to recreate the contact between the **irregular-Profile** and the **Follower-Roller**.

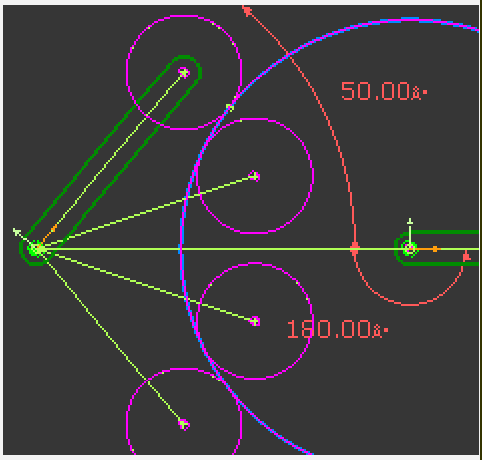
Offset Profile Radius = Radius of Actual Follower-Roller – Radius of CMM Probe

$R = R_{cf} – R_p$

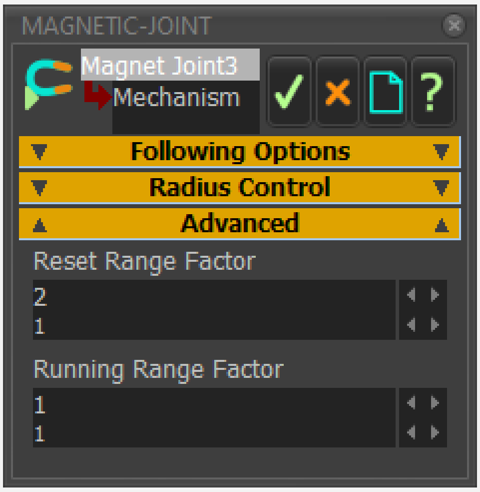
R_{cf} = Follower-Roller Radius;

R_p = CMM Probe Radius.

ADVANCED **(WITH NOTES)**



4 Possible Contact Solutions between Circular-Profile and a simple Irregular-Profile



Magnetic-Joiont dialog Advanced parameters

Notes:

When you add a **MAGNETIC-JOINT**, we use for you numerical techniques to find the contact of the **Circular Profile** with the **Irregular Profile**.

To humans, it is easy to see the contact that you want. But mathematically, even when the **Irregular-Profile** is a simple shape, there are usually a minimum of 4 solutions - see image to the left. **MechDesigner** may find the solution you want, or a solution you do not want, or even fail to find a solution at all.

BEFORE YOU ADD THE MAGNETIC-JOINT - it is best to edit the **BASE-VALUE** parameter in the **MOTION-DIMENSION FB**, to put the **Circular Profile** within **0.5 x Radius of Circular-Profile.**

To edit the starting position of the Circular-Profile

1. **Run menu > Home (or use the Alt+H keyboard shortcut)** to put the **MMA at 0.**
2. Open the MOTION-DIMENSION DIALOG 466 to be controlled by the **MAGNETIC-JOINT.**
3. Edit the **BASE-VALUE** to position the **Circular-Profile** to be **≤ 0.5 × Radius of the Circular-Profile** from the **Irregular-Profile.**

The factors in **ADVANCED** help us to find for you the solution you want.

RESET RANGE FACTOR (DEFAULT = 2)

This factor limits the range of values within which to search for a solution for the **MOTION-DIMENSION**, when the model is at the **HOME** position (**MMA = 0**).

	A RESET RANGE FACTOR = 1 is equal to the **1 × Radius of the Circular Profile**. The smaller RESET RANGE FACTOR, the nearer you should edit the BASE-VALUE to put the **Circular Profile** to the **Irregular-Profile** before you add the MAGNETIC-JOINT. RUNNING RANGE FACTOR (DEFAULT = 1) **MechDesigner** must find a solution for contact between the **Circular** and **Irregular-Profiles** at all steps in the machine-cycle. There are frequently at least 4 solutions - see image, left and top. However, the solution at any step in the machine-cycle should not be hugely different from the previous solution. Use the RUNNING RANGE FACTOR to limit the range of MOTION-DIMENSION values within which to search for a solution from the previous solution, at each step of the solution cycle. RUNNING RANGE FACTOR = 1 is equivalent to **1 × Radius** of **Circular-Profile** that is contact with the **Irregular-Profile**. Reduce the RUNNING RANGE FACTOR if the **Circular-Profile** does not remain in contact with the **Irregular-Profile**, as you cycle the model.

1.5.11.51 Dialog: Gear-Pair

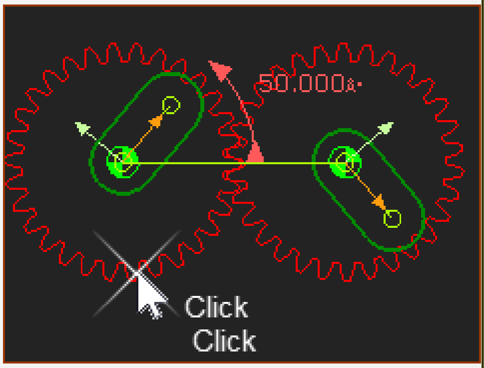
Gear-Pair

See: Add Gear-Pair 141

Gear Terminology

Gear-Wheel (or Gear) :	A **rotating-Part** with **gear-teeth** at a fixed diameter. You control its diameter with the number-of-teeth and **module**.
GEAR-PAIR :	Two inter-locking **gear-wheels**. Their teeth have **External** or **Internal mesh**. The angular velocity of each **gear-wheel** is related by the number-of-teeth on each **gear-wheel**, and the type of **mesh**.
Driving Part :	The **rotating-Part** that is **kinematically-defined**, and whose motion you control (even if it is stationary) before you do Add Gear-Pair.
Driven Part :	The **rotating-Part** whose motion you control by the motion of the **Driven-Part**, the NUMBER-OF-TEETH on each **gear-wheel** in the GEAR-PAIR, and the MESH.
Gear-Mesh (or Mesh) :	Inter-locking **gear-teeth** of a GEAR-PAIR that transmit torque and motion from the **Driving Part** to the **Driven Part**.
External Mesh :	The gear-teeth of the two **gear-wheels** point outwards from their centers-of-rotation.
Internal Mesh :	The gear-teeth of one **gear-wheel** point inwards towards its center-of-rotation.
Simple Gear-Pair :	Two **gear-wheels** that rotate about two fixed centers.
Epicyclic Gear-Pair :	One **gear-wheel** orbits around the center of the other **gear-wheel**.

How to open the Gear-Pair dialog



Example External Gear-Pair

Edit the GEAR-PAIR:

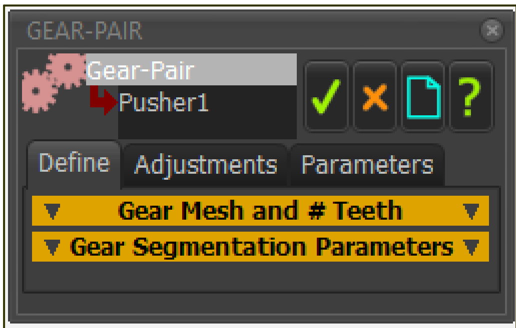
1. Double-click a GEAR-PAIR in the graphics-area or ASSEMBLY-TREE.

OR

1. **See** How to Open a dialog 627

The GEAR-PAIR DIALOG is now open.

Gear-Pair dialog



Gear-Pair dialog

There are three tabs in the GEAR-PAIR DIALOG.

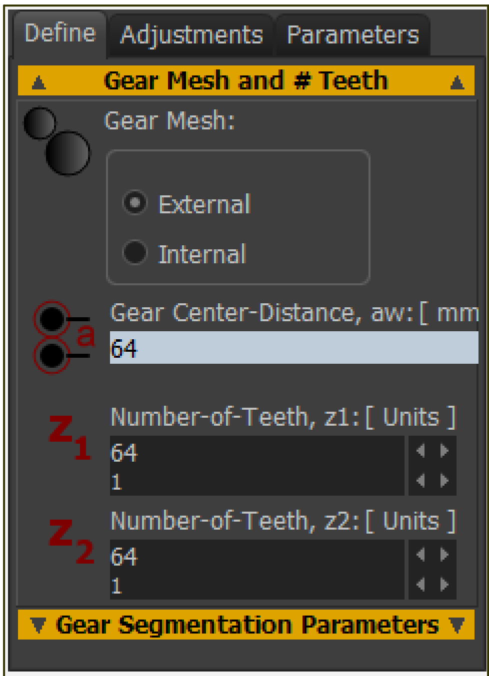
Define tab

Adjustments tab

Parameters tab

Define tab

GEAR MESH AND # TEETH



GEAR MESH - see Terminology above

- EXTERNAL

OR

- INTERNAL

Read-only

GEAR CENTER-DISTANCE

See also CENTER-DISTANCE CALCULATION in Adjustments tab 568

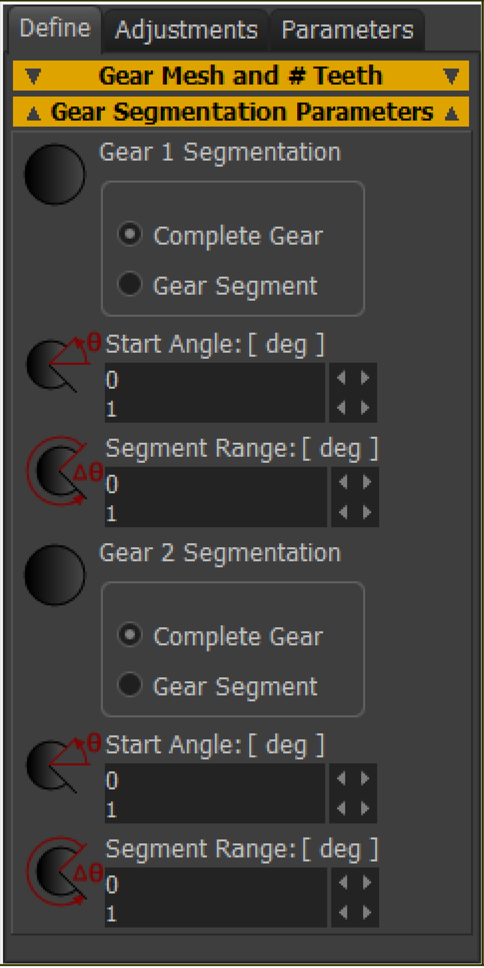
NUMBER-OF-TEETH, Z_1 **(Minimum =5)**

The NUMBER OF-TEETH on the input-gear - usually the **Driving-Gear**

NUMBER-OF-TEETH, Z_2 **(Minimum = 5)**

The NUMBER OF-TEETH on the output gear - usually the **Driven-Gear**

GEAR SEGMENTATION PARAMETERS



Notes:

A GEAR-SEGMENT must not rotate fully. It must oscillate.

GEAR # SEGMENTATION

- ⦿ COMPLETE GEAR - a normal, or full gear
- ⦿ GEAR SEGMENT - a gear that is not complete, it has fewer teeth.

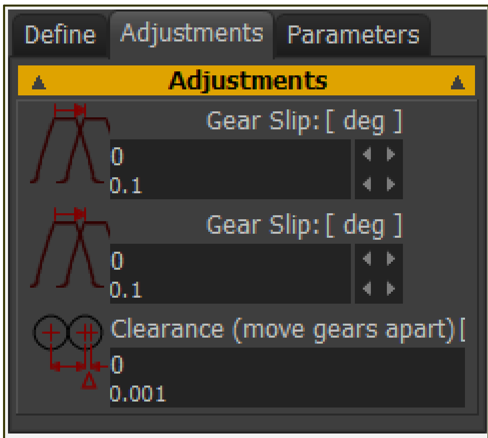
Gear 1 and/or **Gear 2** can be a GEAR-SEGMENT

To reduce the number-of-teeth of **Gear 1** and/or **Gear 2**:

1. Select GEAR-SEGMENT for **Gear 1** and/or **Gear 2**
2. Edit the START-ANGLE : **Minimum = 0, Maximum = 360**
3. Edit the SEGMENT RANGE : **Minimum = 0; Maximum 360**

Adjustments tab

ADJUSTMENTS



GEAR-SLIP (DEGREES)

These parameters rotate **Gear 1** and **Gear 2** around at the PIN-JOINT.

This parameter rotates the gear teeth. It does NOT rotate the PART. I have never used this parameter.

TOP-TIP:

If you add a Gear-Slip to one Gear, then, to keep the gears in mesh:

Gear-Slip 2 = – (# Teeth,z1 / # Teeth, z2) × Gear-Slip 1

E.g.: Gear-Slip 1 = 2 degrees, # Teeth, z1 = 120, # Teeth, z2 = 40.

Gear-Slip 2 = –(120/40)*2 = –6 degrees.

CLEARANCE (MOVE GEARS APART)

This parameter changes the length of the **Line-of-Centers,** the center-distance, between the Gears.

Usually, CLEARANCE is a +ve value for External Gears, and a –ve value for Internal Gears. See Notes on recommended backlash.

An alternative way to change the clearance is to reduce (by machining) the size of the gear-teeth and not to change the center-distance. We do **not** include for you a parameter with this deign option. However, it is the standard method to provide backlash in commercial gear-boxes. Talk with the gear supplier, machinist.

Center-Distance Calculation

If EXTERNAL MESH, then CENTER-DISTANCE = **Clearance + (Module×(Number-of-Teeth Gear1+Number-of-Teeth Gear2)÷2)**

If INTERNAL MESH, then CENTER-DISTANCE = **Clearance + (Module×(Number-of-Teeth Gear1-Number-of-Teeth Gear2)÷2)**

Notes:

Recommend Backlash / Clearance.

- Minimum: 0.006 × $(\text{center-distance})^{0.5}$
- Maximum: 0.024 × $(\text{center-distance})^{0.5}$

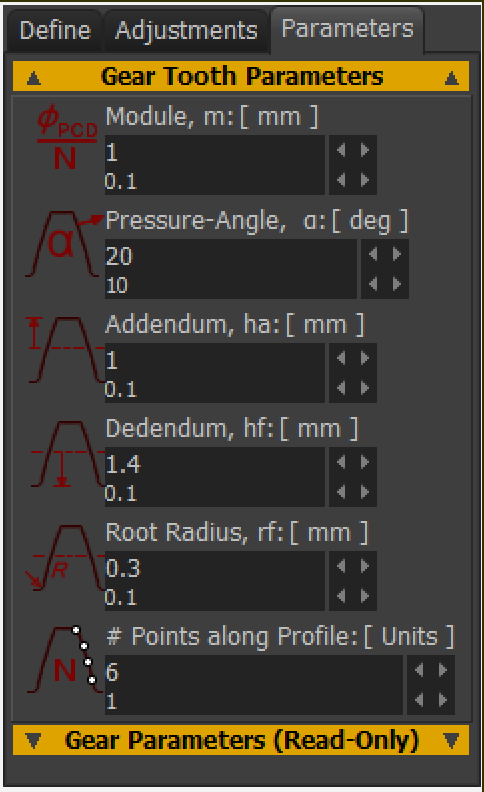
Also, I have read that:

- Minimum normal backlash = 0.03 × module + 0.05 mm

If the torque reverses each machine cycle, then you should aim for the minimum recommended backlash.

Parameters tab

GEAR TOOTH PARAMETERS



MODULE , m

Module, m = P.C.D (in mm) / Number-of-Teeth.

If you increase **module**, the diameter of the Gears increases.

The **module** of the gears in the **GEAR-PAIR** are equal.

PRESSURE-ANGLE α - **default = 20º**

Standard gears are 20º.

Other standards are:

- 14º, 17.5º (weaker, quieter),
- 22.5º and 25º (stronger, noisier).

ADDENDUM, ha - **default = m.**

The radial height of the gear tooth from the Pitch Circle to the top of the tooth.

DEDENDUM, hf - **default = m × 1.25.**

The radial depth of the gear tooth below the Pitch Circle to the root of the tooth.

The DEDENDUM is usually larger than the ADDENDUM to give a working-clearance for the teeth.

If 0.25<m<1, Dedendum is usually = m × 1.4

If m>1, Dedendum is usually = m × 1.25

ROOT-RADIUS, rf - **Default is 0.3 × m**

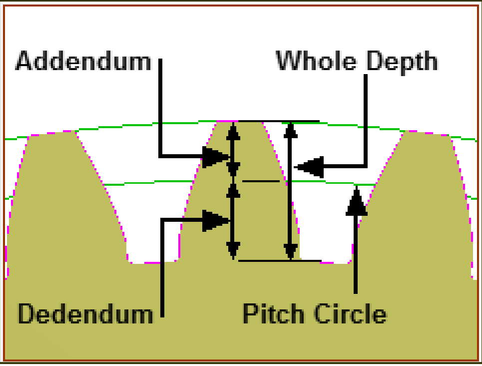
The small fillet between the Flank and the Root of the Gear Tooth.

Note: In reality, if the gear is manufactured from a Hob/Rack Cutter, then the root of the gear is a Trochoid.

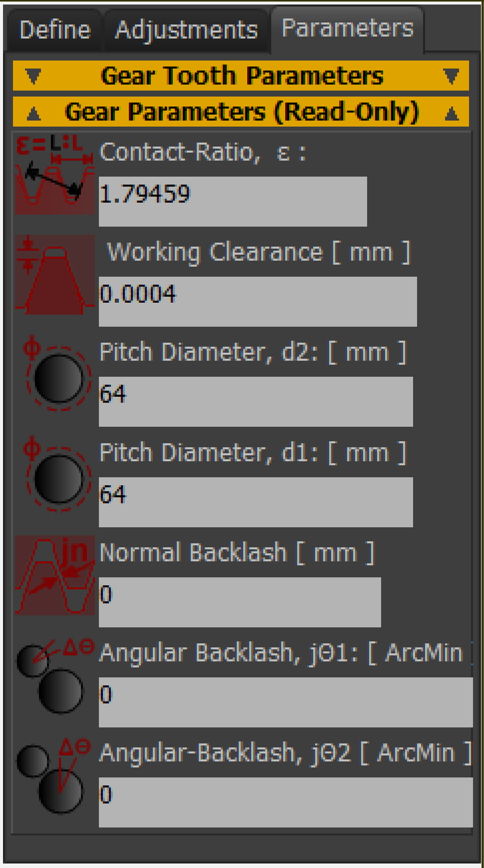
 # POINTS ALONG PROFILE

The number of facets and points along the gear tooth flank (and around the two Root Radii).

To display Gears more accurately, increase the number of points. Generally, do not increase the number

	of Points along the Profiles without a good reason. 4 is OK. 10 is accurate, but not usually needed.
	**For information:** WORKING CLEARANCE = DEDENDUM - ADDENDUM WORKING DEPTH = ADDENDUM × 2 TOTAL DEPTH = ADDENDUM + DEDENDUM

GEAR PARAMETERS

	**ALL READ-ONLY** **CONTACT-RATIO: ϵ** **Contact-Ratio** should **not** be less than 1.1. **Contact-Ratio** should be a minimum of 1.2 for working gears. **WORKING CLEARANCE = DEDENDUM - ADDENDUM** [Note: the units should be [m] not [mm], or let Working-Clearance[mm] = Working-Clearance × 1000] The distance between the top land of a gear tooth and the bottom land of the gear with which is meshed. **GEAR 1 PCD AND GEAR 2 PCD** PCD = Pitch Circle Diameter. PCD = Module × Number-of-Teeth, (m×z) **NORMAL BACKLASH (MM)** This is the gap (backlash) between the gear-flanks you can measure with a 'feeler gauge'. NORMAL BACKLASH is a function of the CENTER DISTANCE ADJUSTMENT [568] parameter ONLY. **ANGULAR BACKLASH - GEAR 1 (DEG) JΘ1**

	This parameter gives the maximum rotation of Gear 1 if you do not move Gear 2. ANGULAR BACKLASH is a function of the CENTER DISTANCE ADJUSTMENT 568 parameter ONLY. **ANGULAR BACKLASH - GEAR 2 (DEG)** This parameter gives the maximum rotation of Gear 2 if you do not move Gear 1. ANGULAR BACKLASH is a function of the CENTER DISTANCE ADJUSTMENT 568 parameter ONLY.

CONTACT-RATIO

The **Contact-Ratio** gives the number-of-teeth that are in contact, on average, as they pass through the meshing point. A **contact ratio** between 1 and 2 means that contact alternates between one and two pairs of teeth. Gears that have a high **contact-ratio** are smoother and quieter. The **contact-ratio** of an Internal Gear-Pair is higher than that of a similar External Gear-Pair.

If the **Contact-Ratio** is too low, then consider these options:

- Decrease the pressure-angle
- Increase the number-of-teeth
- Increase the working-depth

USEFUL GEARING CALCULATIONS AND EQUATIONS

Gearing Equations

TO OBTAIN	FROM KNOWN	USE THIS FORMULA
Pitch Diameter	Module, *m*, number-of-teeth, *N*	$D = mN$
Circular Pitch	Module	$p_c = m.\pi = D.\pi/N$
Module	Diametrical Pitch, P*d*	$m = 25.4/P_d$
Number-of-Teeth	Module, *m*, Pitch Diameter, *D*	$N = D/m$
Addendum	Module, *m*	$a = m$
Dedendum	Module, *m*	$b = 1.25m$
Outside Diameter	Module, *m*, Pitch Diameter, *D*, or number-of-teeth, *N*	$D_o = D + 2m = m(N + 2)$
Root Diameter	Pitch Diameter, *D*, Module, *m*	$D_R = D - 2.5m$
Base Circle Diameter	Pitch Diameter and Pressure Angle	$Db = D \cos \mu$

TO OBTAIN	FROM KNOWN	USE THIS FORMULA
Base Pitch	Module, *m, and* Pressure Angle, μ	$p_b = m \pi \cos \mu$
Tooth Thickness at Standard Pitch Diameter	Module, *m*	$T_{std} = \pi. m / 2$
Center Distance	Module, *m,* number-of-teeth, *N*	$C = m . (N_1 + N_2) / 2$
Contact Ratio for Spur Gears (1 < CR < 2)	Outside Radii, Base Circle Radii, center Distance, Pressure Angle	$CR = (\sqrt{R_{01}^2 - R_{b1}^2} + \sqrt{R_{02}^2 - R_{b2}^2} - C \sin \mu) / m \pi \cos \mu$
Backlash (linear)	Change in center Distance, ΔC	$B = 2(\Delta C)\tan \mu$
Backlash (linear)	Change in Tooth Thickness, ΔT	$B = \Delta T$
Backlash (linear) along Line-of-action	Linear Backlash along Pitch Circle, B	$B_{LA} = B \cos \mu$
Backlash, Angular	Linear Backlash, D	$B_a = 6880 B / D$ (arc minutes)
Min. No. of Teeth for No Undercutting	Pressure Angle, µ	$N_c = 2 / \sin^2 \mu$ Nc (20º) = ~17 Teeth

Useful Gearing Definitions

Term	Definition
Addendum:	the height of the gear tooth above the pitch circle diameter
Backlash:	the angle the output-shaft of the gearbox can move without the input-shaft moving
Base Circle:	an imaginary circle used in involute gearing to generate the involute that forms the tooth profiles
Bevel Gears:	used for right-angle applications. There are two types of bevel gears which are straight and spiral
Center-Distance:	distance between the axes of two meshed gears - Length of the Line-of centers
Circular Thickness:	the thickness of the tooth on the pitch circle.
Dedendum:	the depth of the tooth below the diameter of the pitch circle.
Diametrical Pitch:	the teeth per inch of the diameter of the pitch circle
Differential Gear:	a bevel gear which allows two shafts to rotate at a different speed.

Term	Definition
Gear:	a wheel with teeth that meshes with another wheel with teeth to translate motion.
Gear center:	the center of the pitch circle.
Gear Train:	two or more gears meshed by their teeth. A gear train generates power speed through the meshed gears rotating
Gear Ratio:	the ratio between the numbers of teeth of meshing gears.
Helical Gear:	gear with the gear teeth cut at angles
Line of Contact:	the line or curve along which two tooth surfaces are tangent to each other
Involute:	the curve which describes a line which is unwound from the circumference of the gear
Pinion:	a small cogwheel which fits into a larger gear or track.
Pitch Circle:	the curve of intersection of a pitch surface of revolution and a plane of rotation
Pitch Diameter:	the diameter of the pitch circle
Pitch Radius:	the radius of the pitch circle
Planetary Gears:	a system that consists of three components: the sun gear, ring gear, and two or more planet gears. The sun gear is in the center, the ring gear is the outermost gear, and the planet gears are the gears surrounding the sun gear inside the ring gear.
Pressure Angle:	the angle between the line-of-action and the normal (90º, perpendicular) to the surface of the tooth
Spiral Bevel Gears:	shafts whose axes are perpendicular (90º) to each other and are used in right-angle applications
Spur Gear:	connect parallel shafts which have involute teeth that are parallel to the shaft
Sun Gear:	a gearwheel that rotates around its own axis and has other gears (planet gears) that rotate around it
Torsional Strength:	the measure of the amount of torque that a radial shaft can sustain during its rotation in a mechanical system
Working Depth:	the max depth a tooth of one gear extends into the tooth gear of a mating gear
Worm Gear:	a gear with one or more teeth with screwed threads

Gear Modifications

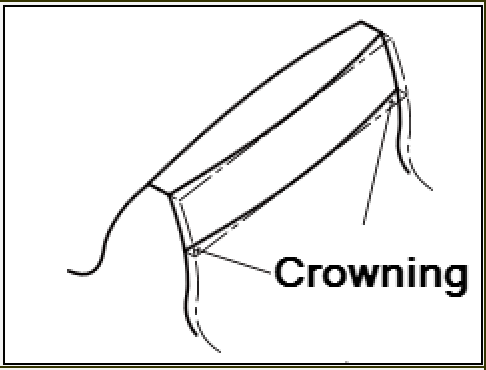
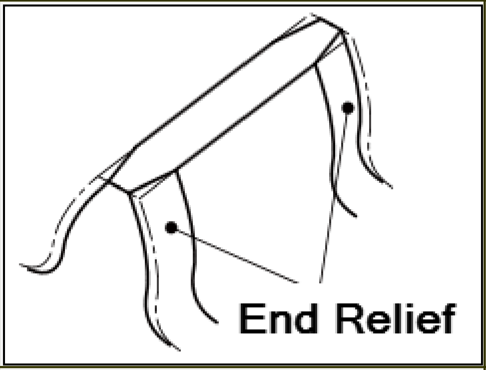
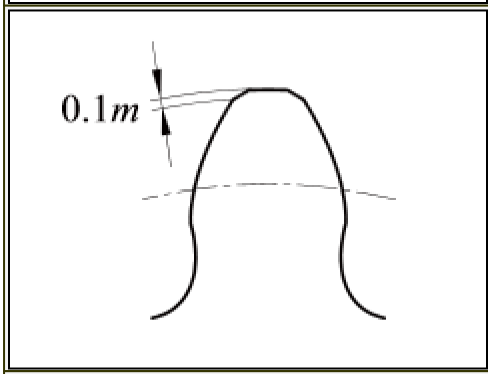
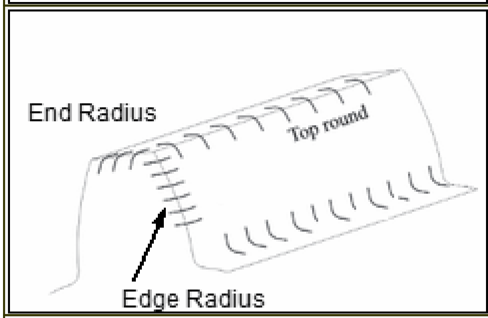
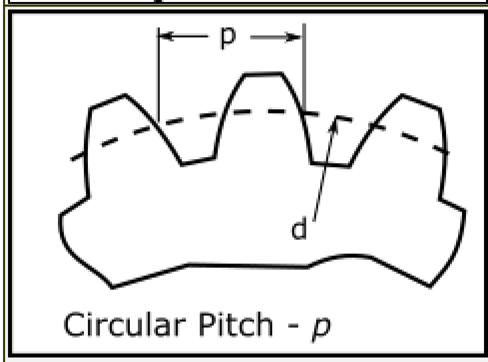
Image	Term
	Crowning:
	End-Relief
	Topping and Semi-Topping
	End Radius and Edge Radius/End Relief Top Round/Semi-topping
	Circular Pitch = pitch circle circumference(pi.d) / number of teeth(z) ; $\mathbf{p = \Pi.d / z}$ Module = Pitch Diameter(d) / Number of Teeth(z) ; $\mathbf{m = d/z}$ Circular Pitch(p) / Module(m) ; $\mathbf{p/m = \Pi}$

Image	Term
	Pitch Diameter(d) = module(m) × number of teeth(z) ; $\mathbf{d = m.z}$

1.5.11.52 Dialog: Rack-Pinion / Ball-screw

Rack-Pinion / Ball-Screw

See: Add Rack-Pinion 136

After you add a **RACK-PINION** element, you can (optionally) convert it to a **BALL-SCREW** and **NUT**.

A **PINION** is a gear-wheel with teeth that engage with a straight gear, or **RACK**.

A **BALL-SCREW** is a shaft with threads that engage with a **NUT** that can move along the screw.

The motion of the **RACK** (or **PINION**) controls the motion of the **PINION** (or **RACK**).

Or, the motion of the **BALL-SCREW** (or **NUT**) controls the motion of the **NUT** (or **BALL-SCREW**).

Use the **RACK-PINION DIALOG** to edit the parameters for the **RACK** and **PINION** (module, number, ...), or a **BALL-SCREW** (Pitch, Diameter, ...).

How to open the Rack-Pinion dialog

After you add a **RACK-PINION**, you will need to edit its parameters - **see** Add Rack-Pinion 136.

To edit the **RACK-PINION**:

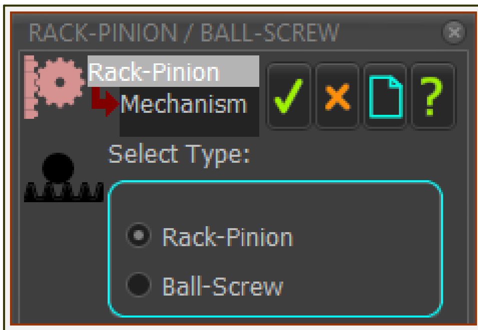
1. Double-click a **RACK-PINION** in the graphics-area or **ASSEMBLY-TREE**.

OR

1. **See** How to Open a dialog 627

The **RACK-PINION DIALOG** is now open.

Rack-Pinion / Ball-Screw dialog



Rack-Pinion / Ball-Screw dialog

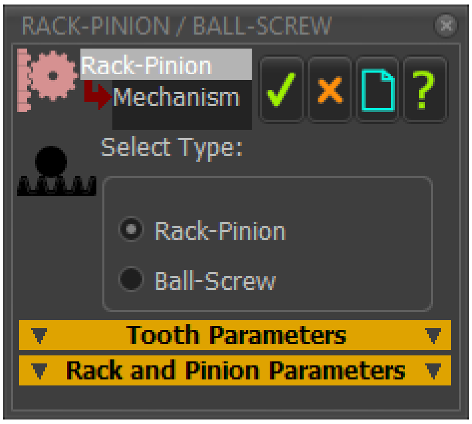
The format of the Rack-Pinion dialog changes when you enable:

- **Rack-Pinion (default)**

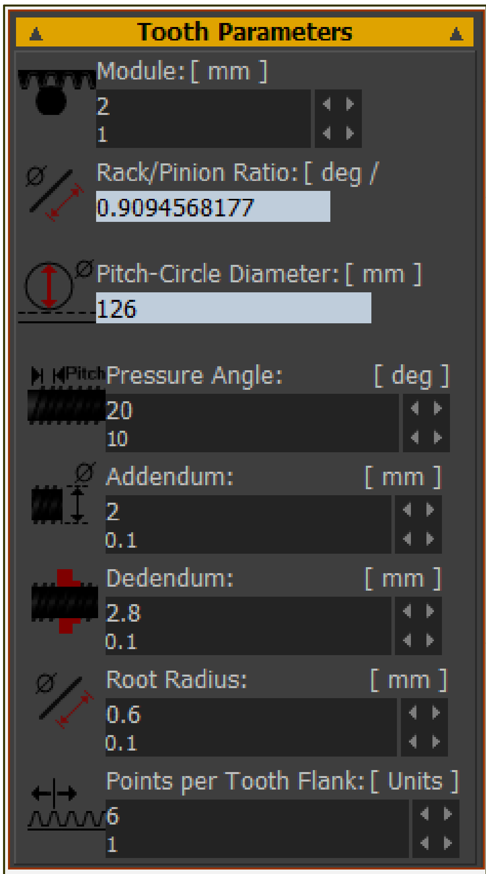
OR

- **Ball-Screw**

Rack-Pinion enabled:



TOOTH PARAMETERS



MODULE = P.C.D. ÷ **NUMBER-OF-TEETH** on **PINION**

Rack/Pinion Ratio (degrees), per Rack Displacement (mm).

Read-only:

> **RACK/PINION RATIO** (deg/mm) - number of degrees the Pinion must rotate to move the Rack by 1mm.
>
> **PITCH CIRCLE DIAMETER** (mm) - the effective diameter of the Pitch Circle of the Pinion. The abbreviation is P.C.D.
>
> P.C.D. (mm) = Number-of-Teeth × Module

PRESSURE ANGLE (Default = 20º).

> The Pressure Angle of gears is usually 20º. Other standard Pressure-Angles are: 14º, 17.5º (weaker, quieter), and 22.5º, 25º (stronger, noisier).

ADDENDUM (Usually = Module).

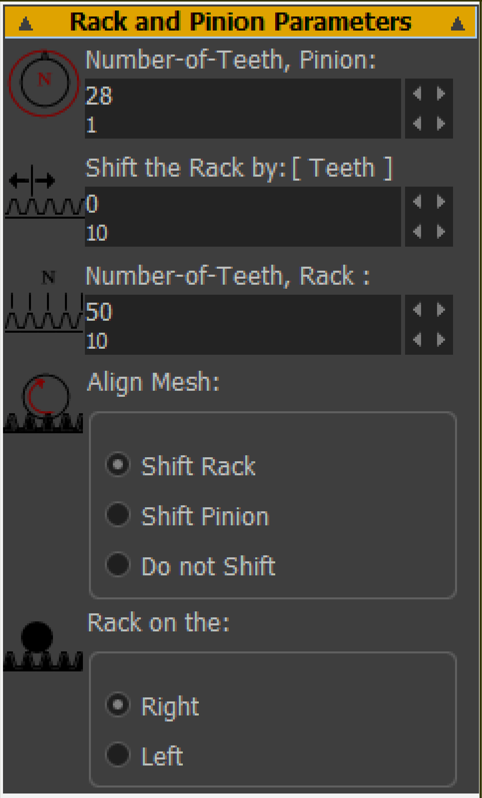
> The height of the gear tooth from the Pitch-Circle to the tip of the tooth.

DEDENDUM (Usually = Module × 1.25 (Module>1)).

> The depth of the gear tooth below the Pitch-Circle to the root of the tooth.
>
> The **DEDENDUM** is larger than the **ADDENDUM** to give clearance for the

	tooth-tip of the two gears that engage with each other.
	ROOT RADIUS (Usually = 0.3 × Module) The small fillet between the Flank and the Root of the Gear Tooth.
	POINTS PER TOOTH FLANK The number of points on each Involute of each gear tooth. 6 is OK. More points make your model slower to edit.

RACK AND PINION PARAMETERS

<table>
<tr>
<td>


</td>
<td>

NUMBER-OF-TEETH, PINION:

The number-of-teeth on the PINION.

As you increase the number-of-teeth, the PCD increase, unless you also edit the Module.

SHIFT THE RACK BY:

Move the RACK along its pitch-line by # number-of-teeth.

NUMBER-OF-TEETH, RACK:

The NUMBER-OF-TEETH on the RACK.

Edit the NUMBER-OF-TEETH on the RACK so that it stays in mesh with the PINION for a machine-cycle

---

ALIGN MESH:

When you add two(2) RACKS to one(1) PINION, you usually see two(2) PINIONS on the same axis. If you want to see one(1) PINION, click one of these options:

⦿ SHIFT RACK

⦿ SHIFT PINION

⦿ DO NOT SHIFT

RACK ON THE:

The positive-direction of **Rack-Pinion** and **Ball-Screw** model are specified when you select RIGHT or LEFT.

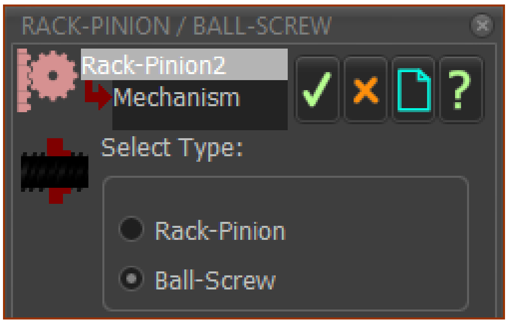
⦿ RIGHT (default)

When the PINION (Ball-Screw Shaft) rotates **Counter-Clockwise**, the RACK

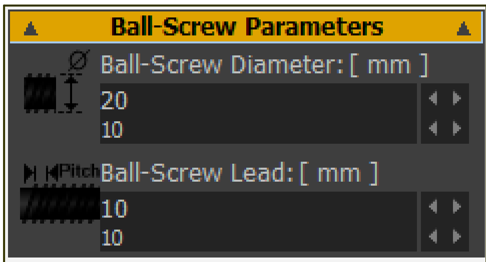
</td>
</tr>
</table>

	(Ball-Screw Nut) move in the **Positive-Direction** of the SLIDE-JOINT. ⦿ LEFT When the PINION (Ball-Screw Shaft) rotates **Clockwise**, the RACK (Ball-Screw Nut) move in the **Negative-Direction** of the SLIDE-JOINT.

Ball-Screw enabled :



BALL SCREWS PARAMETERS

	The symbol in the graphics-area for a Ball-Screw is a **Helix/Screw.** There are two parameters: • BALL-SCREW LEAD (mm) - distance the SLIDING-PART moves after one(1) rotation of the ROTATING-PART. • BALL-SCREW DIAMETER (mm) - diameter of the BALL-SCREW symbol in the graphics-area. The length of the BALL-SCREW is equal to the length of the LINE in the SLIDING-PART - see Add Rack-Pinion[136]. The **Nut** (SLIDING-PART) of the BALL-SCREW moves in the **Positive-Direction** of the SLIDE-JOINT when the RACK-SIDE[579] is set to RIGHT - **see** **General tab**[579]

1.5.11.53 Dialog: Pulley

Pulley

See Add Pulley 160

Use the PULLEY DIALOG to edit the NUMBER-OF-TEETH on a PULLEY.

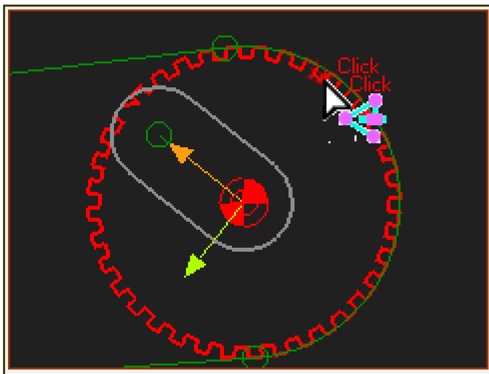
Pulley / Belt Terminology

Term :	Definition
PULLEY :	When you do **Add Pulley**, we add for you the outline of a PULLEY, with **teeth,** to a rotating-Part - see also **Types of Pulley** The rotating-Part of a PULLEY must rotate about the **CENTER-POINT** of an ARC that is on the sketch-path of a **Belt**.
Belt :	A **sketch-path** to represent the path of the **Belt**. The motion of a **MOTION-POINT** along the **sketch-path** represents the motion of the **Belt**.
We relate the angular motion of each PULLEY to the linear motion of the Motion-Point on a **Belt** by the radius of each PULLEY. To control the radius of each PULLEY, you can control its NUMBER-OF-TEETH and the TOOTH-PITCH of the **Belt.**	

Types of Pulley

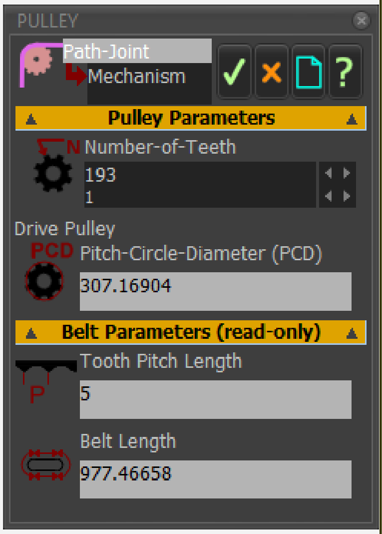
You can do **Add Pulley** to a rotating-Part that is kinematically-defined (**Type 1**) or is not kinematically-defined (**Type 2**).	
Type 1: A Driving-Pulley :	Before you do **Add Pulley,** the rotating-Part is kinematically-defined. After you do **Add Pulley**, we control the linear motion of a **Belt** from the angular motion of the rotating-Part (**Driving-Pulley**). Add a maximum of one **Driving-Pulley** to a **Belt**.
Type 2: A Driven-Pulley :	Before you do **Add Pulley**, the rotating-Part is not kinematically-defined. After you do **Add Pulley**, we control the angular motion of a rotating-Part (**Driven-Pulley**) from the linear motion of the **Belt**.

How to open the Pulley dialog

 Double-Click a Pulley	After you add a PULLEY, you will need to edit the NUMBER-OF-TEETH - **see** Add Pulley 160. To edit the PULLEY: 1. Double-click a PULLEY in the graphics-area or ASSEMBLY-TREE. OR

	1. **See** **How to Open a dialog** [627] The PULLEY DIALOG is now open.

Pulley dialog - and no Transition-Curve in the sketch-path



Pulley dialog

PULLEY PARAMETERS

NUMBER-OF-TEETH

The NUMBER-OF-TEETH around the circumference of the PULLEY.

The NUMBER-OF-TEETH and TOOTH-PITCH (see MOTION-PATH FB [469]) control the P.C.D of the PULLEY and the radius of the ARC in the sketch-path.

PITCH-CIRCLE-DIAMETER (PCD) - **read-only**

The diameter of the Pitch-Circle, which is co-radial with the neutral line, or pitch axis, of the Belt.

$$PCD = (\#\, Teeth\ on\ Pulley \times Tooth\ Pitch)\,/\,\pi$$

BELT PARAMETERS

TOOTH PITCH - **read-only** (Edit with the Motion-Path dialog [474])

The linear distance between two adjacent teeth on the belt.

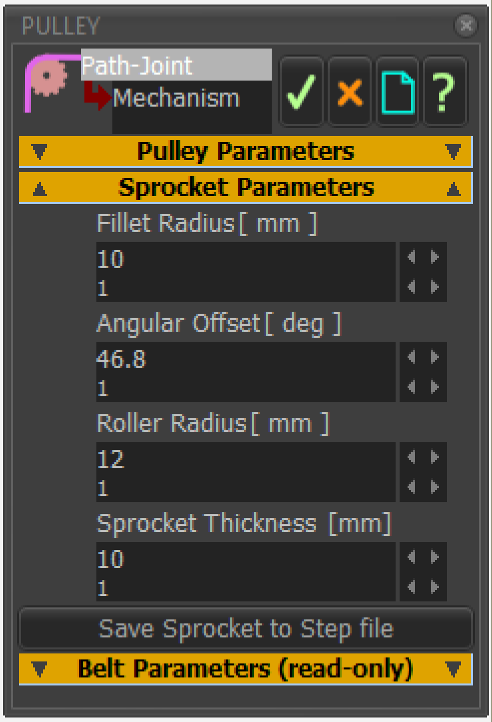
BELT LENGTH - **read-only**

The total length of the belt. It is equal to the length of the **sketch-loop** that wraps around the PULLEYS.

The length of the belt will change as you edit the NUMBER-OF-TEETH on a PULLEY.

You can select a dimension that will control the BELT-LENGTH with the MOTION-PATH DIALOG [474].

Pulley dialog - and Transition-Curve in the sketch-path



Pulley dialog

SPROCKET PARAMETERS

FILLET RADIUS - the radius that blends with the root of the tooth.

ANGULAR OFFSET - to rotate the pulley / sprocket so that the **Motion-Points** engage with the root of the tooth.

ROLLER RADIUS - the radius of the **Follower-Roller** that can engage with the root of the tooth if you want to add a convert the Transition Path to a 2D-Cam.

SPROCKET THICKNESS - the extrusion depth to use when you save the Sprocket as a STEP file.

1.5.11.54 Dialog: Feedscrew [Scroll]

Feedscrew (Scroll)

See Add Scroll 150

We have labeled the dialog as *Feedscrew* and *Scroll* because they are both common terms.

Other terms include: *Worms, Infeed Screws, Gusanos, and Tortillas sin fin.*

Use the *Feedscrew (Scroll)* dialog to:

- Set the number-of-points along the feedscrew surface for each 'rim'
- Set the Start and End - the '*range*' - of the 3D-Cam
- Edit the display of the feedscrew in the graphics-area
- Export the feedscrew to SOLIDWORKS®
- Rebuild the feedscrew with the current or active settings.
- Save the feedscrew data that defines the surface mesh.

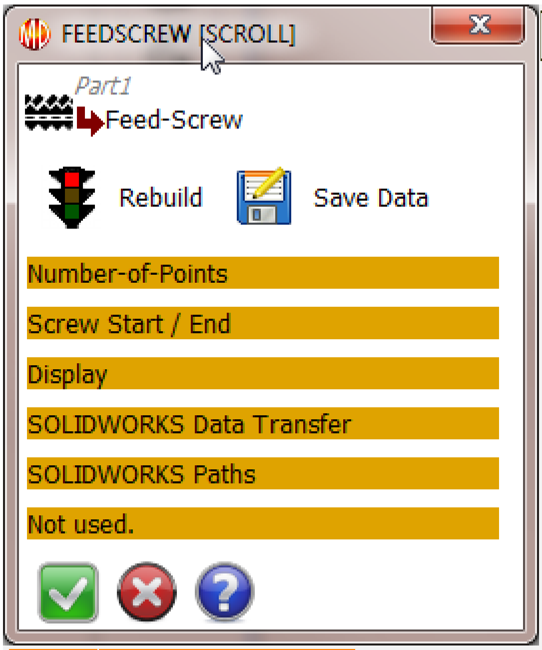
To Open the Feedscrew dialog

1. Double-click a FEEDSCREW in the GRAPHICS-AREA

OR

1. **see** **How to open a dialog** 627

Feedscrew dialog

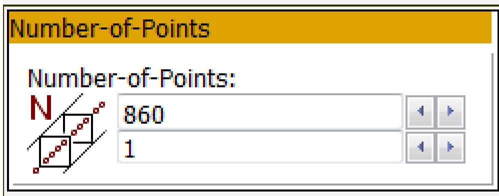


Buttons at top of dialog

Rebuild and Save Data buttons

- Use the **Rebuild** button to
  - re-calculate the points along each 'rim' when you change a parameter
  - before you use the Save Data button
  - before you transfer the Feed-screw to SolidWorks
- Use the **Save Cam** button to save the feedscrew mesh data as text files.

NUMBER OF POINTS



Preamble:

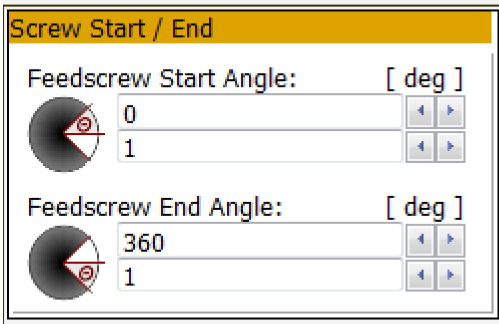
- We specify a Feedscrew with a surface.
- There are a number of lines, that we call *Rims*, along the feedscrew surface.
- There is one Rim for each Motion-Point as defined by the Motion-Path FB.
- There are a number-of-points along each *Rim*.

Parameters:

NUMBER-OF-POINTS:

Number-of-points along each *Rim*. - 860 in dialog to left

SCREW START/END



Preamble:

When you add a Feedscrew, we calculate for you the surface for a complete cycle of the MMA : 0 – 360

Use this separator to edit the range of the MMA for which you want to calculate the feedscrew.

The NUMBER-OF-POINTS along each rim does not change.

Parameters:

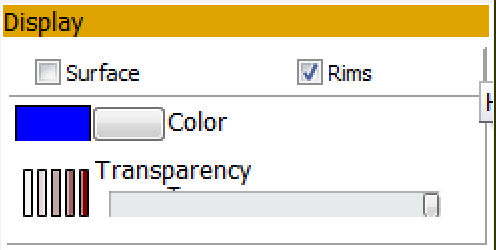
FEEDSCREW START-ANGLE

- Edit the *Start-Angle*

FEEDSCREW END-ANGLE

- Edit the *End-Angle*

DISPLAY



Preamble:

The '**MechDesigner** Display' edits how the surface of the Feedscrew shows in the graphics-area.

Controls:

'Surfaces' ; 'Rims' check-boxes

Use the check-boxes to Show or Hide *Surface*, and Show or Hide *Rims*.

Solids: show or hide, with the color in the 'color' control, and with the Transparency given by the 'Slider'.

Rims: show or hide the Rims along the Feedscrew.

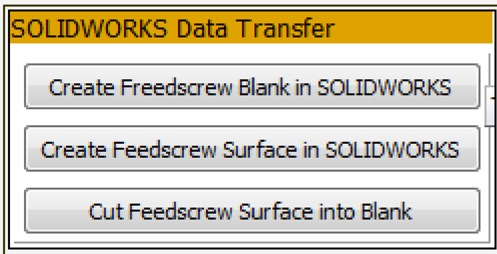
Color

- Use the Windows color picker to select a *color* for the Feedscrew and Rims.

Transparency

- Use the slider to change the *Transparency* of the Feedscrew.

SOLIDWORKS DATA TRANSFER



Preamble: When you have set the correct parameters in this dialog: Number-of-Point and Start/End Angles, then you can export the Feedscrew to SOLIDWORKS. To do this

1. Open SOLIDWORKS
2. Add and Save a new Part
3. Make sure the new Part is the 'active' document in SOLIDWORKS

Buttons:

Create Feedscrew Blank in SolidWorks

- We export for you the sketch of the Feedscrew Blank and its Axis-of-Rotation'

- We instruct SOLIDWORKS for you to use the Feedscrew Blank and Axis to add a 'Revolved' feature

Create Feedscrew Surface in SolidWorks

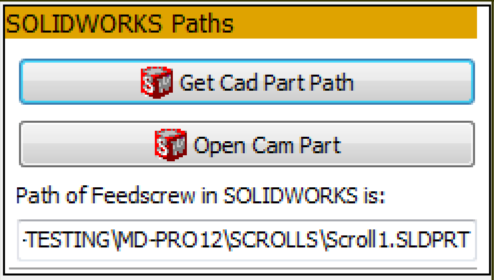
- We export for you the XYZ data of each Rim to a '*Curve*' feature
- We instruct SOLIDWORKS for you to use the *Curves* to Insert a *Boundary Surface* feature.

Cut Feedscrew Surface into Blank.

- We instruct SOLIDWORKS for you to cut the Revolved feature with the Boundary Surface

See Troubleshooting below[587].

SOLIDWORKS PATHS



Preamble:

After you have sent the Feedscrew to SOLIDWORKS, it is often useful to link the its file-name in SOLIDWORKS with the Feedscrew element that is in **MechDesigner.** At a later date, when you open this Feedscrew dialog again, you can reopen the part in SOLIDWORKS.

Buttons:

Get Cad Part Path button: Click this button to link the CAD file-name in SOLIDWORKS with the Feedscrew.

The file-name, with its full path, is put into the 'Path of Feedscrew in SOLIDWORKS is :

Open Cam Part button: Click this button to open the part with the file-name in the 'Path of Feedscrews in SOLIDWORKS is' box.

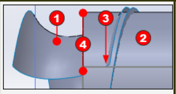
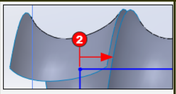
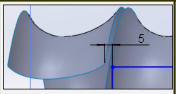
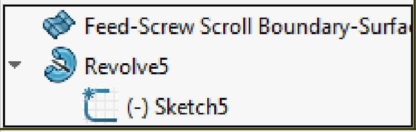
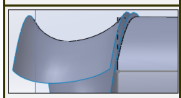
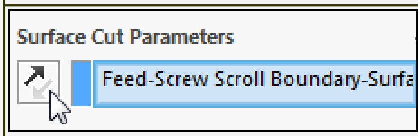
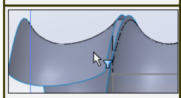
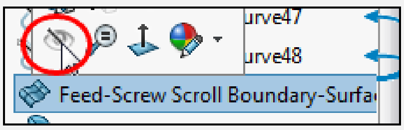
Before this is possible:

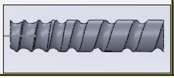
1. You have previously transferred a Feedscrew to SolidWorks and saved the file,

AND

2. You have already clicked the button 'Get Cad Part Path' button.

Trouble-shooting the Feedscrew in SOLIDWORKS

<table>
<tr><td></td><td colspan="2">The last command: 'Cut Feedscrew Surface into Blank' ❸ may not work.
CHECK 1: In SOLIDWORKS, inspect the length of the Scroll Blank❷ relative to the Scroll-Surface❶.
In the image to the left, the left of the Scroll-Blank❹ is to the left of the end of the Scroll-Surface❸.
In this case, the 'Cut Scroll Surface from Blank' (button❸ in dialog) does <u>not</u> work.</td></tr>
<tr><td></td><td colspan="2">You must, in SOLIDWORKS, or MechDesigner
1. Edit the sketch of the Scroll-Blank❷
I prefer to edit the sketch in SOLIDWORKS.</td></tr>
<tr><td></td><td colspan="2">2. Move the end of the sketch to the right of the end of the Scroll-Surface.
In this sketch, I have added a dimension between the end of the Scroll-Surface and the left of the Sketch-Blank.</td></tr>
<tr><td></td><td></td><td>To help, I have, in SOLIDWORKS, dragged the 'Revolve' feature to below 'Feed-Screw Scroll Boundary-Surface'.
Then, as I edit the sketch for the Sketch-Blank I can see the end of the Scroll-Surface.</td></tr>
<tr><td></td><td colspan="2">CHECK 2: After you close the sketch and rebuild the model. the Surface-Cut feature in SOLIDWORKS might cut to the incorrect side of the Scroll-Surface - see image to the left. In this case:</td></tr>
<tr><td></td><td></td><td>1. Edit the Feed-Screw Scroll Boundary-Surface feature in SOLIDWORKS
2. Click the direction arrow - see image- to reverse the direction of the Cut.</td></tr>
<tr><td></td><td colspan="2">In the image, you can see the Scroll-Blank has been cut correctly by the Scroll-Surface.
However, the Feed-Screw Scroll Boundary-Surface feature is still shown in the model</td></tr>
<tr><td></td><td></td><td>CHECK 3: Edit the Feed-Screw Scroll Boundary-Surface feature to hide it from the display.</td></tr>
</table>

		See image.
	Finally, the scroll is correct.	

1.5.11.55 Dialog: Configure Power Source

Configure Power Source

See How to open the Configure Power Source dialog 651

When you want **MechDesigner** to calculate for you the forces at joints, 2D-CAMS, SPRINGS, PULLEYS, you must make sure the Power-Source is at the correct joint or element.

If you do not Configure the Power-Source to be at the correct joint or element, the forces that we calculate for you are not correct!

Power Sources

Each degree-of-freedom in a kinematic-chain that is kinematically-defined has a power-source.

In the default case, the power-source is a motor at the joint (PIN-JOINT or SLIDE-JOINT) whose motion you control with a MOTION-DIMENSION FB. A power-source can also be a 2D-CAM, SPRING, or PULLEY element.

If the power-source is not at the correct joint or element, use the CONFIGURE POWER SOURCE DIALOG to change it to the correct joint or element.

If the Power-Source element is a :

- PIN-JOINT - we calculate for you the Torque (Application-Torque) that you need at the output from a Motor and Gearbox - **see** Gearbox and Servo-Sizing 592 .
- SLIDE-JOINT - we calculate for you the Motive-Force that you need from a Linear-Motor.
- 2D-CAM / CONJUGATE CAM - we calculate for you the **Contact-Force**, **Contact-Stress**, **Cam-Life**, and **Roller-Life** - **see** 2D-Cam dialog 401
- SPRING - we calculate for you the Motive-Force (if you you configure the SPRING as a Linear-Motor).

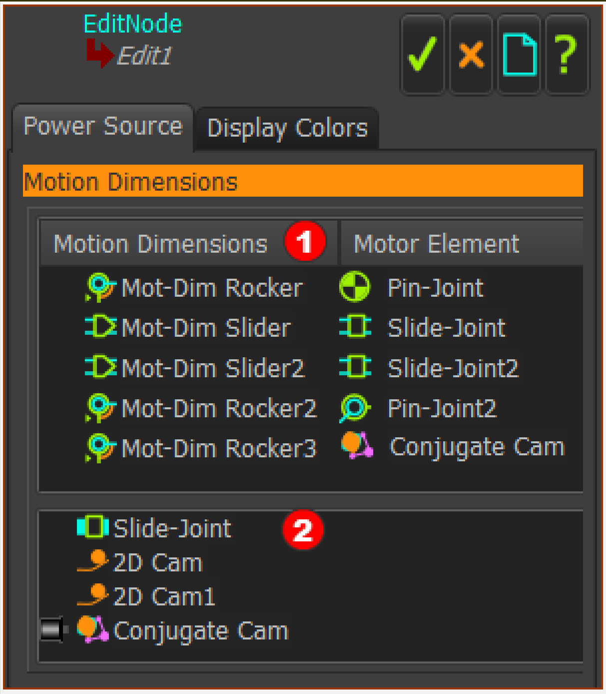
Configure Power Source dialog

You must **Configure the Power Source** for each degree-of-freedom in each **Kinematic-Chain.**

There are two tabs in the CONFIGURE POWER SOURCE DIALOG:

Power Source tab

MOTION DIMENSIONS



Configure Power Source dialog > Power Source

MOTION-DIMENSIONS and **MOTOR ELEMENTS Box** ❶

In box ❶, even if the MOTOR ELEMENT to the right of a MOTION-DIMENSION is correct, please do **1** and **2**

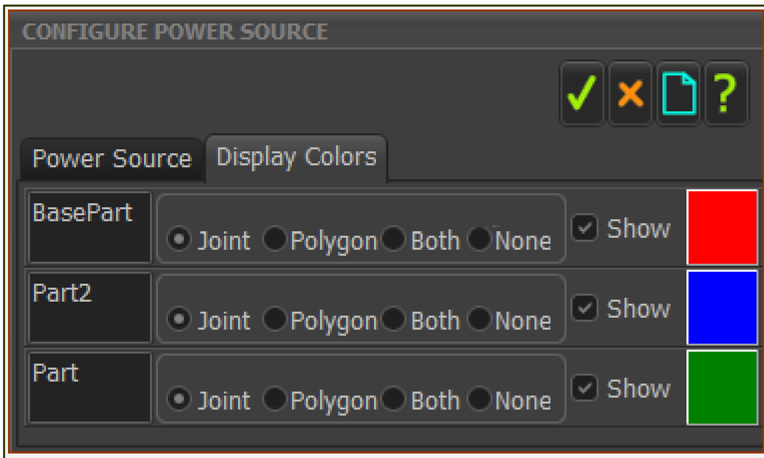
1. In box ❶ - Click a MOTION-DIMENSION - ROCKER or SLIDER - to make it **active**
2. In box ❷ - Click a MOTOR ELEMENT

The MOTOR ELEMENT in box ❷ is now the **POWER-SOURCE** for the **active** MOTION-DIMENSION in box ❶ .

See also : Tutorial 13 - Forces: introduction.

See also : Machine elements toolbar > Add Conjugate-Cam FB 165 .

Display Colors tab



Configure Power Source dialog > Display Colors tab

For each PART you can:

- Change the color of the **PART-OUTLINE** and **FORCE-VECTORS** that act on the **PART**.
- Display the **FORCE-VECTORS** that act on the **PART**:
  - at the Joint
  - as a Polygon of Forces
  - or both: at the Joint and as a Polygon of Forces

(The **Polygon of Forces** does not help me much!).

OR

  - Hide the **FORCE-VECTORS** that act on the **PART**

1.5.11.56 Dialog: Servo-motor and Gearbox Sizing.

Kinetostatic Torque and Speed

Note: The options for a Linear Motor with a SLIDE-JOINT will be available in a later release.

Use the KINETOSTATIC TORQUE AND SPEED DIALOG to:

- Plot the **Torque-Speed** curve for the **Application Load**, in four quadrants
- Select a **Planetary Gearbox** manufacturer and model
- Select a **Servomotor** manufacturer and model.
- Plot the **Gearbox Load Torque-Speed** curve, in four quadrants
- Plot the **Servomotor Torque-Speed** curve, in four quadrants.
- Calculate the Duty-Cycle as a percentage of the machine-cycle
- Calculate the RMS Torque.

Note: Use this tool with one degree-of-freedom kinematic-chains. Email PSMotion if the kinematic-chain has two or more degrees-of-freedom, each with a servomotor.

How to open the Kinetostatic-Torque and Speed dialog

STEP 1: Enable:

- Force toolbar > Force-Vectors: Calculate 229
- Force toolbar > Force-Vectors: Display 237

You should see a **Motor** 1 at a PIN-JOINT - see image below. The Motor is a Power-Source.

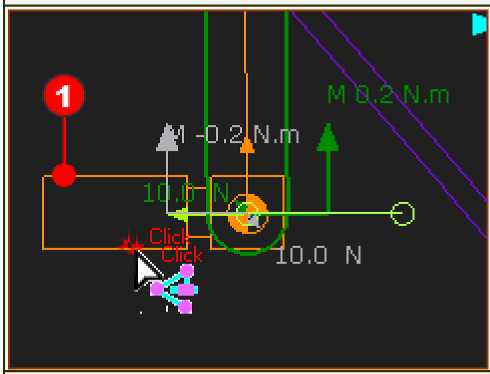
If your servo-motor on your actual machine is not at that PIN-JOINT, you need to move the **Motor** symbol to the correct PIN-JOINT.

STEP 2: If required, move the Motor symbol to the correct joint

See Force toolbar > Configure Power Source 232

Configuring the Power Stage is a major change to the model configuration.

It is good idea to Save the model, and Reopen the model.



STEP 3: Open the Kinetostatic Torque-Speed dialog:

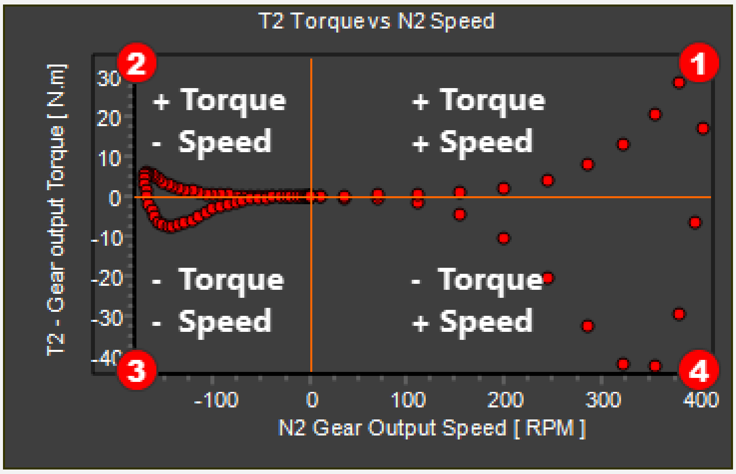
1. Click the **Motor** ❶ in the graphics-area

The **PIN-JOINT** shows in the **SELECTION-WINDOW**.

2. Right-Click the **PIN-JOINT**
3. Click **Edit element** in the shortcut menu.

The **KINETOSTATIC TORQUE-SPEED DIALOG** is now open.

Application (Load) Torque vs Speed plot



FOUR QUADRANT: TORQUE(LOAD) vs SPEED

The plot is **Torque vs Speed** of the **Application Load**, in four-quadrants. The Application Load does NOT include the load to drive the inertia and friction of a Servomotor and Gearbox.

Why Four Quadrants?

When inertia is the dominant load, and the motion moves the load back and forth, the four quadrants are:

❶ + Torque and + Speed : accelerating the load in the positive direction

❷ – Torque and + Speed : decelerating the load in the positive direction

❸ – Torque and – Speed : accelerating the load in the negative direction

❹ + Torque and – Speed : decelerating the load in the negative direction

STEP 1: Auto-Filter and Range-Factor

Auto-Filter check-box

The **Auto-Filter check-box** is at the top and right of the dialog.

❑ **Auto-Filter OFF** - we list all of the gearboxes provided by the manufacturer you select

☑ **Auto-Filter ON** - we list only those gearboxes that have a **Torque Capacity**

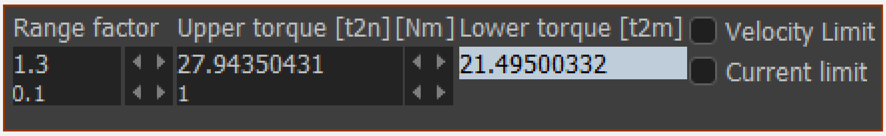
- that is greater than the "**Lower torque, t2m**"

AND

- that is equal or less than the "**Range-Factor** × **Lower-Torque** "

Range Factors

The **Range-Factor** is at the top of the dialog.



Thus, the capacity of the Gearboxes that are listed for you are summarized by:

Application-Load ≤ Gearbox Capacity ≤ Application-Load × Range-Factor

---

Example: Auto-Filter ON, Range-Factor: 1.3

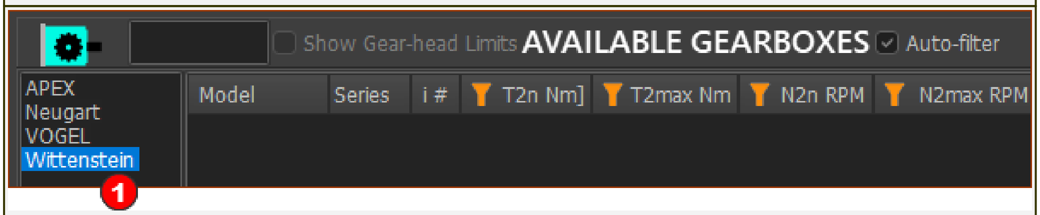
Lower Gearbox Torque Capacity = Equivalent Application (Load) Torque (21.495 N.m.)

Upper Gearbox Torque Capacity = Range Factor × Equivalent Application (Load) Torque (1.3 × 21.495 = 27.944 N.m.)

STEP 2: Select a Gearbox Manufacturer

Select a Gearbox Manufacturer ❶

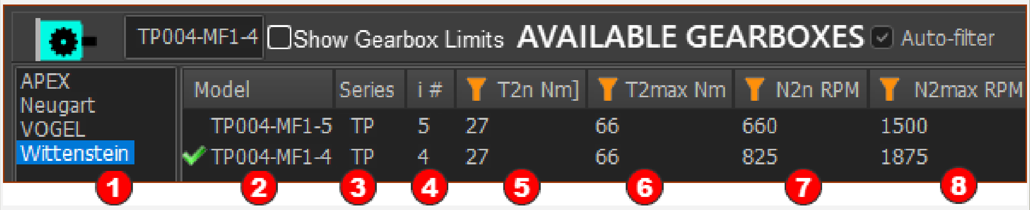
There are four Gearbox manufacturers: APEX, Neugart, Vogel, and Wittenstein



Note: If you need us to list a different Gearbox Manufacturer, then please email us.

STEP 3: Select a Gearbox Model

Select a Gearbox Model ❷



Gearbox manufacturer and Gearbox model part numbers

When you select a **Gearbox Manufacturer**, and **Auto-Filter is ON**, and you have entered a **Range-Factor**, the list of **Gearboxes** is limited to those whose capacity can satisfy these in-equalities:

❶	Manufacturer		The selected Gearbox Manufacturer	
❷	Model		The selected the Gearbox Part Number Each manufacturer has a different Model Part-Number format.	
❸	Series		Series - from the selected Model	
❹	*i*	#	Gearbox Ratio	from the Model
❺	T2N	Nm	Rated Torque at output-shaft	- data sheet -
❻	T2MAX	Nm	Max. Torque at out-put-shaft	- data sheet -
❼	n2N	RPM	Rated Speed at out-put-shaft	- data sheet / i -
❽	n2MAX	RPM	Max. Speed at out-put-shaft	- data sheet / *i* -

$T2_{max} \leq T2_{MAX} \leq RF \times T2_{max}$

Maximum Application (Load) Torque ≤ Maximum Output Torque of the Gearbox ≤ Range-Factor × Maximum Application (Load) Torque

$T2_{m} \leq T2_{N} \leq RF \times T2_{m}$

Equivalent Application (Load) Torque ≤ Rated Output Torque Capacity of the Gearbox ≤ Range-Factor × Equivalent Application (Load) Torque

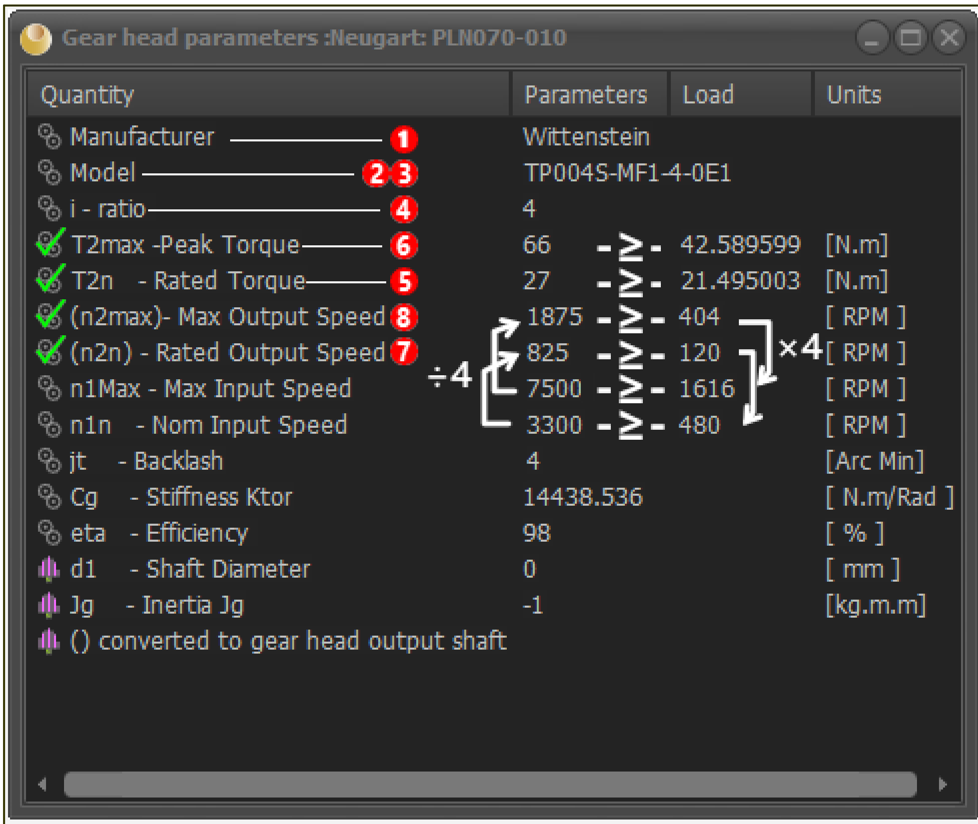
$n2_{max} \times i \leq n1_{MAX}$

Maximum Application (Load) Speed × *Gearbox Ratio (i)* ≤ Maximum Input Speed of the Gearbox

$n2_{n} \times i \leq n1_{N}$

Average Application (Load) Speed (or Equivalent, Mean) × *Gearbox Ratio (i)* ≤ Rated Input Speed of the Gearbox

Gearbox Parameters Check List.



Gearbox Parameters Summary Sheet

After you select a Gearbox model, its **Gearbox Parameters Summary Sheet** show. This form is read-only.

On the left of the sheet, there should be four(4) × ✅ to indicate that the Gearbox has the capacity to drive the Application Load and satisfies the 4 requirements.

❻ Peak Torque ≥ Maximum Application Torque

❺ Rated Torque ≥ Equivalent Application Torque

❽ (Max Output Speed) ≥ Maximum Application (Load) Speed

❼ (Rated Output Speed) ≥ Equivalent Application (Load) Speed

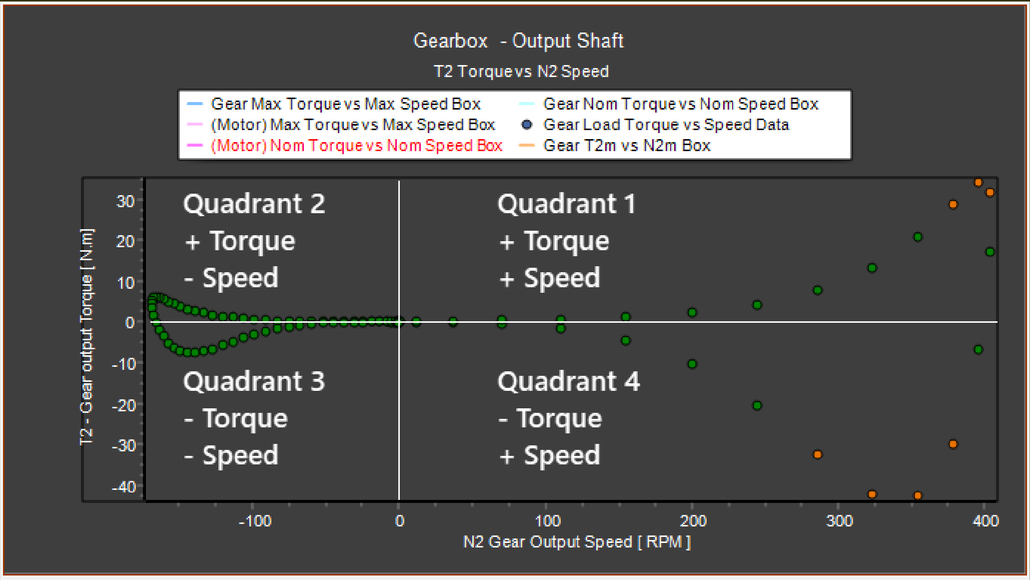
Notes: Speed parameters in brackets **( )** are referred to the output-shaft. They are calculated from the Gear-Ratio of the Gearbox.

Other Parameters include:

- Backlash
- Stiffness
- Efficiency
- Shaft Diameter - the input-shaft diameter, which is not in the list until you select a Servomotor.
- Inertia - referred to the input, which is not in the list until you select a Servomotor.

Note: Not all Gearbox manufacturers provide all of these parameters.

Gearbox Output Torque vs Speed plot

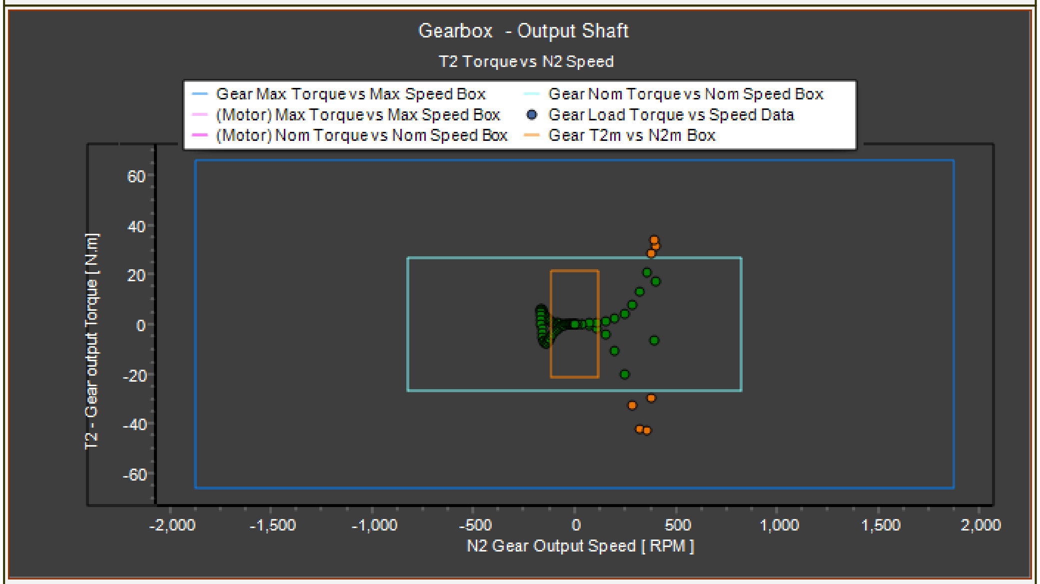


Torque-Speed plot at Output of Gearbox.

When you select a Gearbox, the Torque (N.m.) vs Speed (RPM) plot changes to indicate whether the Gearbox has the capacity to drive the Application Load.

The color code is :

- **Green** : Torque AND Speed of the Load ≤ Rated Gearbox Capacity
- **Amber** : Torque OR Speed of the Load ≥ Rated Gearbox Capacity ≤ Maximum Gearbox Capacity
- **Red** : Torque OR Speed of the Load ≥ Maximum Gearbox Capacity



Torque-Speed at Gearbox at Output with Gearbox Limits

Gearbox Torque and Speed Limits.

The **Show Gearbox Limits** check-list box is located above the Gearbox selection box.

❑ **Show Gearbox Limits ENABLED**

The axes are auto-scaled to the Maximum Torque and Speed, at the output of the Gearbox.

☑ Show Gearbox Limits DISABLED

The axes are auto-scaled to the Maximum Torque and Speed Capacity, referred to the output of the Gearbox.

This helps you compare the Torque and Speed Capacity of the Gearbox with the Application Load.

The Limits of Torque and Speed are shown as boxes.

Before you select a servomotor, the limit boxes and their color codes indicate the:

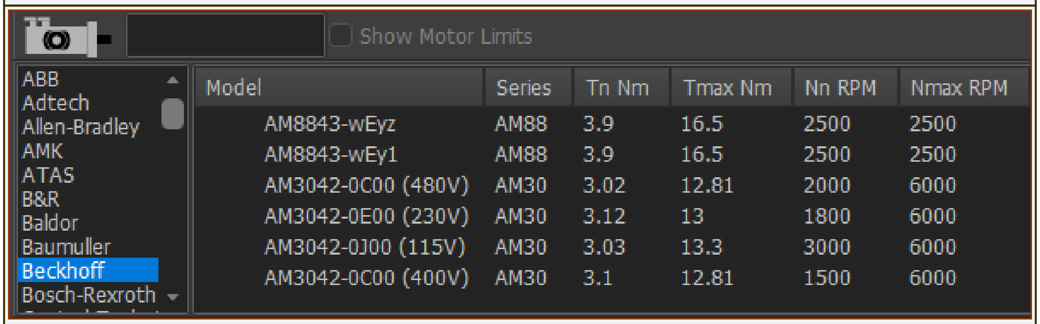
- Dark Blue : Maximum Torque and Speed capacity of the Gearbox
- Light-Blue : Rated (or Nominal) Torque and Speed capacity of the Gearbox
- Light-Brown : Equivalent Torque and Speed of the Application Load

STEP 4: Select a Servo-motor Manufacturer

Select a Servomotor Manufacturer ❶

There are many Servomotor manufacturers from which to select.

When you select a Servomotor Manufacturer, we find for you those Servomotors that have the Torque and Speed Capacity required by the Application Load.

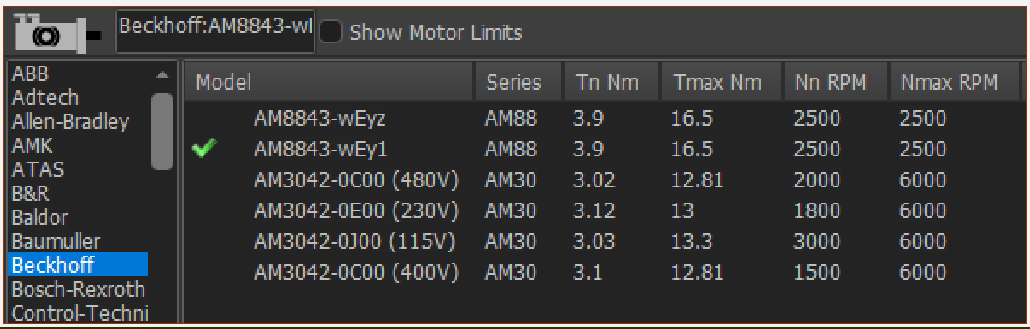


Servo-motor manufacturers and Servo-motor part numbers

Note: If you need us to list a different Servomotor Manufacturer, then please email us.

STEP 5: Select a Servo-motor Model

Select a Servomotor Model



When you select a **Servomotor Manufacturer**, and **Auto-Filter is ON**, and you have entered a **Range-Factor**, the list of **Servomotor** is limited to those whose capacity can satisfy these in-equalities:

❶	**Manufacturer**		The Selected Manufacturer	
❷	**Model**		The Selected the Model. Each manufacturer has a different model format.	
❸	**Series**		Series - from the Selected Model	
❹	*d1*	**mm**	Motor Shaft Diameter	- data sheet -
❺	**Tn**	**Nm**	Rated Torque	- data sheet -
❻	**Tmax**	**Nm**	Max. Torque	- data sheet -
❼	**Nn**	**RPM**	Rated Speed	- data sheet -
❽	**Nmax**	**RPM**	Max Speed	- data sheet -

$d1_{max} \leq D \leq d1_{min}$

The Servomotor Shaft Diameter, D, must fit directly into the Gearbox, d1.

Note: Precision Planetary Gearboxes can accept a range of shaft diameters at their input. The Gearbox inertia, which is referred to its input, is different for each shaft diameter.

$T_{max} \leq T_{mot\ max} \leq RF \times T_{max}$

Maximum Application Load Torque referred to the Gearbox input-shaft

≤ Maximum Servomotor Torque Capacity ≤

Range-Factor × Maximum Application Load Torque referred to the Gearbox input-shaft

---

$T_m \leq T_N \leq RF \times T_m$

Equivalent Application (Load) Torque referred to the Gearbox input-shaft

≤ Rated Servomotor Torque Capacity ≤

Range-Factor × Equivalent Application (Load) Torque referred to the Gearbox input-shaft

---

$n1_{max} \leq N_{max}$

Maximum Application Speed referred to the Gearbox input-shaft ≤ Maximum Servomotor Speed

---

$n1_N \leq N1_N$

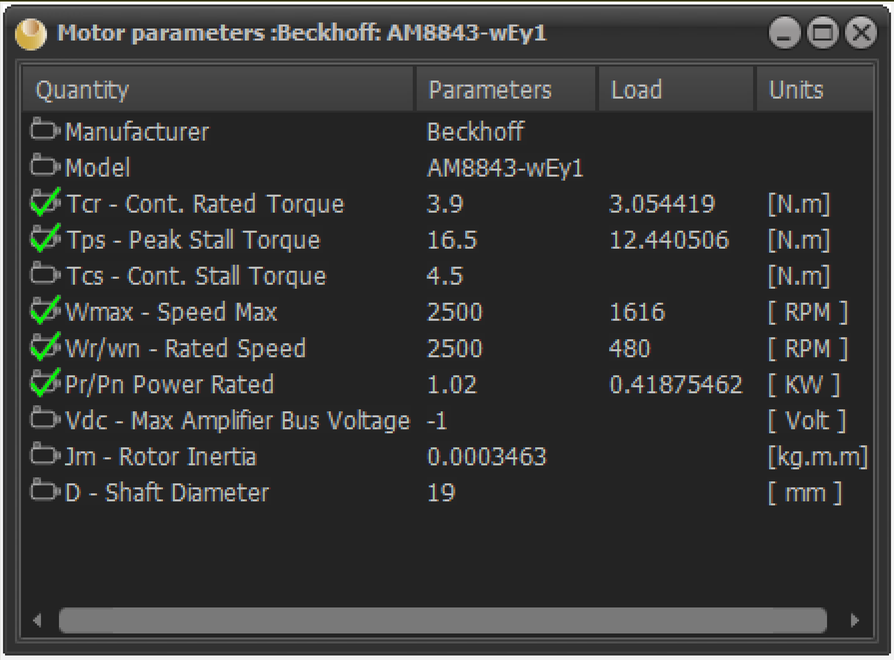
Average Application Speed (or Equivalent, Mean) ≤ Rated Servomotor Speed

---

Pn ≤ Pr

Application Power < Servomotor Power Capacity

Servo-motor Parameters Check List.



Quantity	Parameters	Load	Units
Manufacturer	Beckhoff		
Model	AM8843-wEy1		
Tcr - Cont. Rated Torque	3.9	3.054419	[N.m]
Tps - Peak Stall Torque	16.5	12.440506	[N.m]
Tcs - Cont. Stall Torque	4.5		[N.m]
Wmax - Speed Max	2500	1616	[RPM]
Wr/wn - Rated Speed	2500	480	[RPM]
Pr/Pn Power Rated	1.02	0.41875462	[KW]
Vdc - Max Amplifier Bus Voltage	-1		[Volt]
Jm - Rotor Inertia	0.0003463		[kg.m.m]
D - Shaft Diameter	19		[mm]

Servo-motor Parameters Summary Sheet

When you select a servomotor model, its **Servomotor Parameters Summary Sheet** show. This form is read-only.

To the left of the sheet, there should be five(5) × ✓ to indicate that the Servomotor has the capacity to drive the Application Load and also satisfies those 5 × requirements.

Peak Servomotor Torque ≥ Maximum Application (Load) ÷ i

Rated Servomotor Torque ≥ Equivalent Application (Load) Torque ÷ i

Max Servomotor Speed ≥ Maximum Application (Load) Speed × i

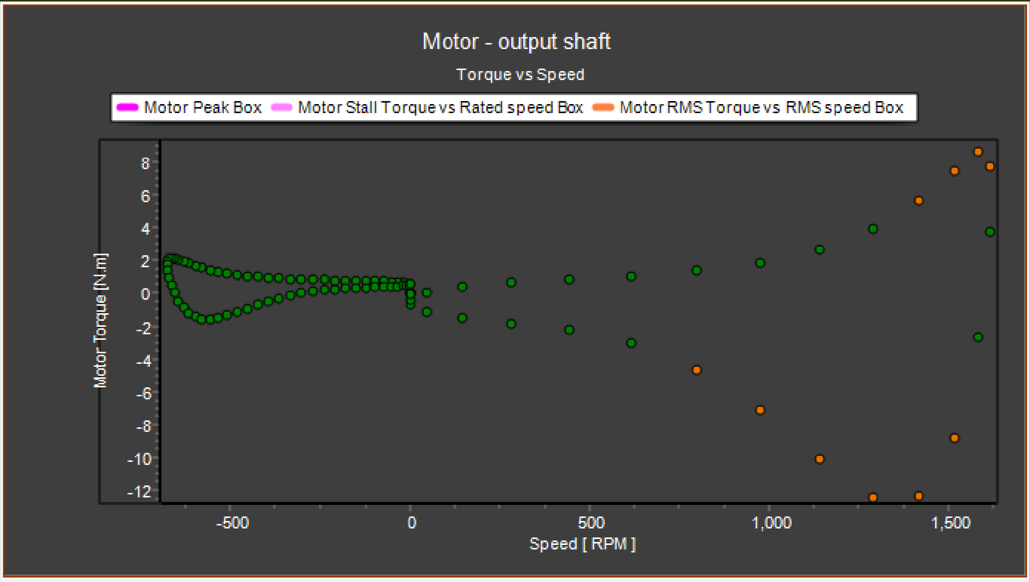
Continuous Servomotor Speed ≥ Equivalent Application (Load) Speed × i

Rated Power > Nominal Load Power.

Other Parameters include:

- Vdc - Bus Voltage for Drive
- Jm - Servomotor Inertia
- D - Servomotor shaft diameter.

Servomotor Torque vs Speed plot

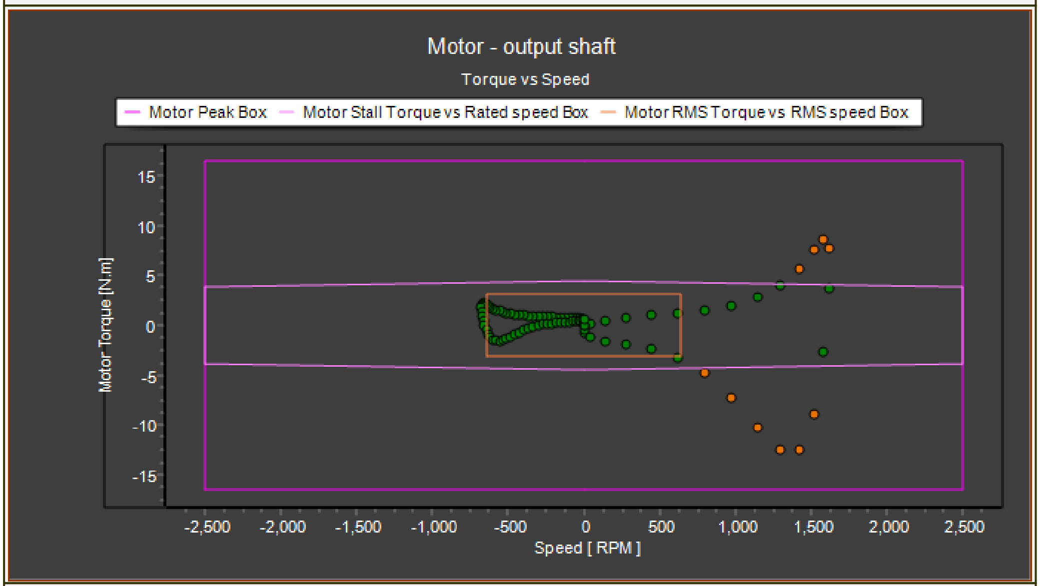


Torque-Speed plot of Servo-motor

When you select a Servomotor, colors of the dots for the **Torque (N.m.) vs Speed (RPM)** plot changes to indicate whether the Servomotor has the Capacity to drive the Application Load or not.

The color code is :

- **Green** : Torque AND Speed of the Load ≤ Rated Servomotor Capacity
- **Amber** : Torque OR Speed of the Load ≥ Rated Servomotor Capacity ≤ Maximum Servomotor Capacity
- **Red** : Torque OR Speed of the Load ≥ Maximum Servomotor Capacity



Motor Torque and Speed Limits.

The Show Motor Limits check-list box is located above the Motor selection box.

❑ **Show Motor Limits ENABLED**

The axes are auto-scaled to the Maximum Torque and Speed, at the Servomotor Drive Shaft.

☑ **Show Motor Limits DISABLED**

The axes are auto-scaled to the Maximum Torque and Speed Capacity of the Selected Servomotor

This helps you compare the Torque and Speed Capacity of the Servomotor with the Application Load referred to its input-shaft.

The Limits of Torque and Speed are shown as boxes.

- Purple : Maximum Torque and Speed capacity of the Servomotor
- Pink : Rated (or Nominal) Torque and Speed capacity of the Servomotor
- Light-Brown : Equivalent Torque and Speed of the Application Load

Why the Motor Torque is different to the Mechanism Torque

The Torque we calculate for you when you Display Force-Vectors [63] is the torque to move the mechanism only. This is the Application Torque. The Application Torque does not include the Torque to move the motor and gearbox. It is necessary to add the Torque to accelerate the motor and the gearbox to the Torque in the graphics-area.

Clearly, the Torque to move a motor depends on the inertia of the motor and gearbox and the gearbox ratio.

The higher the gear ratio, the less Application Torque the motor 'sees'. But the motor must run faster and accelerate more. This influences the overall power, and the system efficiency.

More on Torque vs Speed Curves

The performance characteristics of a brushless servo motor (motor/drive combination) are described by a torque/speed operating envelope.

As shown below, the colored areas of the curve identify the Exceeded Duty, Continuous Duty, and Intermittent Duty working areas of the system.

Exceeded Duty

To maximum speed and/or the maximum torque, of the gearbox and/or Servomotor must be exceeded. Usually, to make sure this cannot happen, there is a Current (amps) Limit on the Power Drive.

Continuous Duty Zone (S1)

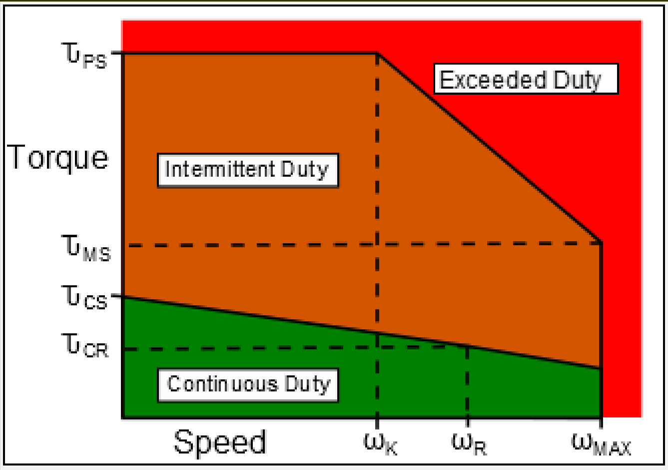
The continuous duty zone is bounded by the maximum continuous stall torque up to the intersection with the intermittent duty line. The continuous torque line is set by either the motor’s maximum rated temperature, or the drive's rated continuous current output, whichever is less.

The system maximum continuous or 'voltage line' is set by the voltage rating of the drives, the line voltage supplied, and the motor winding.

The system can operate on a continuous basis anywhere within this area, assuming the ambient temperature is 40°C or less.

Intermittent Duty Zone (S5)

The intermittent duty zone is bordered by the peak-stall torque and the system voltage line. The peak torque line is set by either the drives' peak current rating, which the drive can give for a limited time, or the maximum rated peak current for the motor, whichever is less. Higher torque levels may be achievable at higher power levels.



Typical Torque / Speed Duty Capability of a Brushless Servomotor.

Peak Torque: (τ_{PS}) The Peak Torque the Motor and Gearbox at Stall Speed

Continuous Stall Torque: (τ_{CS}). The Continuous Torque the Motor and Gearbox can give Continuously at Stall Speed.

Maximum Speed: (ω_{MAX}) Maximum possible speed of the Motor and Gearbox. Not attainable when the voltage is limited by the drive.

Knee Speed: (ω_K) The Speed at 'knee' in peak envelope that is the intersection of the Peak Torque with the Voltage Torque/Speed Limit Line.

Continuous Rated Torque:(τ_{CR}). The Continuous Torque at the Speed of the Rated Power.

Rated Speed: (ω_R) The Rated Speed or Speed at Rated Power. The motor can operate at this speed with the supply voltage.

How we calculate the Motor Torque and Motor Speed

The **Reflected Inertia** at the Motor shaft can be constant or it can continuously change in a machine-cycle.

With **Constant Inertia Mechanical Systems**, it is easy to calculate **Inertia Torque**.

With mechanisms, the Torque is dependent on reflected inertia that is a function of Acceleration, Velocity, and Position.

PSMotion has developed algorithms to calculate these, which give a true indication of the reflected inertia at a motor shaft for even the most complex mechanisms.

The equations below, are calculated at every instant in a machine-cycle.

<table>
<tr><td colspan="2">Usually, you aim to make the Reflected Load Inertia = (Motor + Gearbox) Inertia.
However, when the Load Inertia is not constant, it is more difficult to select the Motor and Gearbox.</td></tr>
<tr><td>Speed:
$\omega_m = N \times \omega_L$
$\alpha_m = N \,.\, \alpha_L$
<hr>Torque
$T_m = -\,\alpha_m\,(J_G + J_M) + sign(T_{VD})$
$T_L = (T_{MD} / N\,) / \eta$
$T_T = T_m + T_L$</td><td>N = Gear Ratio
ω_m = Motor Angular Velocity
ω_L = Load Angular Velocity
T_T = Total Torque
T_m = Motor Torque
T_L = Load referred to Motor Shaft
T_{VD} = Viscous 'Drag' Torque. It is always opposite to the direction of motion
T_{MD} = Torque derived by your model at the Motor Shaft (f{P_L , ω_L, α_L})
J_G = Inertia of Gearbox
J_M = Inertia of Motor
α_m = Motor Acceleration
α_L = Load Acceleration
η = Gearbox Efficiency</td></tr>
</table>

1.5.11.57 Dialog: Movie

Movie

When you continuously-cycle a model, commercial video-recording software may not record each step in a machine-cycle. Also, it is difficult to record exactly one machine-cycle. The **Movie** command solves these problems.

Use the **MOVIE DIALOG** to:

- position and size a "frame" in the graphics-area that you want to record the movie
- browse to a path and enter a file-name for the movie
- control how many images you want to capture for the movie in each machine-cycle
- control the start and end of the movie as a function of the **Master-Machine-Angle**.

Record and save:

- a movie as a **GIF** file-type

OR

- a sequence of images as **PNG, JPG**, **JPEG**, or **BMP** file-type

  We append to the file-name a number to each image. The numbers we append are 000, 001, 002, ...

OR

- save one image as a snapshot of the model.

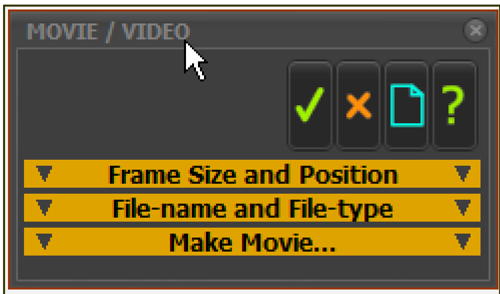
Notes:

The **GIF** format produces a large file when the size and the number of frames are large.

Top-Tips

- Before you start the **Movie** command, move the **Master-Machine-Angle** to zero(0). Click **Run menu** > **Home** or **ALT+H** keyboard short-cut.
- Do not append the file-name with a number

Movie dialog



Make-Movie dialog

When you start the **Movie** command, you open the **MOVIE DIALOG** immediately.

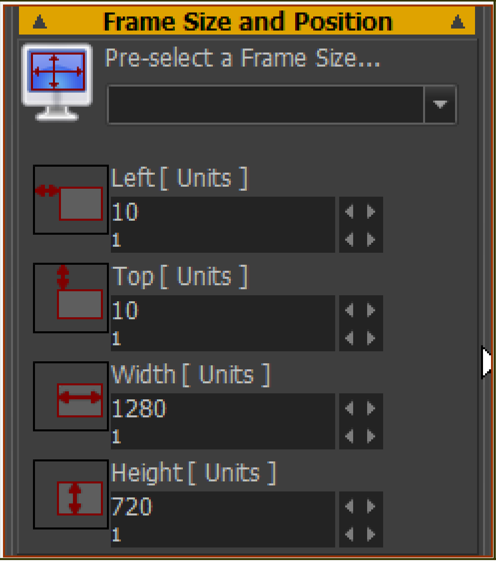
You also see a rectangle in the graphics-area.

The rectangle is the **FRAME**.

You record everything inside the **FRAME**.

	You can edit the size and position of the FRAME and number of FRAMES in the movie.

FRAME SIZE AND POSITION



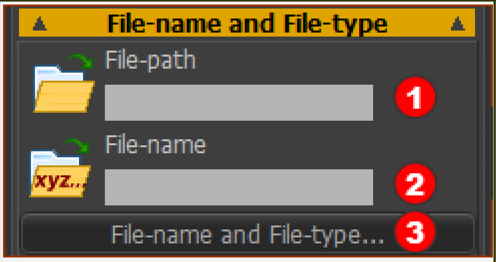
1. Use the **PRE-SELECT A FRAME SIZE...** drop-down list-box to select a typical frame size.

OR

1. Edit the **WIDTH** and **HEIGHT** of the frame.
2. Edit the **LEFT** and **TOP** of the frame.

The rectangle / frame should now be the correct size and position.

FILE-NAME AND FILE-TYPE



1. Click the FILE-NAME and FILE-TYPE... button❸

In the **Windows® Save as** dialog:

a. Browse to a **File-path** and enter a **File-name**

b. Use the **Save as type** list-box to select a file-type.

Select a GIF, PNG, JPG, JPEG, or BMP file-type

c. Click the **Save** button

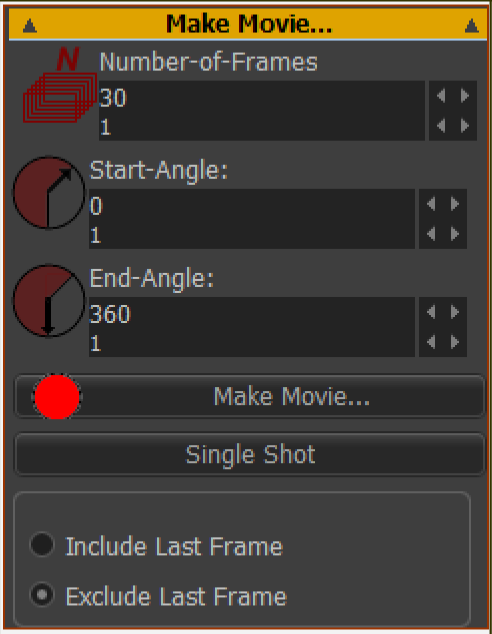
The FILE-PATH and FILE-NAME are now in boxes❶❷.

Note:

GIF is recorded as a movie;

PNG, JPG, JPEG, BMP are recorded as a number of images equal to the NUMBER OF FRAMES - see below.

MAKE MOVIE...



1. Edit the **NUMBER-OF-FRAMES** box (Default = 30 Frames, Minimum=5 ; Maximum=10000)
2. Edit the **START-ANGLE** (Default = 0 ; Minimum > 0, Maximum ≤ Machine End-Angle)
3. Edit the **END-ANGLE** (Default = 360 ; 720 ≥ Maximum > Minimum)
4. Select
   - **INCLUDE LAST FRAME** , or
   - **EXCLUDE LAST FRAME**

Experiment! View the movie in your Video Player to see if there is a stutter at the end of the movie.

MAKE MOVIE button

5. Click the Make Movie button

When you click the Make Movie button:

a) We move the model to the **START-ANGLE**.

b) We compile the movie (GIF file-type), or save the images (PNG, JPG, BMP file-types), at equal increments of the machine-angle, from the **START-ANGLE** to the **END-ANGLE**.

Please **WAIT** while we save for you the file(s) to your PC / Laptop.

OR

SINGLE SHOT button

5. Click the Single Shot button

When you click the Single Shot button, we save for you a **SINGLE SNAPSHOT** of the model at the active **Master-Machine Angle**.

To compile the images as a movie.

To compile **PNG** images as a movie, I use **Avidemux 2.6** - a free tool that you can download from the internet. My lawyer tells me I cannot recommend it.

In **Avidemux 2.6**:

1. Open the first image in the sequence of images - for example, **HINGE-A000.PNG**

Open the first image only. **AVIDEMUX2.6** automatically imports the other images in the numbered sequence.

2. Save the movie with the **MP4** movie format.

Save the Movie file with the same frame-size as the recorded images.

MP4, with the x264 codec, is the recommended format for **YouTube®**.

1.5.11.58 Dialog: Element Properties

Element Properties dialog.

The **Element Properties dialog** is a list of an element's motion and force data at the MASTER MACHINE ANGLE.

Elements Properties are read-only, and include:

- **P** : a Position, or linear value
- **V** : a Vector
- ℝ : a Real Number
- **|*n*|** : Absolute Real Number
- X, Y, ΔX, ΔY, Θ, ω, α, ΔΘ, Δω, Δα

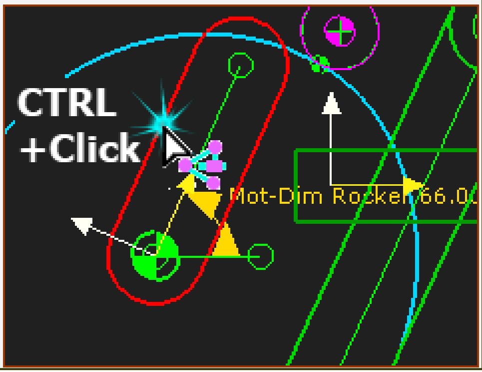
The **Element Properties dialog** can stay open to read the properties at different Master-Machine Angle.

Note:

From MD16-1-372:

When you hover above an element in the graphics-area, the **Element Properties** show in the Extend-Hints box [326] in the **Feedback Area**.

How to open the Element Properties dialog

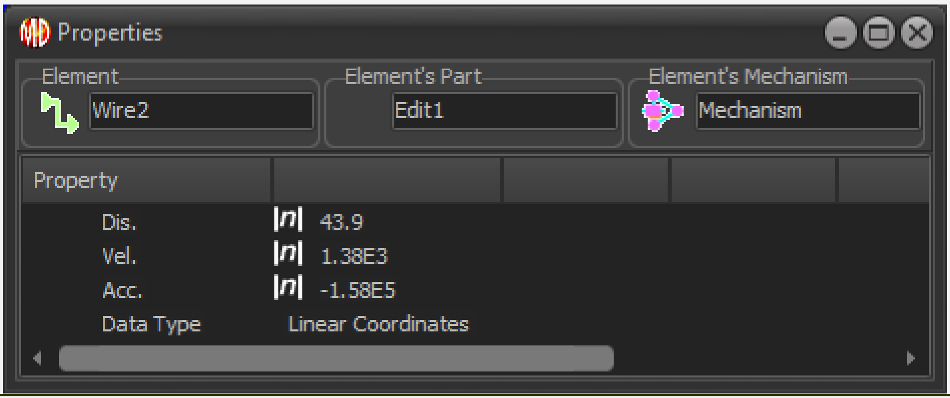
	In the graphics-area:  + Click an element

Element Properties dialog (read-only)

At the top of the dialog you can see the **Element's Name**, the name of the **Element's** PART, and **Element's** MECHANISM.

The **Element** is a child to the **Element's** PART, and the PART is a child to the **Element's** MECHANISM.

Wire Element Properties dialog



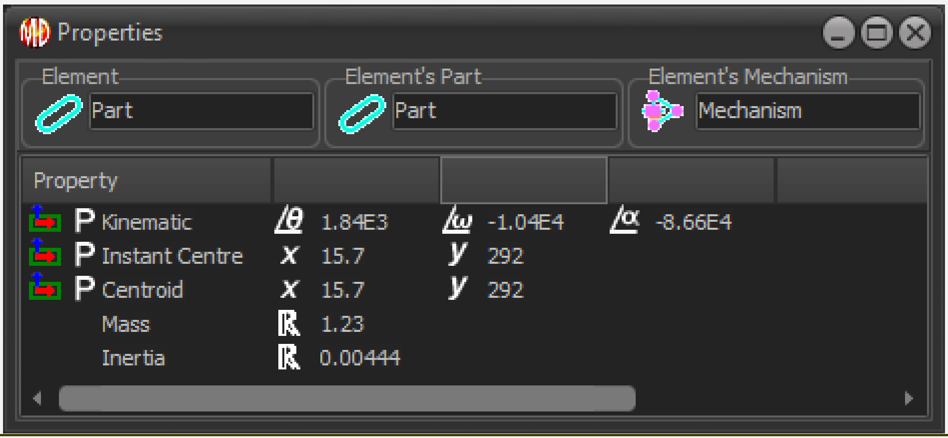
CTRL + Click a wire

Wires connect and transfer, usually, Motion or Force data between Function-Blocks.

A wire has a 3 Data-Channels, with three data-values.

For example, the Data-Channels of a wire that controls the motion of a Motion-Part are Linear or Angular Displacement, Velocity, and Acceleration.

Part Element Properties dialog

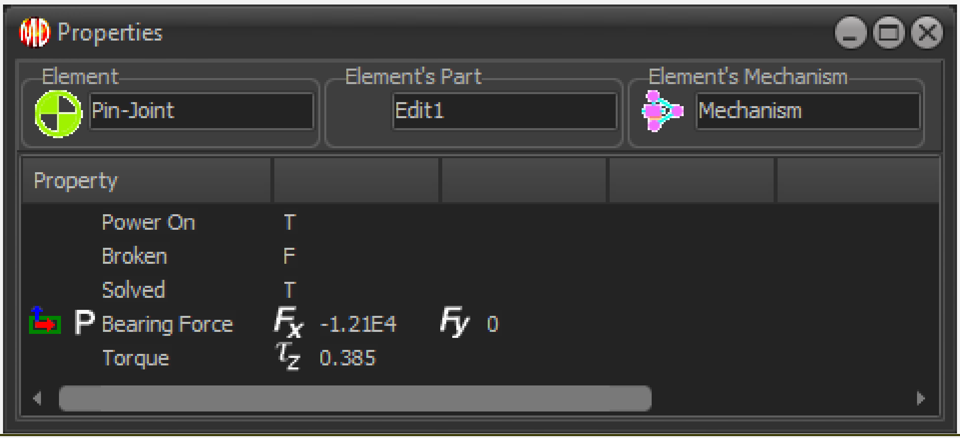


CTRL + Click a Part-Outline

Properties: **(P - Position)**

- **Kinematic**: Angle, Angular Velocity, and Angular Acceleration of PART relative to the Mechanism-Plane
- **Instant Center**: The PART has an instant center of rotation: X and Y co-ordinates of the instant-center in the Mechanism-Plane
- **Centroid**: X and Y coordinates of the Center of Mass in the Mechanism-Plane.
- **Mass**: Value - Real Number
- **Inertia**: Value - Real Number.

Pin-Joint Element Properties dialog



CTRL + Click a Pin-Joint

Property:

- **Power On**: True or False (T or F) - if the **PIN-JOINT** is a Power Source - see Configure Power Source 589
- **Broken**: True or False (T or F) - if the **PIN-JOINT** does not solve (Broken) 318 at this instant in the machine-cycle
- **Solved:** True or False (T or F) - if the **PIN-JOINT** is a child to a kinematic-chain that is **kinematically-defined**
- **Bearing Force**
  - Fx and Fy ; Vectors in Mechanism Coordinates
- **Torque**
  - Tz ; Vector normal to Mechanism Plane (if the **PIN-JOINT** is the Power Source)

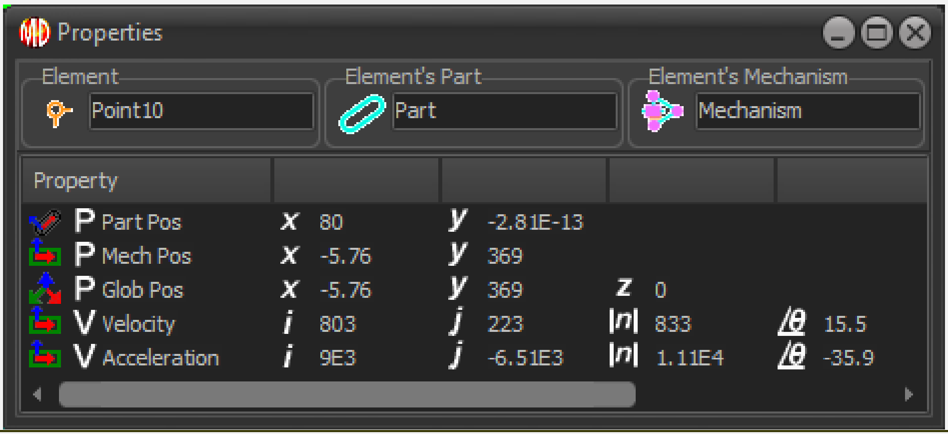
Slide-Joint: Element Properties dialog

CTRL + Click a Slide-Joint

Properties:

- **Power On**: True or False (T or F) - if the **SLIDE-JOINT** is the Power Source - see Configure Power Source 589
- **Broken**: True or False (T or F) - if the **SLIDE-JOINT** does not solve Broken) 318 at this instant in the machine-cycle
- **Solved** : True or False (T or F) - if the **SLIDE-JOINT** is a child to a kinematic-chain that is **kinematically-defined**
- **Drive Force** Fx ; Force along positive direction of **SLIDE-JOINT**, if the Power Source is the **SLIDE-JOINT**

Point: Element Properties dialog

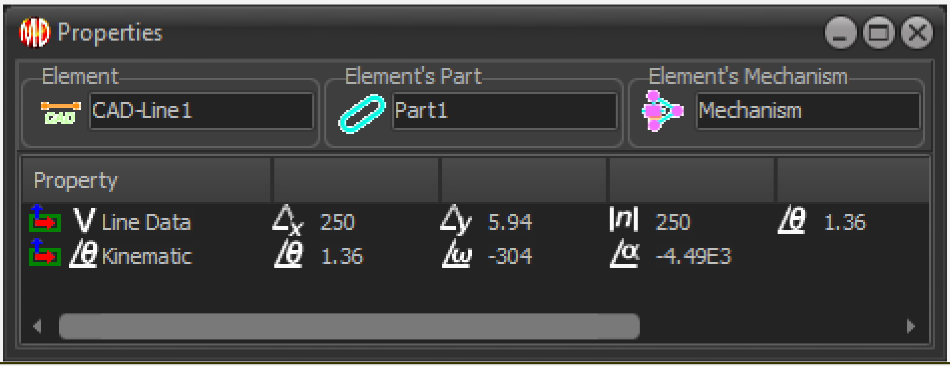


CTRL + Click a Point

Properties: (P - Position ; V- Vectors)

- **P Part Pos**: Position of the Point; Part Coordinates
- **P Mech Pos**: Position of the Point; Mechanism Coordinates
- **P Glob Pos**: Position of the Point; Global Coordinates (Z does not show!)
- **V Velocity, V Acceleration**
    - **i,j:** the coordinates of the Velocity / Acceleration Vector, X and Y directions; Mechanism Coordinates
    - **|n|:** the magnitude of the Velocity / Acceleration Vector
    - **Θ:** the direction of the Velocity / Vector

Line: Element Properties dialog



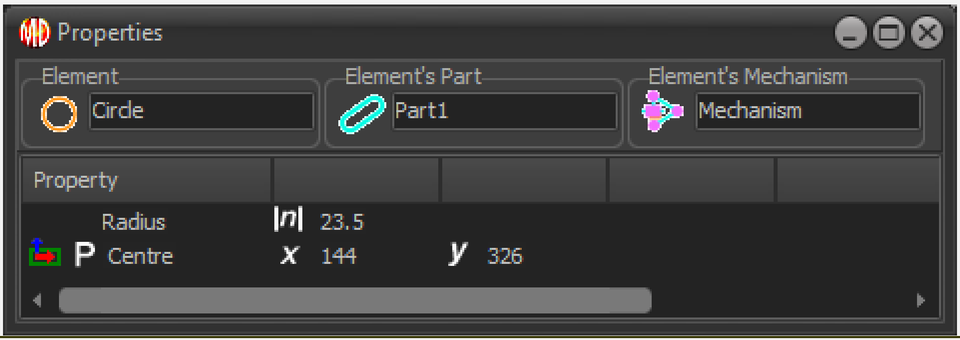
CTRL + Click a Line.

Property: (V- Vectors)

- Line Data:
    - Δx, Δy : the change in x and y from the LINE'S START-POINT and END-POINT
    - |n|: the length of the LINE
    - Θ: the angle of the LINE in the Mechanism-Plane
- Kinematic:

- ○ Θ: the angle of the **LINE** in the Mechanism-Plane
- ○ ω : angular velocity of the **LINE**
- ○ α : angular acceleration of the **LINE**

Circle: Element Properties dialog

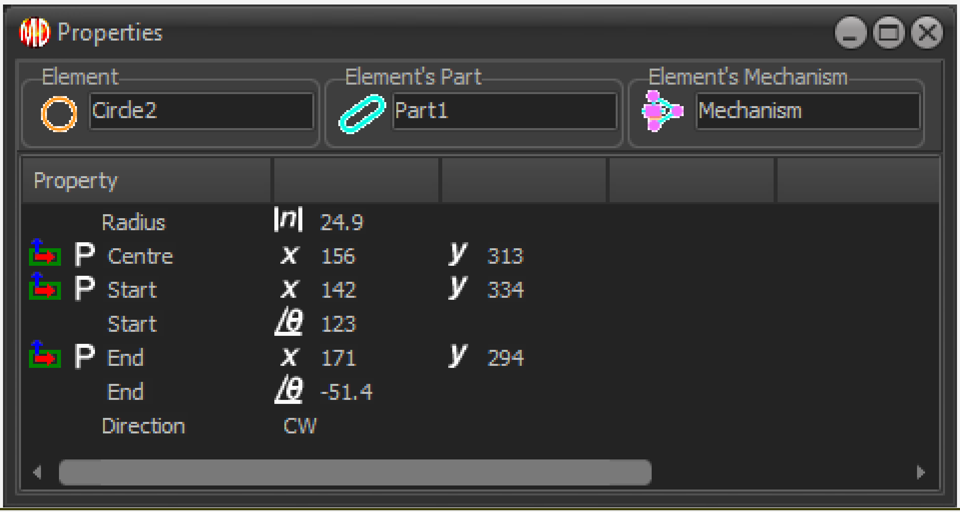


CTRL + Click a Circle.

Property: (P - Position)

- **Radius:**
  - ○ |*n*|: the Radius of the **CIRCLE**
- **center:**
  - ○ x and y : the position of the center of the **CIRCLE** in Mechanism Plane

Arc: Element Properties dialog



CTRL + Click an Arc.

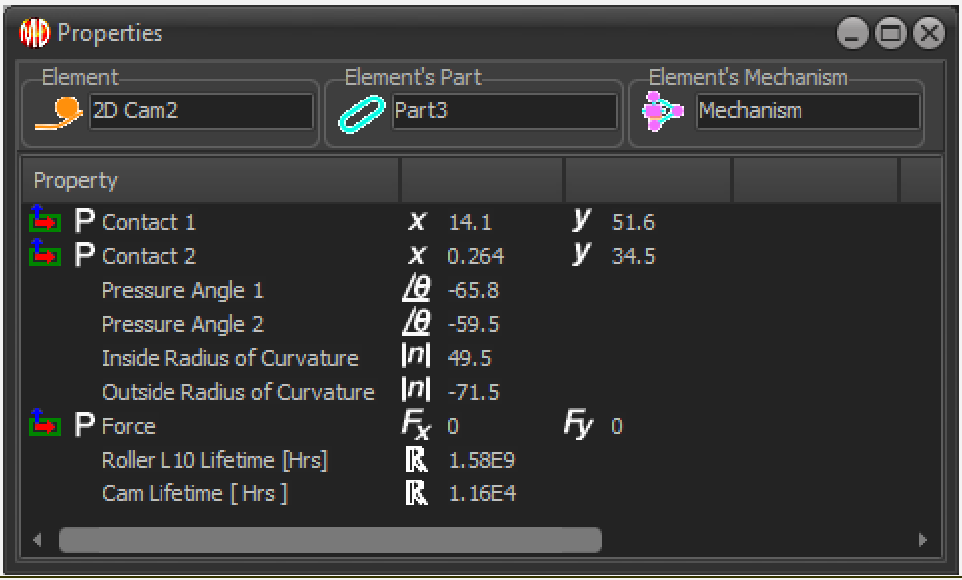
Property: (P - Position)

- **Radius:**
  - ○ |*n*|: the Radius of the Circle
- **center:**
  - ○ x and y **:** the position of the center of the **ARC** in the Mechanism-Plane
- **Start**

- **x** and **y** : the position of the **START-POINT** of the **ARC** in the Mechanism-Plane
- **Θ** : the angle of the **START-POINT** from the center of the Arc

- **End**
  - **x** and **y,** the position of the **END-POINT** of the **ARC** in the Mechanism-Plane
  - **Θ** : the angle of the **END-POINT** from the center of the **ARC**

Cam: Element Properties dialog



CTRL + Click a 2D-Cam.

Property: (P - Position)

Contact 1 and **2:**

- **x** and **y***:* the coordinates of the contact between the Inner and Outer Cam-Profiles and the Follower-Profile.

Pressure Angle 1 and **2:**

- ***Θ*** *:* the Pressure Angle of the Follower-Roller with the Inner and Outer Cam-Profiles

Curvature 1 and **2:**

- |*n*| *:* the Radius of Curvature of the Inner and Outer Cam-Profiles

Force

- **Fx** and **Fy** *:* the Contact Force of the Cam on the Roller, given in the X and Y directions, with Mechanism Coordinates

If you have selected a **Follower-Roller** and **Steel Type** for a **2D-CAM** with the **2D-CAM DIALOG**:

Roller L10 Lifetime [Hrs] - Lifetime in Hours of the Follower-Roller, Lubrication Conditions, and Factor-of-Safety that you select in the 2D-CAM DIALOG 411.

Cam Lifetime [Hrs] - Lifetime in hours of the Cam-Profile (Outer or Inner), with the Steel Type, Heat-Treatment, Quality, Hardness, and Factor-of-Safety that you enter in the **2D-CAM DIALOG**.

1.5.11.59 Dialog: Select Elements

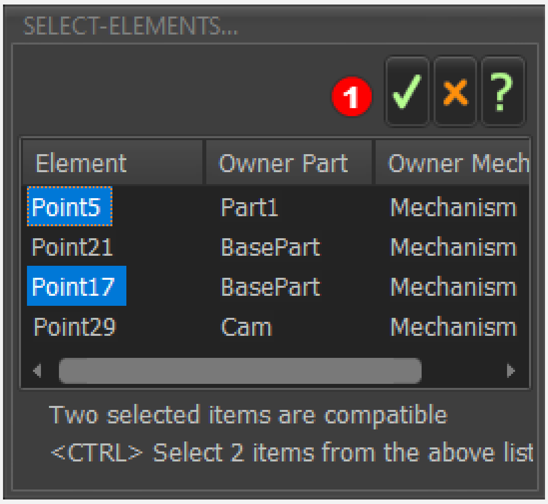
Select Elements

If, when you select elements to do a command, there is ambiguity as to which ELEMENT(S) to actually use for the command, the **SELECT ELEMENTS DIALOG** opens automatically.

It lists all of the elements that you select, including the POINTS you want to select.

You must CTRL + Click all of the elements you need to do the command.

Select-Elements dialog



Select-Elements dialog

In the **SELECT-ELEMENTS DIALOG:**

1. 

+ Click **ALL** of the elements you need to do the command.

The ✓ is colorized only after you select the elements that are compatible with the active command.

2. Click ✓ to close the **SELECT-ELEMENTS DIALOG**

If the **COMMAND-MANAGER** is also active:

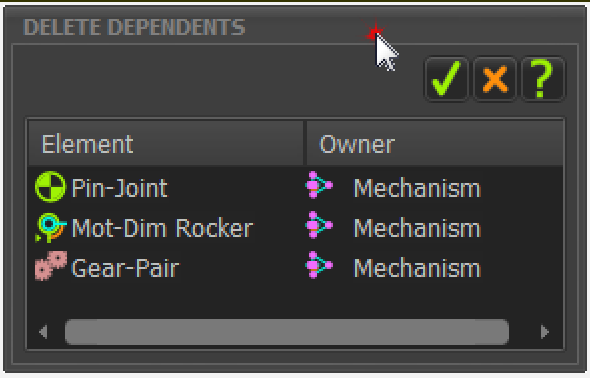
3. Continue to select the elements, as required.

and / or

4. Click ✓ in the **COMMAND-MANAGER** to complete the command.

1.5.11.60 Dialog: Delete Dependent Elements

Delete Dependent Elements



Warning for Delete Dependents

Many elements **depend on (need) other elements**

The **Delete Dependents dialog** is a warning to you that, if you want to delete an element, you will also delete one or more other elements.

You can:

- **Delete element and Dependents**- click the ✓ button

OR

- **Cancel Delete** - click the ✗ button

For example:

When you add a **PIN-JOINT**, you select two **POINTS** in two different **PARTS**.

If you want to delete the one of the **POINTS** that needs the **PIN-JOINT**, you are warned that you also delete the **PIN-JOINT**.

1.5.11.61 Dialog: View References

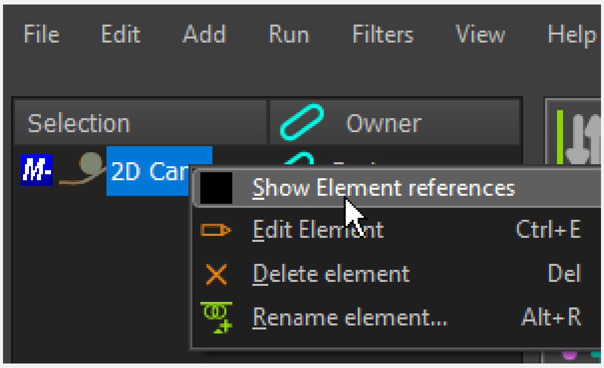
Show Element References

See also: Delete Dependent Elements 617

Many elements reference, or need, other elements.

Show Element References is a list of those elements that a more complex element needs.

For example, when you add a PIN-JOINT, you select one POINT from two different PARTS. Therefore, the **Reference Elements** of the PIN-JOINT are the two POINTS.



Selection--Window: Right-Click

To Show **Element References** for an element:

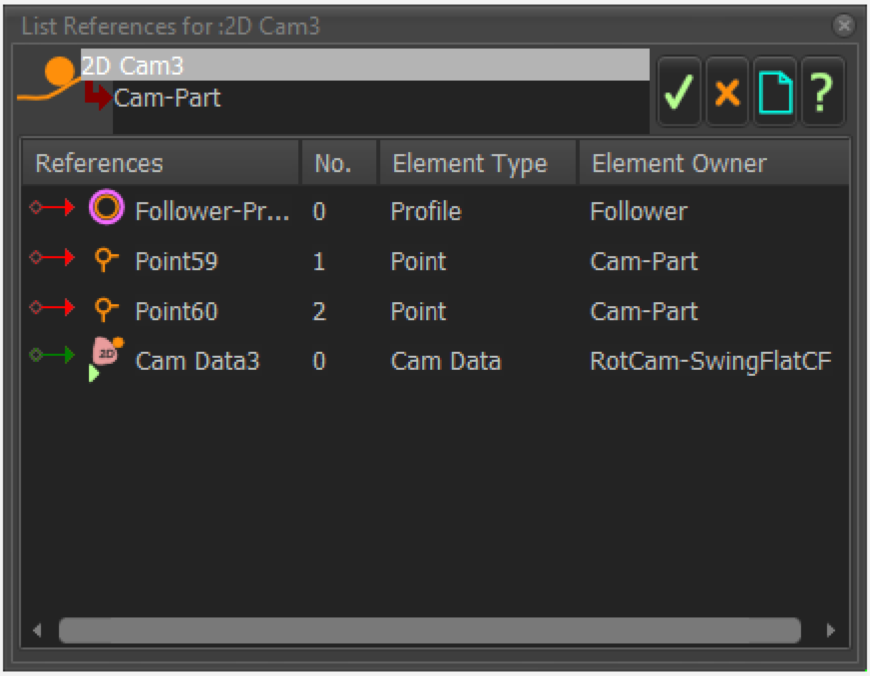
1. Click an ELEMENT in the graphics-area, or the ASSEMBLY-TREE

The element should be in the SELECTION-WINDOW.

Right-click the ELEMENT in the SELECTION-WINDOW

2. Click **Show Element References** in the shortcut menu

The **List References for: element-name** shows.



EXAMPLE: Element References for a 2D-Cam

The example shows the:

- **Reference Element name**
- **Number**
- **Reference Element Type**
- **Reference Element Owner**

1.5.11.62 Dialog: Tutorials

Download Tutorials

To open the Download Tutorials dialog

	File toolbar > Download Tutorial Videos
	File menu > Download Tutorial Videos

Download Tutorials dialog

When the Download Tutorials dialog opens:

1. Click a video on the left of the dialog.

If this is the first time you have downloaded that video. please wait until it downloads to your hard drive.

If, at a different time, you click to play the same video, it should play immediately from your hard drive.

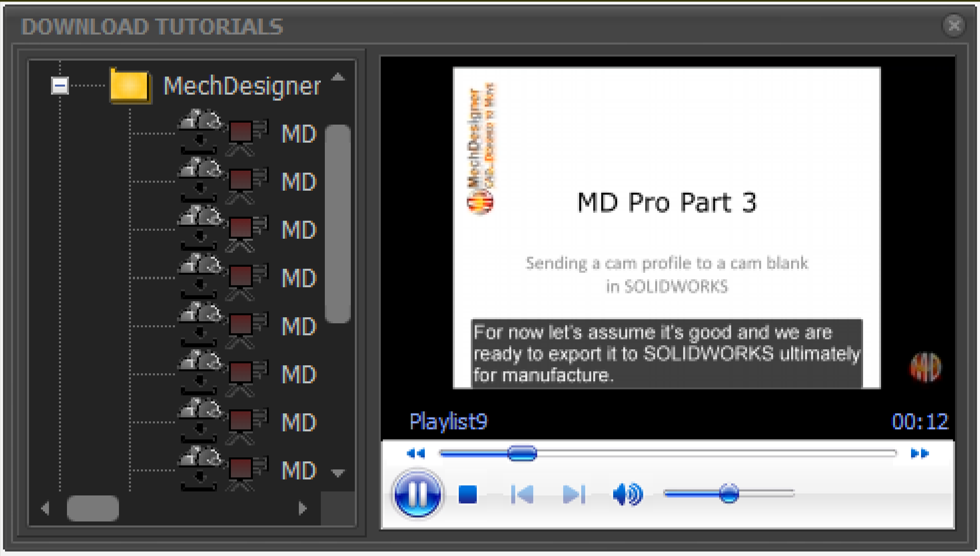
Video display too small?

If the video dialog is too small, drag the right and bottom sides of the dialog to increase its size.

Where do the Videos download to?

The default path is **<LocalAppData> \ Tutorials\ *.mp4**

To change the download path, see Application-Settings > General tab > File Options separator > Tutorial Video Directory[341].



Download Tutorials dialog

1.5.12 How to... and FAQs

How to... and FAQs

1.5.12.1 General: How to and FAQs

General FAQs

1.5.12.1.1 How to...

How to...?

1.5.12.1.1.1 ... edit, save, and move my Styling

How to edit your Settings, Styles and Theme.

We can use the term "**Styling**" for the **Style**, **Theme**, and **Settings**.

Each time you exit **MechDesigner**, we save for you your **Styling** to **MechDesigner.INI** and **MechDesigner.XML.**

MechDesigner uses the **Styling** automatically the each it starts.

Styling Definitions:

Theme :	**Border, Icon, and dialog colors** **To select a Theme:** **1.** Edit menu > Application Settings : General tab > THEME SETTINGS > Target Theme **2.** Select a theme from: Windows, **Charcoal Dark Slate**, Aqua Light Slate, Windows10 Dark, Tablet Dark, Slate Classico, Windows10 Slate Gray, Windows 10. This help uses **Charcoal Dark Slate**. **3.** Exit and Restart **MechDesigner**.
Style :	**To Load a Style** 1. Click the *Load* button to open: **Dark.XML** - use with dark themes, for example, Charcoal Dark Slate. **Light.XML** - use with light themes, for example, Aqua Light Slate. **my-style-name.XML** - a style you have saved previously. **To Save a Style** 1. Click the *Save* button to save 2. Save the changes you have made to **my-style-name.XML**. **Do NOT overwrite Dark.XML or Light.XML.**
Application Settings :	**Other settings that become part of your Styling:** **1.** Application-Settings > Graphics tab > **DISPLAY COLORS** **2.** Edit icon-sizes, number-formats, and colors for different element types

---

Note:

<CommonAppData> is usually **C:\ProgramData\PSMotion** If you cannot see **C:\ProgramData** ... then, in Windows File Explorer©:

a) Click the **View** tab

b) Click the **Hidden Items** check-box in the **Show/hide** group-box.

Save your Styling

To save your styling:

1. Edit menu > Application-Settings : Click the *Save* button at the bottom of the dialog.
2. Save your styling to e.g.: **<CommonAppData>\Style\my-style-name.XML**

   DO NOT OVERWRITE the **Dark.XML** or **Light.XML** styles in this path.

Move your Styling

To move your styling:

On the workstation with the "**Styling**" that you want to move:

1. Save your **Styling** - see above 625
2. Exit **MechDesigner**
3. Navigate to **<CommonAppData>\PSMotion\style**
4. Copy and Paste to a memory stick or network drive: **my-style-name.XML**
5. Navigate to **<LocalAppData> e.g. C:\users\<username>\AppData\Local\PSMotion\IniFiles**
6. Copy and Paste to a memory stick or network drive: **MechDesigner.INI** and **MechDesigner.XML.**

On the destination workstation:

1. Navigate to **<LocalAppData> e.g. C:\users\<username>\AppData\Local\PSMotion\IniFiles**
2. Copy and Paste from the memory-stick or network drive: **MechDesigner.INI** and **MechDesigner.XML**
3. Navigate to **<CommonAppData> e.g. C:\documents\ProgramData\PSMotion\style**
4. Copy and Paste from the memory stick or network drive: **my-style-name.XML**

Load the styling:

1. Start **MechDesigner**
2. Click Edit menu > Application-Settings : Click the *Load* button, at the bottom of the dialog.
3. Explore to **<CommonAppData>\PSMotion\style**
4. Find and load **My-style-name.XML**

The **Theme**, **Style** and **Settings** are now the new "**Styling**", which will load automatically as defaults.

1.5.12.1.1.2 ... deselect the active command

How to deselect the active command.

Usually, you cannot edit an element when there is an active command to add an element.

You must deselect the active command before you can edit an element.

To deselect a command:

1. Right-click you mouse

OR

1. Click the ESC key on your keyboard

OR

1. Start a new command

1.5.12.1.1.3 ... open a dialog

Edit an element - open the element's dialog

To edit an element, you must open the element's dialog. There are many methods.

With each method, you must select the element. You can select the element in three places:

- Graphics-Area
- Assembly-Tree
- Selection-Window

It may be helpful to use a **Selection-Filter** to filter for the type of element you want to edit.

See Selection-Filters 68

How to open a dialog:

Do one of these methods:

Method 1: Use the Selection-Window

1. Click the element you want to edit (see also the **SHIFT-CLICK** exception below) in the graphics-area or the **ASSEMBLY-TREE**

   The element is now in the **SELECTION-WINDOW**
2. Right-click the element in the **SELECTION-WINDOW**

   A shortcut menu shows next to your pointer
3. Click **Edit element** in the shortcut menu

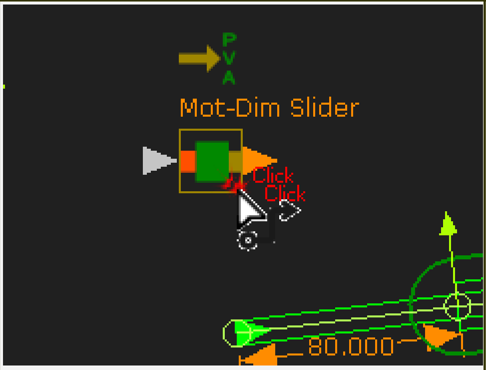
   The element's dialog opens.

Method 2: Double-Click the element

Summary:

To open the dialog, double-click **one** element in the:

- Graphics-Area
- **ASSEMBLY-TREE**
- **SELECTION-WINDOW**



Double-click in the graphics-area

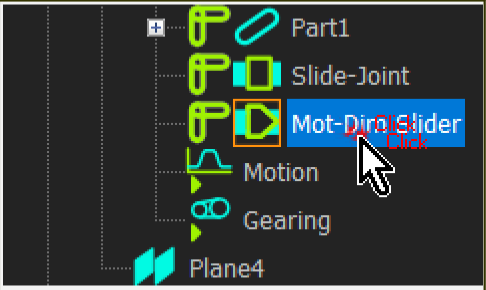
EXAMPLE: EDIT A MOTION-DIMENSION FB

Double-Click in the graphics-area

1. Move your mouse-pointer above the ELEMENT so that **only** the element you want to edit changes color to the Selection Color (see Application-Settings > Graphics tab[345] > Display Colors)
2. Double-click the element

If it is difficult to double-click **only** the element in the graphics-area:

- Use Selection Filters[68] to filter for the element type you want to edit.
- Use Display Filters to hide other element types

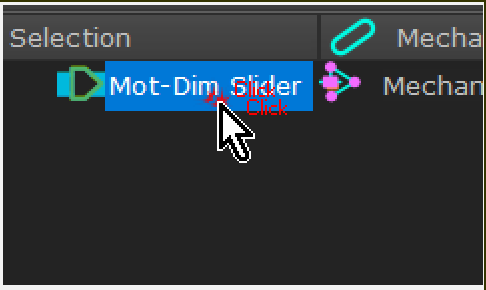


Double-Click in Assembly-Tree

OR

Double-click in the Assembly-Tree

1. Double-click the ELEMENT in the ASSEMBLY-TREE.



Double-Click in Selection-Window

OR

Double-click in the Selection-Window

1. First, click the ELEMENT in the graphics-area or the ASSEMBLY-TREE one time so that it shows in the SELECTION-WINDOW.

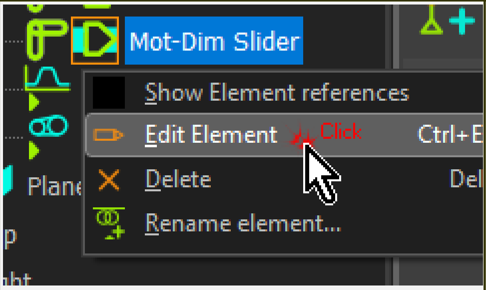
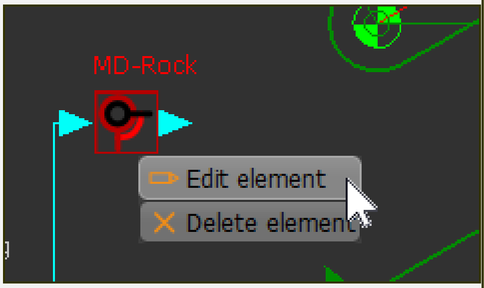
When the ELEMENT is in SELECTION-WINDOW,

2. Double-click the ELEMENT in the SELECTION-WINDOW.

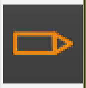
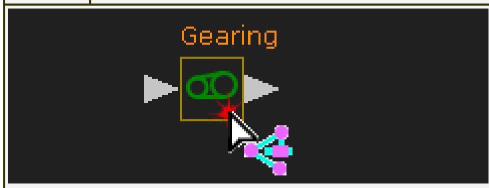
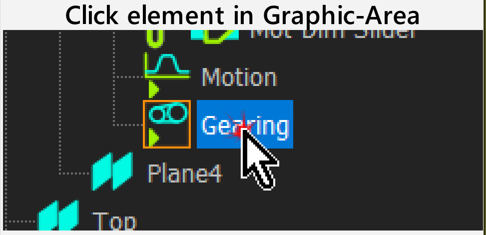
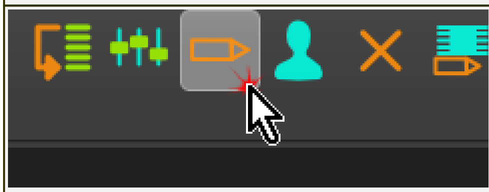
Method 3: Right-Click the element

Summary:

1. Right-click the ELEMENT in the SELECTION-WINDOW, the ASSEMBLY-TREE and graphics-area
2. Click **Edit-Element** in the shortcut menu.

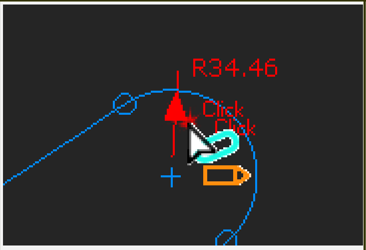
 Click, then Right-Click in Assembly-Tree	**EXAMPLE: EDIT A MOTION-DIMENSION FB** **In the Assembly-Tree:** 1. Click to select the ELEMENT in the ASSEMBLY-TREE 2. Right-click the ELEMENT In the shortcut menu: 3. Click **Edit Element**
 Right-click in the graphic-area	**In the graphics-area:** 1. Click the graphics-area to deselect all elements 2. Hover + Right-click an ELEMENT. The shortcut menu shows. In the shortcut menu: 3. Click **Edit Element**

Method 4: Edit toolbar > Edit Element tool

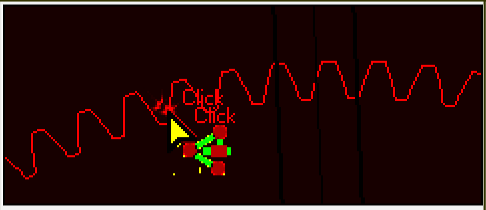
	You must pre-select the element you want to edit. 1. Click the element you want to edit in the SELECTION-WINDOW, ASSEMBLY-TREE or graphics-area 2. Click Edit toolbar > Edit Element icon
 Click element in Graphic-Area  Click element in Assembly-Tree	For example: To edit a GEARING FB: 1. Click the GEARING FB in the SELECTION-WINDOW **OR** 1. Click the GEARING FB in the graphics-area **OR** 1. Click the GEARING FB in the ASSEMBLY-TREE
 Click 'Edit-Element' icon in Edit menu	Then 2. Click Edit toolbar > Edit Element The GEARING-FB DIALOG is now open.

Special Cases:

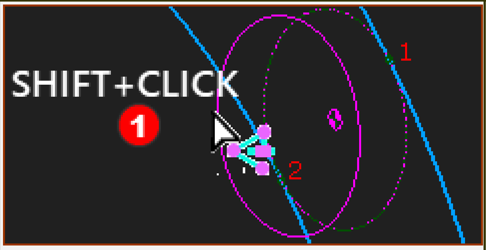
To edit a dimension in the Part-Editor

 Double-click Arrowhead	1. Make sure you **deselect** all other commands. Frequently, **Add Dimension** is the active command. You must deselect it. E.g click the ESC key on your keyboard. 2. Double-Click the **arrowhead** of a DIMENSION to open the DIMENSION DIALOG If you try to click the dimension **number** - **R34.46** in the image to the left - **MechDesigner** does not respond.

To edit a Gear-Pair or 2D-Cam

	When you click a GEAR-PAIR or 2D-CAM, it is possible to click **four** ELEMENTS: • the GEAR-PAIR (or 2D-CAM) - select it in the SELECTION-WINDOW • a POLYLINE - you can only add or update the shape of a POLYLINE • a PROFILE and EXTRUSION - you can only edit the EXTRUSION

To edit an Extrusion

 Shift-click a Profile	To edit an EXTRUSION that you cannot see, but you can see its PROFILE or AUTO-PROFILE. 1. **SHIFT-CLICK** the PINK PROFILE ELEMENT The PROFILE AND EXTRUSION ELEMENTS are now in the SELECTION-WINDOW. 2. Right-click the EXTRUSION ELEMENT in the SELECTION-WINDOW 3. Click **Edit element** in the shortcut menu.

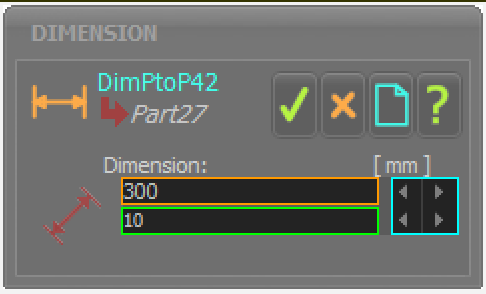
Reasons you cannot edit an element

You cannot edit an ELEMENT when: • A different dialog is open. **Close all other dialogs.** (ALT+F4 if you cannot see the dialog). • You **double-click** two or more elements. You open none or one dialog. • A command is active, in the COMMAND-MANAGER. You must complete or cancel that command. • You cannot edit the element - for example, a SLIDE-JOINT

1.5.12.1.1.4 ... edit a Parameter in a dialog

Edit a parameter in a dialog

In this example, the parameter-name is **DIMENSION** in the **DIMENSION DIALOG**, and the parameter-value is **300**.

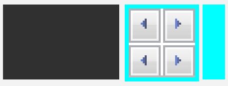


Dimension dialog

In the image, I have added three colored boxes.

PARAMETER-VALUE - the value in the data-box.

Spin-Increment - the change to the PARAMETER-VALUE each time you click a **Spin-Box arrow** - see Spin-Box tool[632]



Spin-Box tool: see more Spin-Box tool[632]

If you cannot see the **Spin-Box tool:**

Double-click, with your mouse-pointer in the data-box, to toggle from show to hide, and then from hide to show the **Spin-Box**.

Double-click to hide Spin-Box

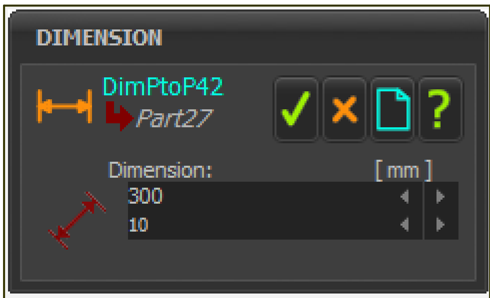
< > Double-Click

Double-click to hide Spin-Box

How to edit parameters in a dialog.

There are three different methods to edit a value in a parameter box.

Method 1: Keyboard

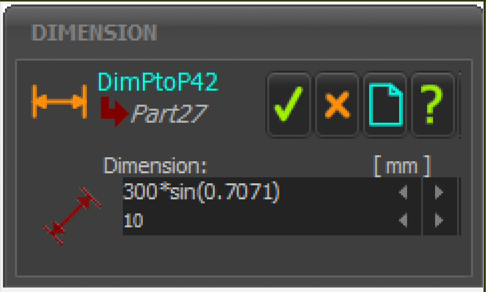


Dimension dialog-box

Enter a value directly:

1. Use your keyboard to enter a value in the data-box
2. Press the **Enter** key (↵) on your keyboard to update the parameter to the new value

You must press the **Enter** key.



Equation in Dimension box

Enter a value as a symbolic equation:

1. Use your keyboard to enter a symbolic-equation in the data-box
2. Press the Enter key (↵) on your keyboard to update to the new value

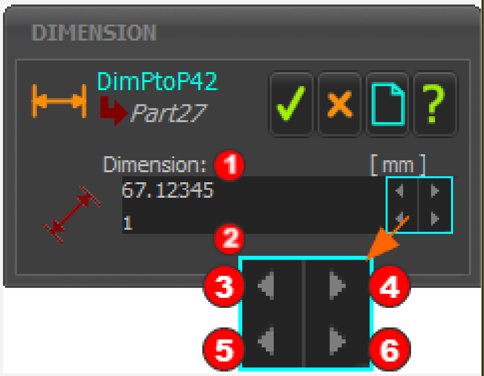
You must press the Enter key.

SYMBOLIC PARAMETERS FOR AN EQUATION:

- **Simple Arithmetic**: +, −, *, /
- ^ (power), **Sqrt()**
- **Trigonometric** (Angles are Radians): pi, Sin(), Cos(), Tan(), Sinh(), Cosh(), Tansh(), ArcSin(), ArcCos(), ArcTan2(;)

Method 2: Spin-Box tool

Spin-Box arrowhead buttons (in the CYAN-BOX)



Spin-Box tool

❸ **Top, Left arrowhead**:

Subtract the **Spin-Increment**❷ from the PARAMETER-VALUE❶

❹ **Top, Right arrowhead**:

Add the **Spin-Increment**❷ to the PARAMETER-VALUE❹

❺ **Bottom, Left arrowhead**:

Divide the **Spin-Increment**❷ by 10

❻ **Bottom, Right arrowhead**:

Multiply the **Spin-Increment**❷ by 10

EXAMPLE:

Edit the PARAMETER-VALUE

Click the Top, Left arrowhead❸

PARAMETER-VALUE - **Spin-Increment (1)** = new PARAMETER-VALUE

67.12345 – 1 = 66.12345

Click the Top, Right❹ arrowhead two times:

PARAMETER-VALUE + **Spin-Increment** + **Spin-Increment** = new PARAMETER-VALUE

66.12345 + 1 + 1 = 68.12345

Edit the Spin-Increment

Click the Bottom, Left arrowhead❺

Spin-Increment / 10 = new **Spin-Increment**

1 / 10 = 0.1

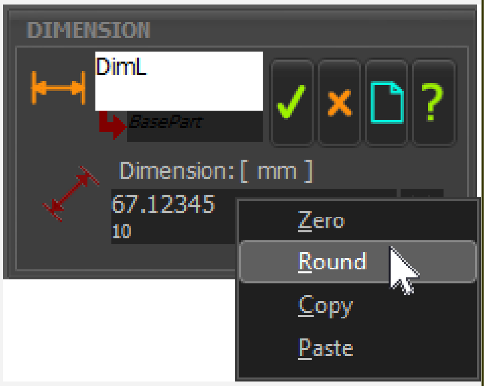
Click the Bottom, Right❻ arrowhead two times:

Spin-Increment * 10 * 10 = new Spin-Increment

0.1 * 10 * 10 = 10

WARNING: The model re-builds each time you click the top arrowhead buttons in the **Spin-Box tool**. If the model is complex, it can take a long time to update the model.

Method 3: Zero / Round / Copy / Paste



To see the Zero / Round / Paste / Copy shortcut menu:

Right-click with your mouse-pointer inside the parameter box

- **Zero** - the parameter-value changes to zero(0), or the smallest possible value for the parameter.
- **Round** - the parameter-value changes to the nearest value that is exactly divisible by the **Spin-Increment**

  In the image, the Spin-Increment is 10. Therefore, the parameter value will change from 67.12345 to 70.

- **Copy** - to copy the parameter-value to your clipboard.
- **Paste** - to paste your clipboard to the parameter-value.

1.5.12.1.1.5 ... rename an element

See **Rename dialog** 335

1.5.12.1.1.6 ... save the elements to a DXF file

The elements you can save to a DXF file.

It is possible to save the layout of these elements in a MECHANISM-EDITOR to a DXF file.

- PART and BASE-PART XY-axes
- CAD-LINES, CIRCLES, and ARCS sketch-elements in each PART (NOT SPLINES or BLEND-CURVES)
- 2D-CAMS (as line segments)
- POLYLINES of 2D-GEARS and GEAR-PAIRS (as line segments)

To save a DXF of the Mechanism-Editor:

1. Select the ASSEMBLY-TREE
2. Select the MECHANISM-EDITOR you want to save as a DXF file

Before the next step, make sure that the MECHANISM element is in the **Selection-Window**.

3. Select File menu > Save as

The **Save as type** should already be set to DXF

4. Enter a file name for the DXF file.

To save a DXF of a Part

1. Select the ASSEMBLY-TREE
2. Select the PART you want to save as a DXF file

Before the next step, make sure that the MECHANISM element is in the **Selection-Window**.

3. Select File menu > Save as

The **Save as type** should already be set to DXF

4. Enter a file name for the DXF file

To save a Gear-Pair to the DXF file

You must add a POLYLINE to the GEAR-PAIR -see MD-Solids> Add / Update Polyline 246

Then save the MECHANISM or PART elements to a DXF file - see above

---

1.5.12.1.2 FAQs

FAQs

1.5.12.1.2.1 What are the system requirements?

System Requirements

Operating System :	Windows 10, 11 64-bit **only**
PC Memory (RAM) :	Minimum 8GB Recommended: 16GB and more
Hard Drive Space :	Minimum: 20GB of available space Recommended: 100GB or more - keep your hard drive healthy. Recommended: SSD - Solid State Disk
Graphics Card :	High-performance Graphics-Card GPU OpenGL 3.5+ Minimum: 2GB VRAM Recommended: 16GB VRAM.
Screen Resolution :	Minimum : 1920 × 1080 Recommended : 4K (3840 × 2160)
Windows DPI Setting :	If Screen Resolution is 1920 × 1080 , then set to 100% If Screen Resolution is 4K, then set to Windows DPI to 150%. Shortcut for Display-Settings: Right-click Windows Desktop, select Display settings.

Windows Permissions

Installation :	**Administrator Rights.**
Download Help : **Download Tutorials :**	**Administrator Rights** to download the **Local Help** and **Tutorials** with the **Help menu** 1. Right-click the **MD** application open 2. Click **Run as Administrator** in the shortcut-menu
General Running :	**Administrator Rights** are not needed. However, you do need an internet connection. ***MechDesigner*** occasionally checks your license with CopyMinder.

Software Protection

We use **CopyMinder®** for our software protection. When you buy **MechDesigner**, we email you a **Product Key.**

You need the **Product-Key** to run **MechDesigner** the first time, or to move **MechDesigner** to a different computer.

If you have a **Network-License** (also called a **Floating-License**), your I.T. department should install **MechDesigner.** I.T. should keep the **Product Key**.

1.5.12.1.2.2 Why are there so many files with the same file-name?

Why so many CXL and MTD files?

If you use Windows Explorer or File Explorer to find your model, you may find many files with the same name, but different file extensions.

Question:

Why so many files?

Answer:

The **CXL** and the **MTD** are the last saved or the active model in RAM.

The other files are backup files.

For example, if the number of backup files is 3, you can see:

- **CXL.3** & **MTD.3** (oldest), **CXL.2** & **MTD.2**, **CXL.1** & **MTD.1** (most recent).
- **~CXL** and **~MTD**, which we replace with the active model files (**CXL** & **MTD)** every number of commands.

To control the number of backups, auto-save, and number of commands between each auto-save:

- Application-Settings > General tab > FILE OPTIONS > : MAXIMUM # BACKUP FILES.
- Application-Settings > General tab > FILE OPTIONS > : ENABLE AUTO-SAVE
- Application-Settings > General tab > FILE OPTIONS > : # COMMANDS TO AUTO-SAVE

WARNING : You overwrite the original model with each **Auto-Save.**

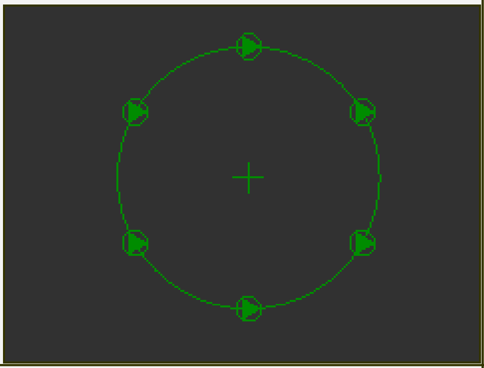
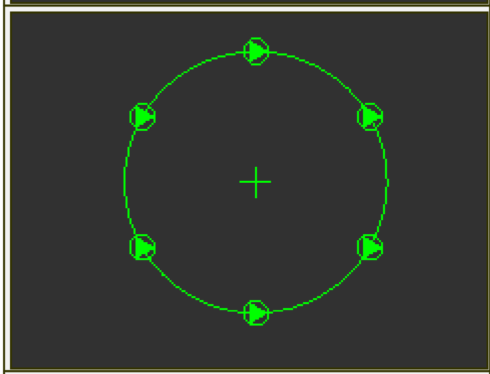
1.5.12.1.2.3 Why is it taking a long time to add elements?

Tips for Working with Large Models:

- Disable **Auto-Rebuild**[49]. Then experiment. You can continue to add many elements successfully when rebuild is not active**.** Use Rebuild-Now[49] every 4-5 commands to rebuild.
- Number-of-Steps[351] : Make 90 steps, or even less. You do not need many steps as you build the model.
- Disable Show Solids in Mechanisms[66] : You do not need to show the SOLIDS to add elements, to review the kinematics, or to calculate Forces.
- Image Quality[345] : If you must show **MD-SOLIDS**, then experiment with the Image-Quality. Do this when there are many **SOLIDS** in the model.
- Spin-Box tool[632]. Do **not** use the Spin-Box tool. The model re-calculates with each click of the Spin-Box. Use your keyboard to enter new values in each data- box.

1.5.12.1.2.4 Why is the model so 'dull'?

System Requirements

	Occasionally, when you open a model, the kinematic-elements are "dull". You can manually correct this with the Lighting conditions in Model Options dialog.
	You can also try this much faster method. In the Quick Access toolbar, or Visibility toolbar: Toggle on and off "**Show Solids in Mechanisms**[66]". You can see that the sketch-elements are now much brighter.

1.5.12.1.2.5 Cam-Terminology

Cam Terminology

Terms :	Definitions
Cam (or **Cam-Part**) :	The PART to which you add the (2D-CAM) to generate the shape of the **Cam-Profile.**
Cam-Shaft :	The most common **Cam-Part**. It is a **rotating-Part** (a shaft), to which you add the 2D-CAM (or 3D-CAM) as a **Cam-Profile**. A **Cam-Shaft** usually rotates with a constant angular-velocity.
Cam-Profile :	The Cam-Flank and surface that is an extrusion of a 2D-CAM (or 3D-CAM) which is in continuous contact with the **Follower-Profile**.
Track-Cam or **Groove-Cam :**	A groove that is cut into a **Cam-Blank** with an Outer and an Inner **Cam-Profile**. A **Follower-Roller** fits in the groove.
Follower (or **Follower-Part**) :	The PART that supports the **Follower-Profile**.
Follower Kinematic-Chain (or **Kinematic Mechanism**) :	The **Follower-Part** and the other PARTS that you join to the **Follower-Part**, to move the **Tooling** or **Tool-Part**.
Follower-Profile :	The surface of a machine component that is rigidly connected to the **Follower-Part**. The surface is in continuous contact with the **Cam-Profile**.
Follower-Roller :	A **Follower-Profile** that is cylindrical or barrel-shaped that is rigidly connected to the **Follower-Part**.
Flat-faced Follower :	A **Follower-Profile** that is a flat surface that is rigidly connected to the **Follower-Part**.
Translating Follower :	A **Follower-Part** that that moves along a straight axis.
Reciprocating Motion :	A **Translating Follower** with a non-progressive motion.
Rotating Follower :	A **Follower-Part** that rotates about a fixed axis.
Oscillating Motion :	A **rotating-Part** with a non-progressive motion.
Progressive Motion :	A motion, usually followed by a Dwell, that moves the **Follower-Part** progressively in one direction.
Non-Progressive Motion :	A motion that returns the **Follower-Part** to its original position after each machine cycle.
Indexing :	A **progressive motion**, usually rotating.
Indexer :	A device whose input is a constant-speed (usually) **Cam-Shaft** and output is a rotating-Part with a **progressive motion**. The input rotates one time to index the output one time. The index-angle is such that 360º/(Index-Angle) is an integer.
Cam-Blank :	The material from which you cut the shape of the **Cam-Profile**.

1.5.12.2 Model Editor: How to... and FAQs

Model-Editor FAQs

1.5.12.2.1 How to stop Solids turning red

How to stop Solids turning Red as your mouse-pointer moves over them.

In the **MODEL-EDITOR**, **SOLIDS** turn to the Selection-Color as you mouse-over them (default color in Application-Settings > Graphics tab 57)

To stop this, filter for an element that is **not** in the **MODEL-EDITOR**.

For example, **Filter for Points**. **POINTS** are not in the **MODEL-EDITOR**, and therefore **SOLIDS** are not selected as you move your mouse-over them.

See Filters menu (Filters toolbar) > Filter Points 68 .

1.5.12.2.2 I cannot SHIFT+Drag to Spin or CTRL+Drag to Pan the model

You will find you cannot **Spin** or **Pan** your model with the **Drag technique** if your mouse is above an element such that it changes to the **Selected-Color**.

Make sure your mouse-pointer (cursor) is not above any other element before you **Mouse-Button-Down** to start to drag.

Note:

We recommend you use your keyboard arrow-keys (up-down-left-right) to Spin the model - **see more : Keyboard shortcuts 26 .**

1.5.12.3 Mechanism Editor: How to... and FAQs

Mechanism-Editor: How to ... and FAQs

How to ...

FAQs

Troubleshooting

1.5.12.3.1 How to...

How to...

1.5.12.3.1.1 ... connect Function-Blocks with wires

How to connect Function-Blocks:

Double-click to watch Video Clip

1.5.12.3.1.2 ... show Velocity & Acceleration Vectors

How to show Velocity and Acceleration Vectors

You can show the Velocity and Acceleration Vectors of any moving **POINT** *.

The **POINT** must be a child to a kinematic-chain that is kinematically-defined.

To show the Velocity or Acceleration Vectors:

1. Edit the **POINT** to open the Point Properties dialog. 543

See How to edit an element 627

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* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**, **MOTION-POINT**

1.5.12.3.1.3 ... edit a 2D-Cam, Gear-Pair, or Profile

How to edit a 2D-Cam / Gear-Pair with Polyline and Profile elements.

When you add a **POLYLINE** to a **2D-CAM*** and then add a **PROFILE** to the **POLYLINE****, there are three coincident elements.

This topic describes how to edit, update, and delete these elements so that their shapes are coincident.

---

* **2D-CAM** and **GEAR-PAIR**, throughout this topic, unless noted otherwise.

** There is also an **EXTRUSION** as a child to the **PROFILE** element.

Element 1: **2D-CAM** (or **GEAR-PAIR**)

The shape of the **2D-CAM** is a function of the motion and geometry of the **Follower**.

If you edit a parameter that changes the shape of the **2D-CAM**, the **POLYLINE** does **NOT** automatically change its shape.

To update the shape of the **POLYLINE**, you must do **Add / Update Polyline** again - Solids menu > Add / Update Polyline[246].

The **PROFILE** updates to the new shape of the **POLYLINE** automatically.

If you delete the **2D-CAM**, the **POLYLINE** and **PROFILE/EXTRUSION** elements remain in the graphics-area.

Element 2: **POLYLINE**

If the shape of the **2D-CAM** changes, do **Add Polyline** again to update its shape to that of the **2D-CAM** - see Solids menu > Add / Update Polyline[246].

To delete the **POLYLINE**, you must edit the **Cam-Part**.

If you delete a **POLYLINE**, in the **PART-EDITOR**, you are warned that you will also delete the **PROFILE/EXTRUSION** elements.

Elements 3/4: **PROFILE** / **EXTRUSION**

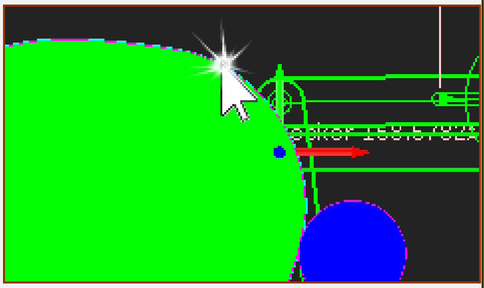
You can delete the **PROFILE**. You will also delete the **EXTRUSION**.

You cannot edit the shape of the **PROFILE** as it is controlled by the shape of the **POLYLINE**, which, in turn, is controlled by the shape of the **2D-CAM**.

You can edit the **EXTRUSION**, but not its shape - see Extrusion dialog[360].

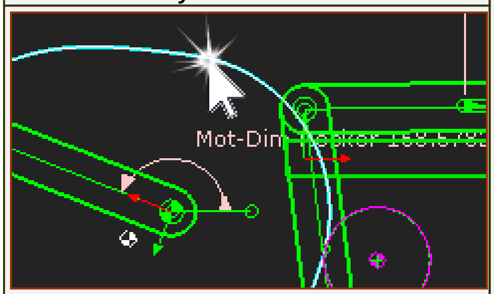
To delete an **EXTRUSION** you must delete the **PROFILE**.

To edit the 2D-Cam OR the Extrusion:



2DCam>Polyline>Profile>Extrusion

The Extrusion is visible in graphics-area .



2DCam>Polyline>Profile>Extrusion

In the graphics-area:

1. **Click** the **2D-CAM** you want to edit - or the edge of the **EXTRUSION**

All four elements (**2D-CAM**, **POLYLINE**, **PROFILE**, **EXTRUSION**) show in the SELECTION-WINDOW[310]

In the **SELECTION-WINDOW**:

2. Right-click the **2D-CAM** that you want to edit

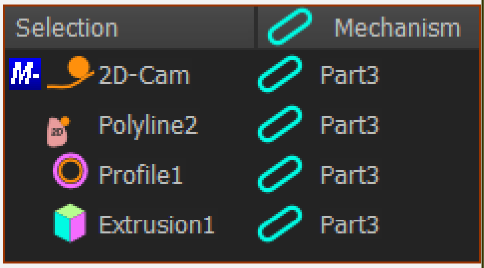
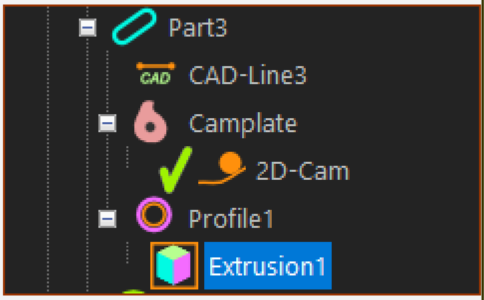
OR

2. Right-click the **EXTRUSION** you want to edit

Then:

3. Click **Edit Element** in the shortcut menu

The Extrusion is NOT visible in graphics-area.

 4 Elements in Selection-Window	In the graphics-area: 1. **SHIFT + Click** the **2D-CAM** you want to edit - or the edge of the **EXTRUSION** All four elements (**2D-CAM**, **POLYLINE**, **PROFILE**, **EXTRUSION**) show in the **SELECTION-WINDOW** 310 In the **SELECTION-WINDOW**: 2. Right-click the **2D-CAM** that you want to edit **OR** 2. Right-click the **EXTRUSION** you want to edit Then: 3. Click **Edit Element** in the short-cut menu
 Part, 2D-Cam, Profile, and Extrusion elements in the Assembly-Tree	**In the Assembly-Tree:** 1. Find and expand the **PART** element in the **ASSEMBLY-TREE** 2. Click the **2D-CAM** or the **EXTRUSION** in the **ASSEMBLY-TREE** 3. Right-click the **2D-CAM** or the **EXTRUSION** 4. Click **Edit Element** in the short-cut menu

1.5.12.3.1.4 ... edit Profiles and Extrusions

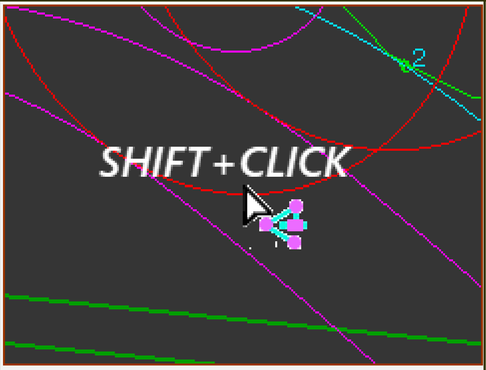
How to edit Extrusion elements

NOTE:

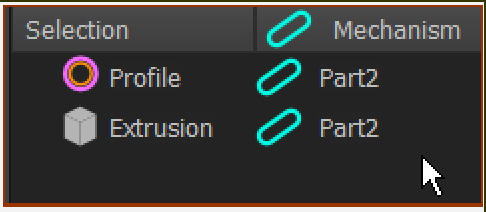
An **EXTRUSION** is a child to a **PROFILE.**

- **You can ONLY EDIT EXTRUSIONS**
- **You can ONLY DELETE PROFILES**, which also deletes its child **EXTRUSION**.

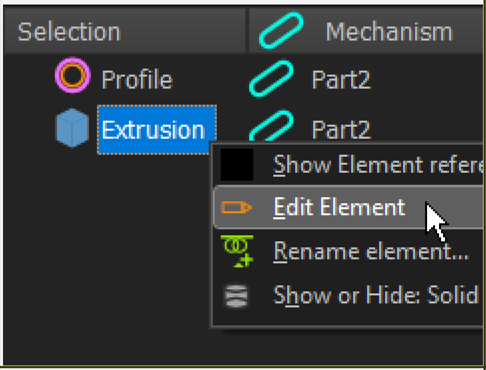
Edit the Extrusion



SHIFT+CLICK Profile element



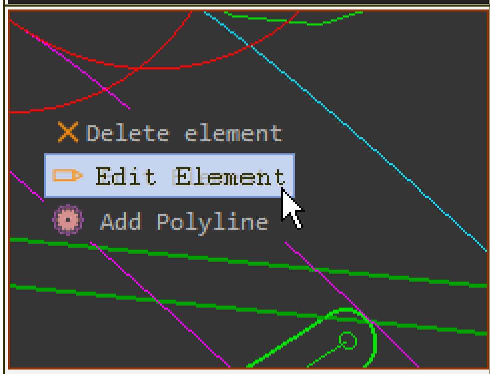
Profile AND Extrusion in Selection-Window



GRAPHICS-AREA - OPTION 1:

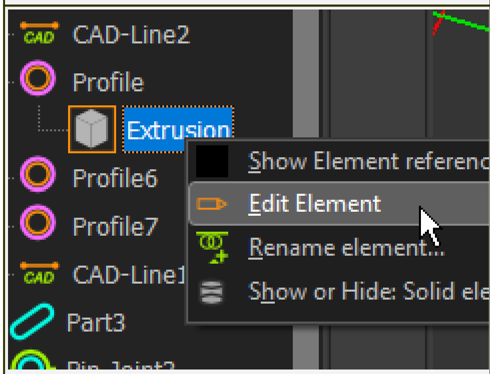
The image to the left shows **PROFILES** contours (Pink is the default color) in the graphics-area. The **EXTRUSION** is not in the graphics-area.

1. **MECHANISM-EDITOR**: Click a Mechanism **name-tab**
2. **MECHANISM-EDITOR**: Spin the View to show the Pink **PROFILE** contours in the graphics-area
3. **SHIFT+ Click** a **PROFILE**
4. **SELECTION-WINDOW**: Make sure the **PROFILE** and **EXTRUSION** show in the **SELECTION-WINDOW**
5. **SELECTION-WINDOW**: Right-click the **EXTRUSION** in the **SELECTION-WINDOW**
6. **SELECTION-WINDOW**: Click **Edit element** in the shortcut menu



GRAPHICS-AREA - OPTION 2:

1. **MECHANISM-EDITOR**: Hover + Click one **PROFILE/EXTRUSION**
2. **MECHANISM-EDITOR**: Right-Click the **PROFILE/EXTRUSION** in the graphics-area
3. **MECHANISM-EDITOR**: Click **Edit Element** in the shortcut menu



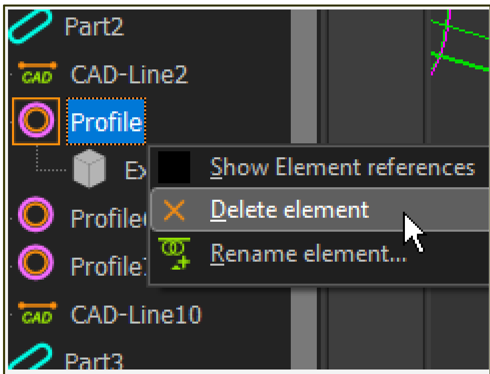
ASSEMBLY-TREE - OPTION 3:

1. **MECHANISM-EDITOR**: In the graphics-area, click the **PART** that is the parent to the **PROFILE**

In the **ASSEMBLY-TREE**, the **PART** element shows with a square around the Element icon.

	2. ASSEMBLY-TREE: Expand the tree for the PART to show the PROFILE and EXTRUSION elements 3. ASSEMBLY-TREE: Right-click the EXTRUSION 4. ASSEMBLY-TREE: Click **Edit element** in the shortcut menu

Delete a Profile?

	Delete the Profile (and the Extrusion) 1. MECHANISM-EDITOR: Click a PROFILE in the ASSEMBLY-TREE or the graphics-area The PROFILE shows in the SELECTION-WINDOW. 2. Right-Click the PROFILE 3. Click **Delete element** in the shortcut menu

1.5.12.3.1.5 ... change the assembly configuration of a mechanism

How to change the Assembly-Configurations of a Mechanism.

Mechanisms, with the same number and length of PARTS, and number and types of joints, can be arranged in different configurations.

We call this the mechanisms closures, or the **Dyad Closure**.

See : Change the Closure of a Dyad [119]

1.5.12.3.1.6 ... move a Motion-Dimension (not the FB)

How to move a Motion-Dimension that controls the position of a Rocker or Slider.

This topic is "How to move the MOT-DIM FB in the graphics-area".

You can simply drag nearly all FBs in the graphics-area. How the MOT-DIM FB behaves differently.

> To move the MOTION-DIMENSION (that is, the dimension only)
>
> CTRL + Drag the MOTION-DIMENSION FB
>
> OR
>
> To move only the FB
>
> - Drag the MOTION-DIMENSION FB

1.5.12.3.1.7 ... model a Pin in a Slot

How to model a Pin in a Slot

See INTERNET LINK MechDesigner: Getting Started Tutorial 2A: Four-Bar Kinematic-Chains STEP 2.8 Kinematic-Chains: Model a Pin in a Slot.

1.5.12.3.1.8 ... export a Cam to SOLIDWORKS

How to export a Cam to SOLIDWORKS or Solid Edge

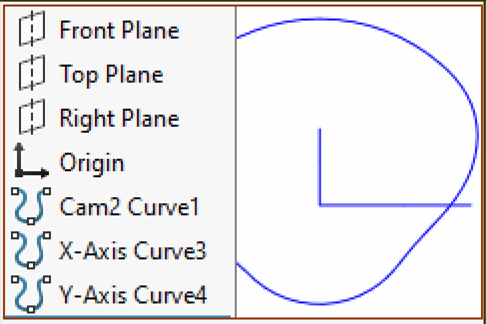
Calculate the coordinates of the cam profile with a Cam-Data FB[446].

You can calculate the cam profile as a series of Points or as a series of BiArcs.

To export the cam profile data to SOLIDWORKS from MechDesigner as a series of Points

1. Make sure SOLIDWORKS is open, and a Part document, existing or new, is the active document.
2. Open a CAM-DATA DIALOG
3. Link a 2D-CAM to the CAM-DATA FB
4. Calculate the Cam-Coordinates at EQUAL INCREMENTS of the Master Machine Angle - say 360 for a typical plate size of cam
5. Click the "Send to SOLIDWORKS" button in the Cam-Data FB toolbar

The data in SOLIDWORKS is a Curve feature.



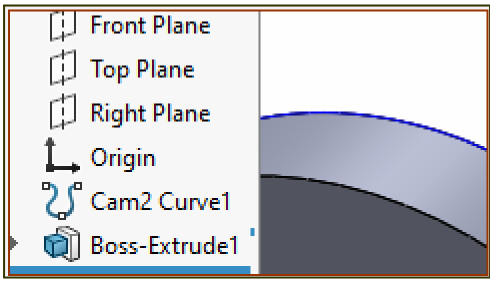
The Curve feature is on the XY-Plane, which is the Front View in SOLIDWORKS.

Note: To move the Curve feature to the XZ or the YZ Plane. In the CAM-COORDINATED DIALOG:

1. Save the Data as a SLDCRV file-type (in the Cam-Data FB > Save)
2. Edit the data in Excel®, and swap the X-data, or Y-data, and the Z-data
3. Save the data to NotePad®

In SOLIDWORKS:

4. Click Insert menu > Curve > Curve Through XYZ Points
5. Import the data, and close the Curve feature dialog
6. Select a Plane that is coplanar or parallel to the Curve feature
7. Start a sketch on the Plane
8. Use **Convert Entities** in SOLIDWORKS® sketch editor



9. Extrude the Curve.

You can see the Cam does not have any facets.

To import into other CAD

Open Excel®

1. Open the file, with **file-type as... *.TXT**
2. Select delimiter, as a ',' or 'tab'.

You want the 'X' and 'Y' Cam Points in separate columns.

Experiment with the import options if necessary.

3. Tidy up the data, remove headers etc.
4. Move all the data so the first X Point starts at Cell A1, and the first Y Point at B1.
5. If necessary, make the first and last X and Y points equal - you may need to add a row of data.
6. Add a Column for the Z-Axis, and fill it with Zeros (0).

Experiment as necessary.

7. If necessary, scale the Cam-Data to the units you are working in your CAD.
8. Save your data to an Excel® spreadsheet.
9. Save your Data to a NotePad® file.

You may be able to import the Excel® or the NotePad® file into your CAD.

Import Cam Data into Solid Edge

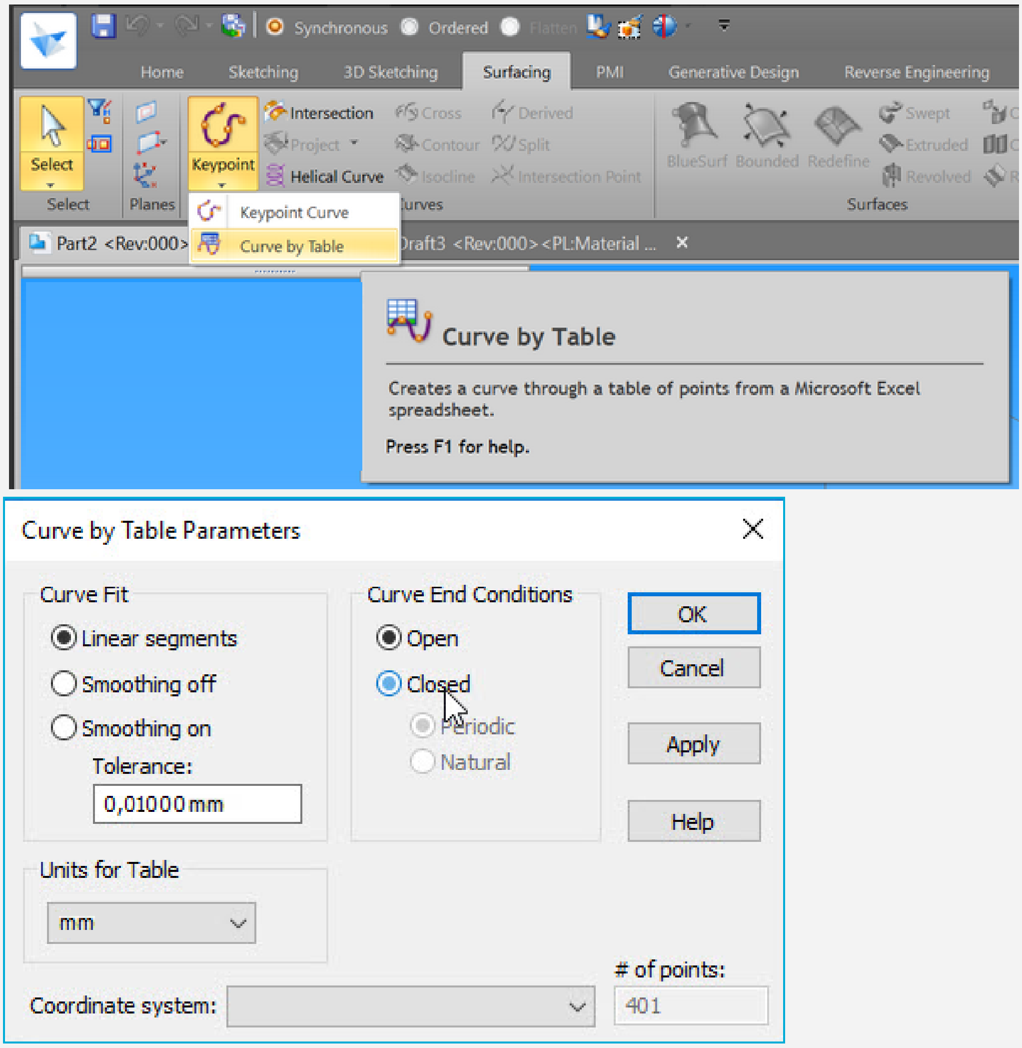
Insert Object / Curve by Table

Select:

1. Surfacing tab → Curves group → Keypoint → Curve By Table
2. On the Insert Object dialog, set the **Create from File** option and click OK.

Browse to and Open your Excel® spreadsheet

Curve by Table uses an Excel spreadsheet to define a construction curve. The spreadsheet, which is embedded in the Solid Edge document, allows you to more easily import your data.



Solid Edge: Curve by Table Parameters dialog

CURVE BY TABLE PARAMETERS

Curve Fit

- Linear Segment

  Creates line segments between the data points in the table.

- Smoothing Off

  Applies the direct curve fit method to the data points in the table. Using this method, the curve passes directly through the points.

- Smoothing On

  Applies the 'least squares' curve fit method to the data points in the table. When you select this option, you enable the tolerance drop list. Using this method, the curve path is controlled by the tolerance value and does need to touch the points.

- Tolerance

  Allows you to specify a tolerance for the Smoothing On option. It is the maximum distance the curve can deviate from the points.

Curve End Conditions

- Open

To specify an open curve. For example, the first and last data points do not touch each other or any part of the curve.

- Closed

To specify a closed curve. For example, the first and last data points can touch one another or any part of the curve. When this option is set, the Periodic and Natural options are available.

- Periodic

Connects the first data point with the last data point to make a smooth tangent closed curve.

- Natural

Creates a closed curve without a tangent condition.

Note: The **Curve by Table** feature fails if the first and last data points in the spreadsheet are coincident. If you select 'Closed', delete the last point in the table if it is coincident with the first point.

Coordinate System

Allows you to select coordinate systems to offset the curve data to. Make the coordinate system prior to creating the curve through table of points.

Number-of-points

Records the total number-of-points in spreadsheet.

Possible Problems with Curve by Table

The following are possible error messages resulting from Curve by Table:

- Invalid Geometry: Edit Feature Inputs

The data points in the spreadsheet are incorrect. Check the spreadsheet and make certain you have input at least two rows of X,Y,Z coordinates, have not skipped any cells, and have not entered data points that define a curve that runs back through itself either in 2D or 3D.

- Curve Is Self Intersecting

The curve runs back through itself in 2D or 3D. Change the data points in the spreadsheet.

- Units Set Out Of Range

The units are too large. Make sure the diameter of the model is less than five kilometers.

- Curve By Table Feature Failed

Closed and Periodic options are set on the Curve Table Parameters dialog, and the first and last data points in the spreadsheet are coincident. Change one of the coincident data points.

1.5.12.3.1.9 ... open Configure Power Source dialog

How to open the Configure Power Source dialog

You must first select a Kinematic-Chain in the **KINEMATICS-TREE**.

1. Click the **KINEMATICS-TREE** in the Element-Explorer 315

2. Click the **Kinematic-Chain** whose Power Source you want to specify

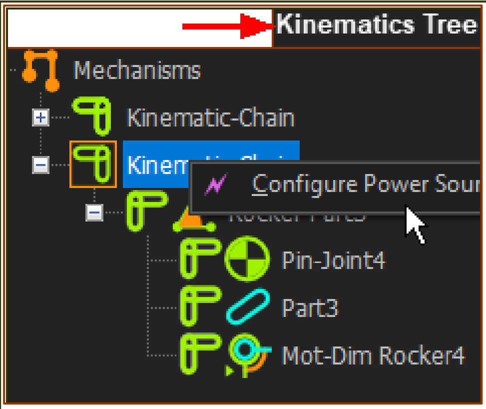
The color of the Kinematic-Chain should now be blue.

When the color of the Kinematic-Chain is blue, you can use three different methods to open the **CONFIGURE POWER SOURCE DIALOG**:

METHOD 1 : Forces toolbar / menu

1. Click Force toolbar / menu > Configure Power Source icon

METHOD 2 : Shortcut menu



Configure Power Source from Kinematics-Tree

1. Right-click the Kinematic-Chain
2. Click **Configure Power Source** in the shortcut menu

METHOD 3 : Key combination

1. Press the **ALT+P** keyboard shortcut on your keyboard.

The **CONFIGURE POWER SOURCE DIALOG** is now open.

1.5.12.3.2 FAQs

FAQs

1.5.12.3.2.1 Why can't I SHIFT+Drag to Spin (or CTRL+Drag to Pan) the model

Shift+Drag and CTRL+Drag do not work?

Occasionally, you cannot **Spin** or **Pan** your model with the **SHIFT+Drag** or **CTRL+Drag**, keys on your keyboard.

There are two possible reasons:

A. Your mouse-pointer is above an element (e.g. a **PLANE**), before you press the **SHIFT** or **CTRL DE: STRG** key.

Make sure your mouse-pointer (cursor) is not above an element before you Mouse-Button-Down to start to drag or pan.

OR

B. A bug - MechDesigner just stops responding to the keyboard and mouse controls as we expect.

We cannot find why this happens.

You must re-start **MechDesigner**.

Note:

We recommend you press the **left-arrow**, **right-arrow**, **up-arrow**, and **down-arrow keys** on your keyboard to **Spin** the model by 10º each click (or Shift + Click = 90º , Ctrl + Click = 30º)

See also : Keyboard shortcuts 26

1.5.12.3.2.2 What is a Part-Outline and why different colors?

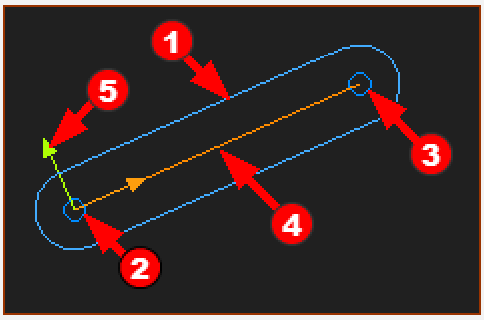
What is a Part-Outline?

The **PART-OUTLINE** is the symbol for a **PART**. You can not edit the shape of **PART-OUTLINES**.

You select **PART-OUTLINES:**

- to edit a PART with the **PART-EDITOR**
- to add a more complex element, e.g. a PULLEY.

An added PART:



Added Part: Part-Outline, and elements

❶ **An "Oval" Part-Outline**: the symbol of a PART you have added to the model.

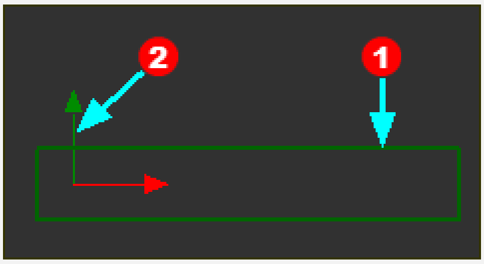
The other elements and symbols in a PART you add to the model are:

❷ **START-POINT** and ❸ **END-POINT** of the PART

❹ CAD-LINE from the **START-POINT** to the **END-POINT**

❺ **X-axis and Y-axes**: at the **START-POINT** (origin)

The BASE-PART:



Base-Part - Part Outline

❶ **"Rectangular" Part-Outline** : the symbol and shape of the BASE-PART.

❷ **X-axis and Y-axes** at the origin of the BASE-PART.

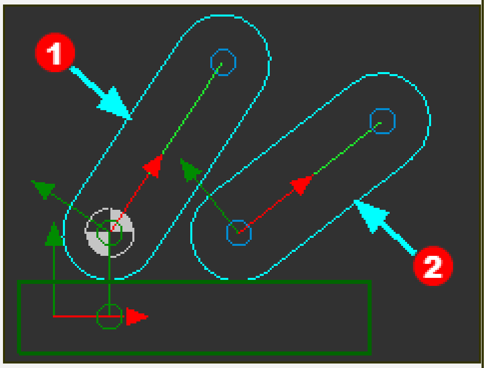
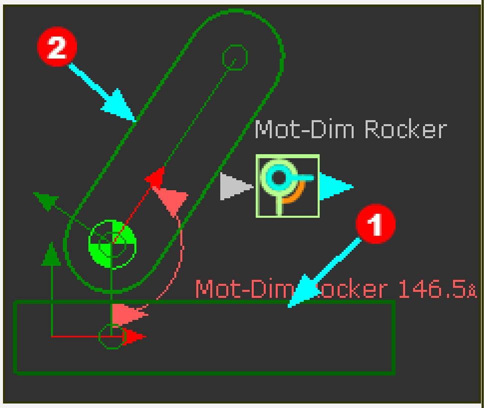
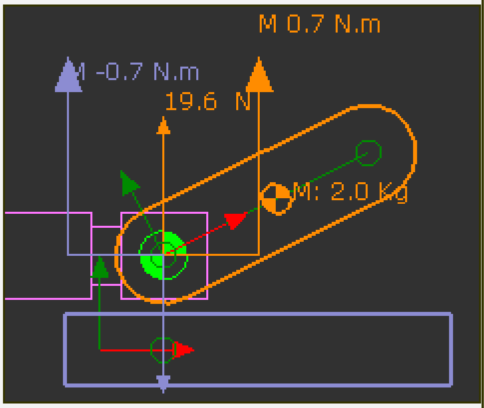
Colors of Part-Outlines

You can edit the colors of **PART-OUTLINES** for those PARTS that are **kinematically-defined** and **not kinematically-defined.**

In the Application Settings dialog 345, we use these terms:

- **"Part Solved"** for a PART that is **kinematically-defined**
- **"Part Not Solved"** for a PART that is not **kinematically-defined**

When you display Forces, we automatically change the colors of all **PART-OUTLINES** to have different colors.

 Free (1) / Completely-Free(3)	**Blue Part-Outlines - or approximately Blue.** The PART is NOT **kinematically-defined**. Blue PARTS are: • **Completely-Free**❸ - without a Joint • **Free**❶ - with a Joint, but not **kinematically-defined** • **Part Not Solved**
 2 Parts kinematically-defined	**Green Part-Outlines - or approximately Green** The PART is **kinematically-defined**. Other names for Green PARTS are: • **kinematically-defined**❶❷ • **Part Solved**❶❷ **Note:** The BASE-PART is always **kinematically-defined** and. therefore, **Green.**
 Part-Outlines : Forces Vectors	**Multi-colored Part-Outlines** Each PART has a random color when, in the Forces Toolbar[226], you: • Enable Calculate Forces[229] **AND** • Display Force-Vectors[63] The color of the **Part-Outline** is the same as the color of the **Force-Vector** that acts-on the PART.

1.5.12.3.2.3 What is the hierarchy of Extrusions?

What is the Hierarchy of Extrusion?

The Parent to Child hierarchy is as follows:

MODEL > PLANE > MECHANISM > PARTS > (sketch-loop) > (Auto) PROFILE > EXTRUSION or HOLE

There are a number of elements that must 'co-exist' to add Extrusions to model solids. It is helpful to understand the: • Commands that you need to use • Elements that **MechDesigner** adds to the model for you.

Command 1 :	**Add sketch-elements** to LINES, CAD-LINES, ARCS, CIRCLES to define the shape of a sketch-loop OR **Add Polyline** to a 2D-CAM or a GEAR-PAIR				
MechDesigner :	➔	**Sketch-Loops:** ...we recognize for you a sketch-loop			
Command 2 :		➔	**Add Profile:** You select a sketch-element that is one sketch-element in a sketch-loop		
MechDesigner :			➔	**Extrusions:** ...we add an EXTRUSION with **Add-Profile**	
Command 3 :				➔	**Add Holes:** Through EXTRUSIONS

See Tutorial 4 How to add sketch-loops 672

1.5.12.3.2.4 What does kinematically-defined mean?

What does kinematically-defined mean?

When the **Mobility** of a kinematic-chain is zero, it is **kinematically-defined**.

In summary: All PARTS in the model must be **kinematically-defined** before you should analyze any kinematic and force data.

There are two kinematic-states of PARTS.

Not kinematically-defined :	The Mobility of a PART is one or more.
kinematically-defined :	The Mobility of a PART is zero.

Mobility of a Kinematic-chain = # Degrees-of-Freedom – # Motion-Dimensions.

 # Degrees-of-Freedom of a kinematic-chain $= 3.(N-1) - 2.J$

N = Number of PARTS

J= Number of JOINTS

1.5.12.3.2.5 I cannot select the Part-Outline! What to do?

Why can I not select the Part-Outline?

With some graphic-cards, you cannot select the PART-OUTLINE easily.

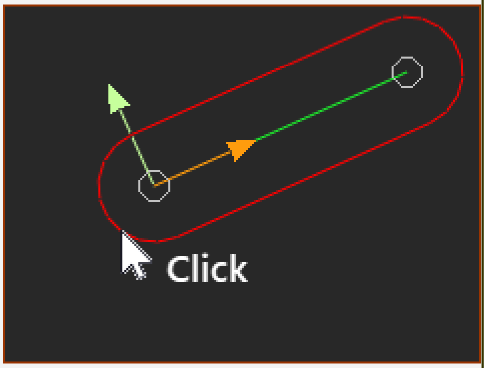
Basic Checks

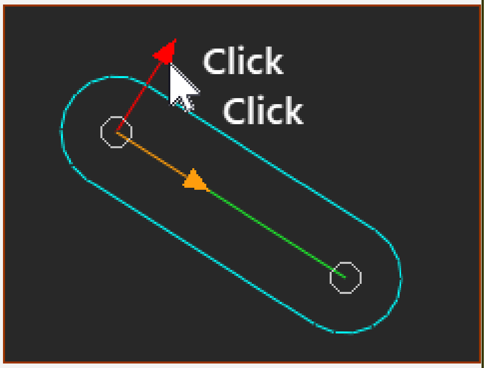
- Do you have a **Selection-Filter** selected? - See **Filters menu** > **Selection-Filters**
- Are you using an **Intel graphics-card**? - See **Help menu** > **About** > **Graphics tab** > **Graphics-Card**

  Your laptop may have two graphics-cards. If this is the case, force your laptop to use the other graphics-card (that is, NOT the Intel) when you start **MechDesigner**.

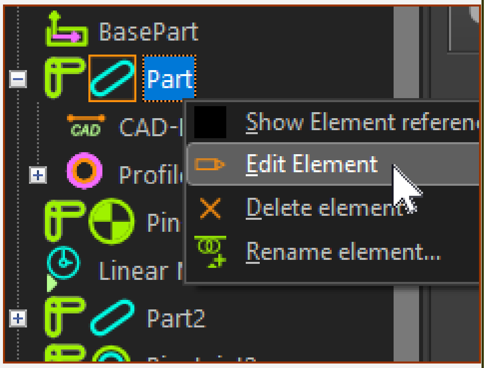
Alternative Methods

If the **Basic Checks** are not helpful, then there are three other **METHODS** to select a PART-OUTLINE, or PART.

<table>
<tr><td colspan="2">METHOD 1:</td></tr>
<tr><td>

METHOD 1: Select near start-Point.</td><td>The Arc near the Part's start-Point method
1. Move your pointer above the arc of the PART-OUTLINE - see image
2. Double-Click your mouse
or
2. Click your mouse
The PART should be in the SELECTION-WINDOW
3. Right-Click the PART
4. Click Edit element in the shortcut menu</td></tr>
<tr><td colspan="2">METHOD 2:</td></tr>
<tr><td>

METHOD 2: Double-click the Y-axis</td><td>The Y-axis method.
1. Double-click the Y-axis to edit a PART,</td></tr>
<tr><td colspan="2">METHOD 3:</td></tr>
</table>



METHOD 3: Select in the Assembly-Tree

The Assembly-Tree method.

In the **ASSEMBLY-TREE:**

1. Right-Click the **PART**
2. Select **Edit element** in the short-cut menu

1.5.12.3.2.6 What are the different 2D-Cam elements?

2D-Cam: Elements, Properties, Parameters, Analysis, Coordinates

These are the different elements and Function-Blocks you need to know, and how they are related.

Usually, do these steps

1. Add a **2D-CAM** - **see** Add 2D-Cam [128]

If the new **2D-CAM** is one of a **Conjugate-Cam pair**, or one Flank of a **Groove-Cam** (BODY-CLOSED CAM) then:

1.a. Add a **CONJUGATE-CAM FB**

1.b. Edit the **CONJUGATE-CAM FB** to add the the flanks of two **2D-CAMS** - **see** Conjugate-Cam dialog [436].

Then:

2. Select the **2D-CAM** or the **CONJUGATE-CAM** as the **Power Source** for the **Follower** - **see** Configure-Power Source [589]

Then:

3. Open the 2D-CAM DIALOG [401] to review **2D-CAM'S PROPERTIES**.

2D-CAM PROPERTIES dialog:

- Display the **INNER** OR **OUTER**, **INNER** AND **OUTER**, **PITCH-CIRCLE**
- Display Cam-Profile as **PROFILE-ONLY**, **PRESSURE ANGLE**, **CONTACT-FORCE**, **SHEAR-STRESS**
- Indicate at Contact-Point the **PRESSURE ANGLE**, **CONTACT-FORCE**, **SHEAR-STRESS**, **RADIUS-OF-CURVATURE**
- Display **COLOR**, **LINE THICKNESS** of **CAM-PROFILE**
- **ROLLER LIFE**: Edit the Roller manufacturer, Roller model, Oil/Grease Lubrication Temperature, Oil/Grease Viscosity Properties, Oil/Grease Contamination.
- **CAM LIFE**: Edit the Cam's Steel Category/Type, Steel Quality, Steel Heat-Treatment, Steel Hardness.

Then:

4. Add a **CAM-DATA FB** - **see** Add Cam-Data FB [199]

5. Link a 2D-CAM to the CAM-DATA FB - **see** [Link the Cam-Data FB to a 2D-Cam](440)

Then:

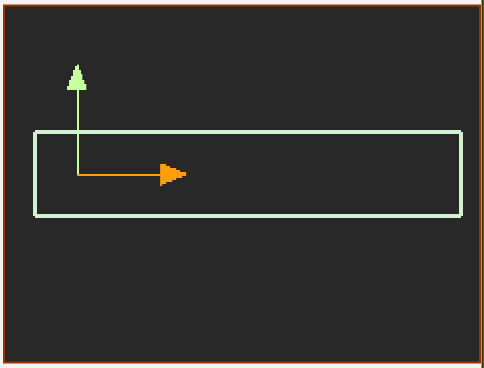
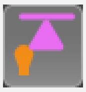
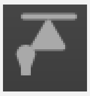
6. Connect wires from the CAM-DATA FB to a GRAPH FB to analyze 5 different parameters of the 2D-CAM - **see** [Cam-Analysis Parameters](442)
7. Calculate the Cam-Coordinates - **see** [Cam-Coordinates dialog](446)

Output-Connectors from CAM-DATA FB:	[Calculate Cam-Coordinates](446)
➔ CONTACT-FORCE ➔ CONTACT-SHEAR-STRESS ➔ RADIUS-OF-CURVATURE ➔ PRESSURE-ANGLE ➔ SLIDING VELOCITY	➔ Save as DXF, TXT, STEP ➔ Transfer Cam directly to SOLIDWORKS ➔ Save as: XY-Coordinates, Bi-arcs, STEP

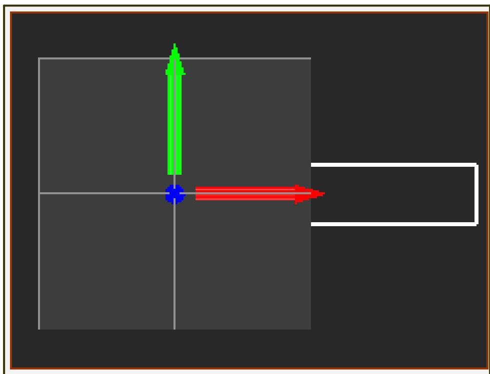
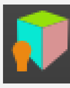
1.5.12.3.2.7 Why can I not see the Base-Part properly?

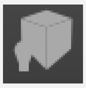
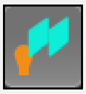
Reasons the Base-Part does not show correctly.

Why is the Base-Part not Green?

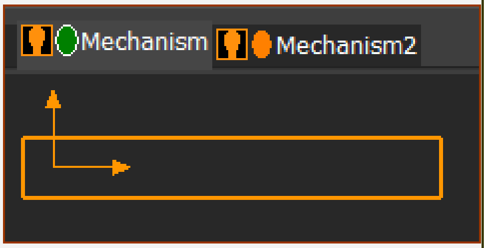
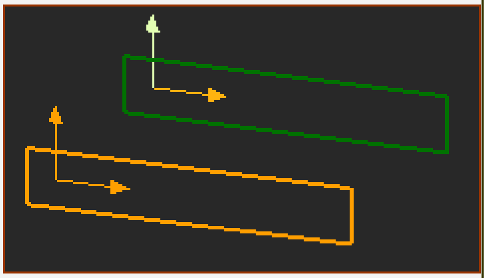
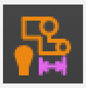
 The Base-Part is not Green!	If the BASE-PART is a not Green, it is possible that **Force-Vectors: Display** is enabled.  Force toolbar > Force-Vectors: Display is enabled 1. Click to disable **Force Vectors: Display** **RESULT**  Force toolbar >Force-Vectors: Display is disabled The BASE-PART should be Green.

Why is half of the Base-Part hidden by a Plane?

 Base-Part partial hidden by a Plane.	If the BASE-PART is partly hidden by a PLANE, then:  Visibility toolbar > Show Solids in Mechanism is enabled When you enable **Show Solids in Mechanism**, we also show PLANES. To hide PLANES, do:

	 Disable **Visibility toolbar > Show Solids in Mechanism** to hide **SOLIDS** and **PLANES**. AND / OR  Disable **Display toolbar > Display Planes** to hide Planes

Why is the Base-Part not Green?

 The Base-Part is not green.  The Part-Outline of the Base-Part is in a different Mechansim-Editor.	You can see **Kinematic and sketch-elements** of other **MECHANISM-EDITORS** when these are enabled:  Enable **Show other Kinematic and Sketch-Elements** - **(Visibility toolbar)** **Click to disable.** AND Enable **Mechanism name-tab light-bulb** in the other **MECHANISM-EDITOR** (Right-click Mechanism name-tab)

1.5.12.3.2.8 I cannot add an Angle (or Linear) Motion Dimension FB. Why?

Motion-Dimension: Commands and Elements.

You must select three elements when you add a **MOTION-DIMENSION FB** as a **Rocker**. They are:

- A **PIN-JOINT**...
- ...followed by two **LINE** sketch-elements.

However, you may find you cannot select one of the **LINES** to complete the command.

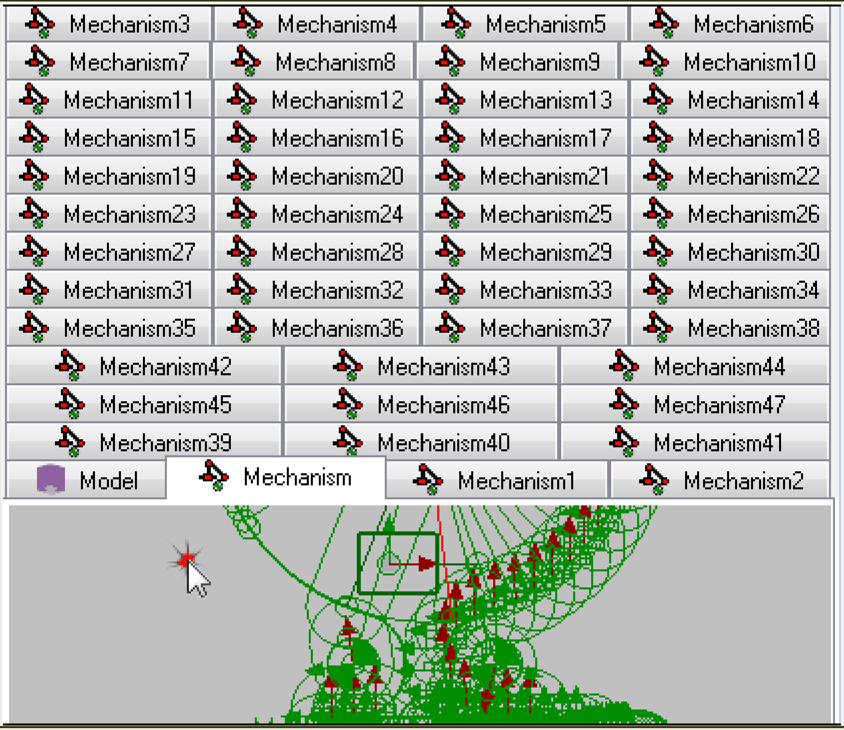
This can happen when:

- there is already a **MOTION-DIMENSION FB** at the **PIN-JOINT**
- the **POINT** at the **PIN-JOINT** is not a child to the **LINE** that radiates from the **PIN-JOINT**.
- the **PIN-JOINT** that you select is not a **PIN-JOINT** between the two **LINES** you want to select.

Read this topic: Add Motion-Dimension[179] for more details.

1.5.12.3.2.9 How many Mechanism Editors can I add?

How many Mechanism-Editors/Tabs can I add?



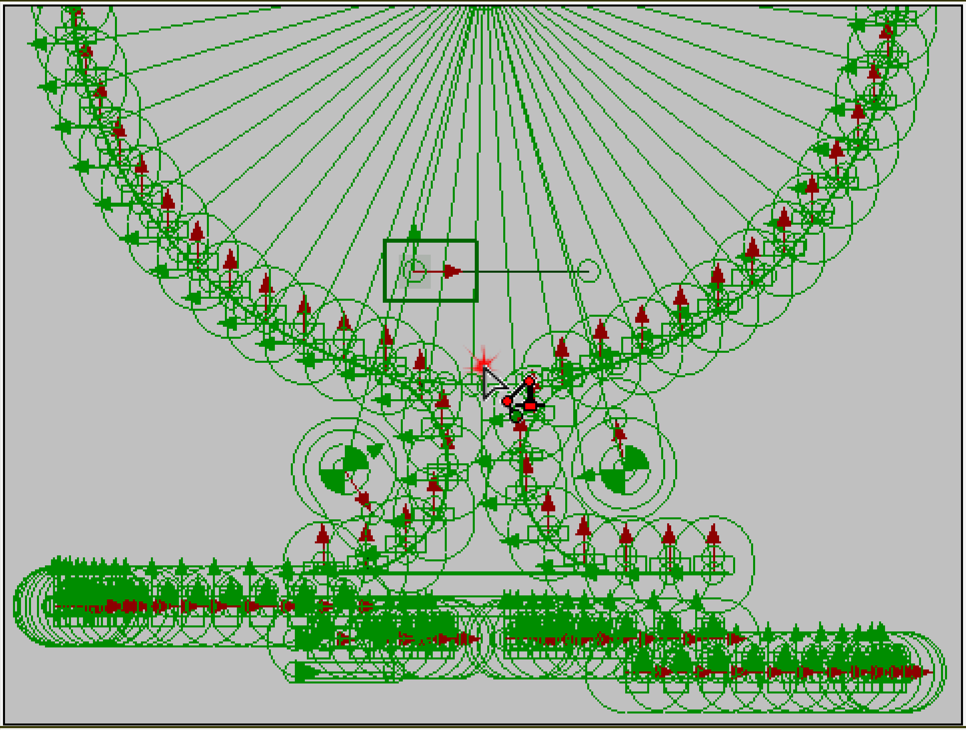
You can add as many Mechanism-Editors and Tabs to as many Planes as you like.

It is possible to design complete machines in one Mechanism-Editor. Alternatively, you can model a machine with many Mechanisms Editors, each contributing a kinematic-chain.

The model to the left shows 47 Mechanism-Editors.

1.5.12.3.2.10 How many Kinematic-Chains in a Mechanism Editor?

How many Kinematic-Chains can I add to each Mechanism-Editor?



You can add as many Kinematic-chains as you need to model your machine. Within the capacity of your PC and RAM.

For example, in the image to the left, I have modeled 160 kinematic-chains on one Mechanism-Editor - all Sliders with a Motion

1.5.12.3.2.11 Why are Graph values different in the graphics-area?

In the graphics area, we evaluate the values exactly at the Master Machine Angle.

In a Graph FB we evaluate the values at each machine-step. See Machine Settings dialog > Number-of-Steps 351.

The **Master Machine Angle** can be any angle from 0 to 360. which may not be equal to the angle of step in the machine-angle

The values that you can display in the graphics-area and plot with a Graph FB include:

- Velocity vectors
- Acceleration vectors
- Force vectors
- Torque vectors
- Angle Motion-Dimension of a Rocker
- Linear Motion-Dimension of a Slider
- 2D-Cam Radius of Curvature
- 2D-Cam Pressure Angle
- 2D-Cam Contact-Force
- 2D-Cam Contact-Stress
- 2D-Cam Sliding-Velocity

1.5.12.3.3 Troubleshooting

Troubleshooting

1.5.12.3.3.1 Profiles are not above the sketch-elements

Problem:

The position of the **PROFILE** and the **EXTRUSION** elements are not above the **sketch-loops or Polylines.**

Solutions:

Sketch-loops

1. Click the **Home** key on your keyboard, or do **Run menu > Home -** to move the Master Machine Angle to zero.
2. Open the **PART** with the sketch-loops in the **PART-EDITOR**, and then close the **PART-EDITOR** immediately.
3. Click **Rebuild Now** 50 to rebuild the model.

Polylines

1. Click the **Home** key on your keyboard, or do **Run menu > Home -** to move the Master Machine Angle to zero.
2. Click the **2D-CAM** or **GEAR-PAIR** that you want to move to the correct position.
3. Click **Rebuild Now** to rebuild the model.

1.5.12.3.3.2 Badly-Faceted Sketch-elements

Problem:

The **CIRCLE** and **ARC** sketch-elements have large facets.

Solution:

Open the **PART** with the sketch-elements in the **PART-EDITOR**, and then close the **PART-EDITOR** immediately.

1.5.12.4 Part Editor: How to... and FAQs

Part-Editor: How to... and FAQs

How to...

FAQs

1.5.12.4.1 How to...

How to...

... start the Part-Editor 259

... edit the Length of a Part 670

... delete Sketch-Elements 671

... delete Constraints 672

... add a Sketch-Loop 672

1.5.12.4.1.1 ... start the Part-Editor

How to start (open) the Part Editor

Use the **PART-EDITOR** to edit one **PART** at a time.

To edit a different **PART**:

1. Exit (close) the **PART-EDITOR** - **see also** How to exit (close) the Part-Editor 263
2. Select and edit a different **PART**.

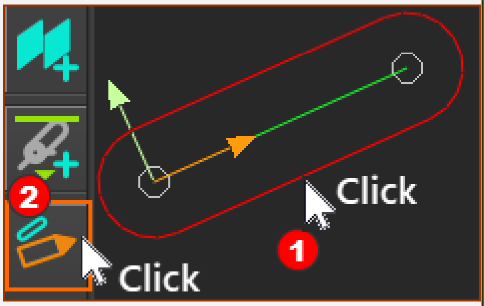
Video: How to start the Part-Editor:

Double-click to watch

How to start the Part-Editor - more details

Do one these methods.

METHOD 1: Edit-Part tool



STEP 1: Click a **PART-OUTLINE** ❶ in the graphics-area

STEP 2: Click **Edit toolbar > Edit Part** ❷ (**MD17: Toggle "Part-Editor"**)

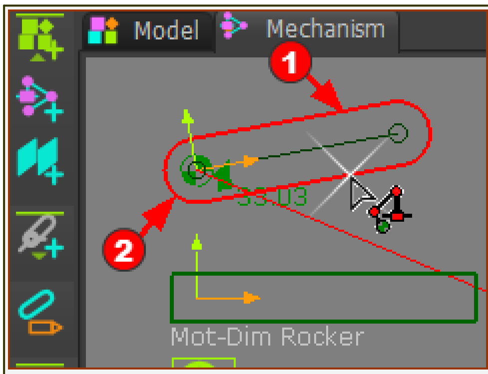
You can now use the **PART-EDITOR** to add, edit, or delete sketch-elements and constraints in the **PART-EDITOR**.

See How to delete Constraints 672

Note: The (**MD17: Toggle "Part-Editor"**) icon is to the left of the graphics-area.

See also: How to close the Part-Editor: Method 1 263

METHOD 2: Selection-Window



STEP 1: Click a Part-Outline

STEP 1: Select the Part

In the graphics-area:

1. Click the **PART-OUTLINE** ❶ (or at ❷ with some graphic-cards).

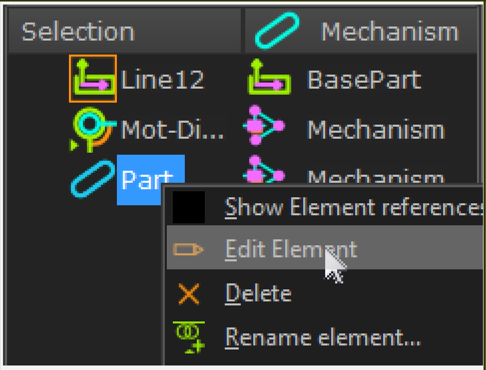
OR

Assembly-Tree:

1. Click the **PART** element

STEP 2: In the Selection-Window

1. Find the **PART** from the list of elements in the **SELECTION-WINDOW**

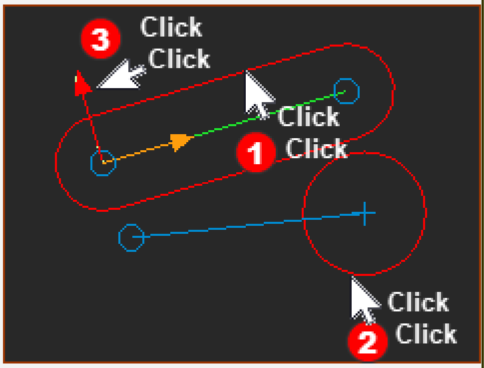


STEP 2: Right-click the Part in the Selection-Window, Click Edit element

2. Right-click the **PART** element
   In the shortcut menu
3. Click **Edit Element**

The **PART** is now open in the **PART-EDITOR**.

METHOD 3: Double-Click



Double-click a Part-Outline in the graphic-area

STEP 1:

Double-click ... in the graphics-area:

1. Double-click the **PART-OUTLINE** ❶

OR

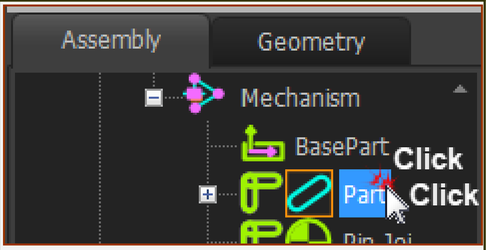
1. Double-click a **LINE**, **ARC**, or **CIRCLE SKETCH-ELEMENT**❷ that is in the **PART**

OR

1. Double-click the **Y-AXIS**❸ of the **PART**

The **PART** is now open in the **PART-EDITOR**.

OR



Double-click a Part in the Assembly-Tree

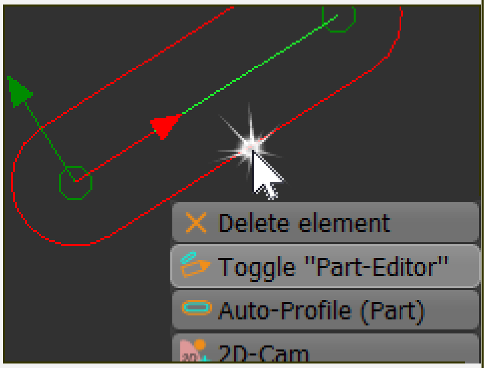
Double-click ... in the Assembly-Tree:

1. Double-click the **PART** element

The **PART** is now open in the **PART-EDITOR**.

If you double-click a:	
CAD-Line	... the CAD-Line dialog 364 opens
Blend-Curve	... the Blend-Curve dialog 549 opens
Point	... the Point Properties dialog 543 opens
More than one element	... nothing happens.

METHOD 4: Right-Click



Hover+ Right-click a Part-Outline in the graphic-area

In the graphics-area:

1. Move your mouse above the **PART-OUTLINE**

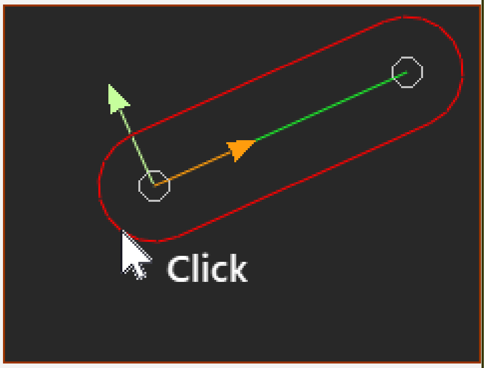
Note: With some graphic-cards, move your mouse to the arc at the end of the **PART-OUTLINE** near to the **START-POINT** of the **PART** and **CAD-LINE**.

2. Right-Click the **PART-OUTLINE**
3. Click **Toggle "Part-Editor"** (MD16: **Edit in Part-Editor**) from the shortcut menu.

The **PART** is now open in the **PART-EDITOR**.

Occasionally, there is a problem with a Graphic-Card

With **some** graphics cards, you cannot select the **PART-OUTLINE** to edit a **PART**. Try these methods:



Select the Part-Outline near start-Point.

METHOD 1: Graphics-area

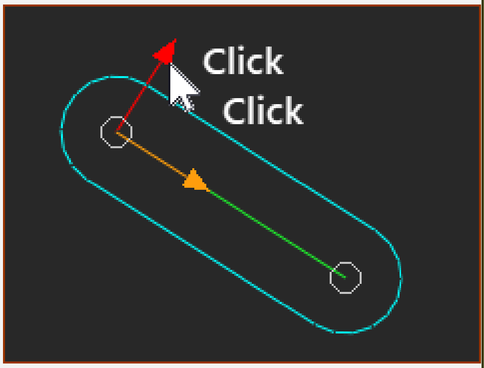
1. Move your mouse-pointer above the **arc** of the **PART-OUTLINE** near to the Part-axes -(see image)
2. Double-click your mouse

METHOD 2: Selection-Window

1. Move your pointer above the **arc** of the **PART-OUTLINE** - see image
2. Click your mouse one time.

In the **SELECTION-WINDOW**:

3. Right-Click the **PART**
4. Click **Edit element**

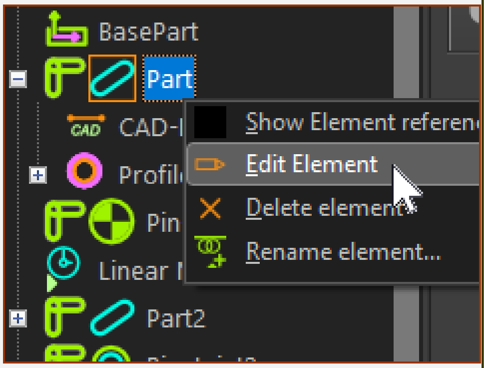


OR Double-click the Y-axis

METHOD 3:

OR

1. Double-click the **Y-axis.**

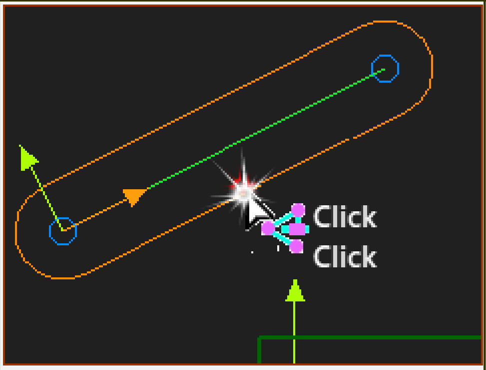
 Select a Part in the Assembly-Tree	**Method 4:** OR In the **ASSEMBLY-TREE** **1.** Right-Click the **PART** **2.** Select **Edit element** in the short-cut menu.

1.5.12.4.1.2 ... edit the Length of a Part

How to edit the Length of a Part, or to edit a Dimension

You must edit the **PART** in the **PART-EDITOR** to edit the length dimension of the **PART**.

STEP 1: Select the Part and start the Part-Editor



Part in Mechanism-Editor

There are many ways to start the **PART-EDITOR** - see here259.

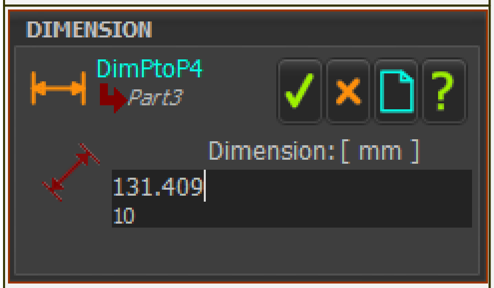
E.g.

1. Double-Click the **PART-OUTLINE** of the **PART** you want to edit

STEP 2: Edit the dimension

The length of the **PART** is the dimension of the **CAD-LINE** that is coincident with the **X-axis** of the **PART**.

Double-click arrowhead of dimension



Dimension dialog-box

1. Double-Click the arrowhead of the dimension

The **DIMENSION DIALOG** opens.

2. Enter a new dimension

There are four(4) methods you can use to enter a new value to edit the dimension:

A: Enter a new dimension with your keyboard

B: Enter an equation with your keyboard

C: Use the spin-box tool

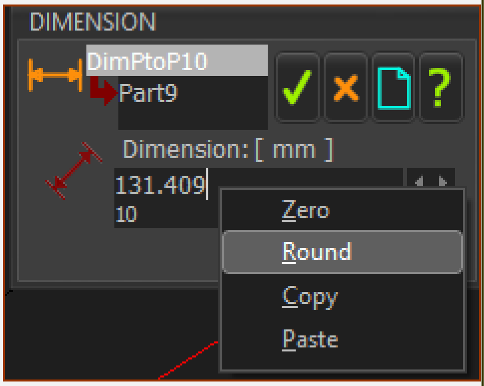
D: Right-click the data-box, then click Zero, Round, Copy or Paste.

Notes:

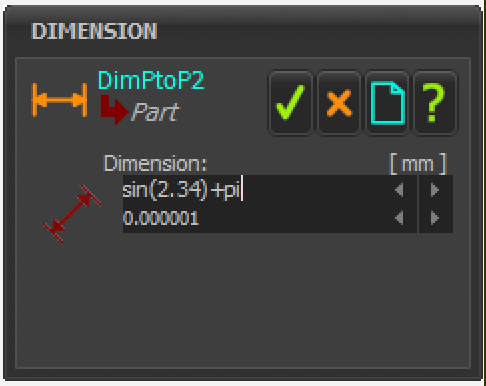
A and B: Direct and Equation: Click the ENTER key (↵) on your keyboard to update the dimension to the new value.

C: Spin-Box: The dimension AND the model updates immediately - if the model is large, there is a delay after each click.

D: Round: The dimension changes to the nearest value that is exactly divisible by the Spin-Increment.



Dimension dialog-box - contextual menu



Enter an equation for the dimension

More on EQUATIONS:

You can enter:

- **Simple Arithmetic**: +, −, *,/
- **Powers**: ^, Sqrt()
- **Trigonometric (Angle in Radians)**
  - Sin(), Cos(), Tan(),
  - Sihn, Cosh, Tansh
  - ArcSin(), ArcCos(), ArcTan2(;)

Usually 3.14159 is accurate enough for π.

1.5.12.4.1.3 ... delete Sketch-Elements

How to delete Sketch-Elements:

To delete **ONE** sketch-element - and you can select one sketch-element.

1. Click the sketch-element in the graphics-area
2. Click the **Delete** key on your keyboard

To delete **ONE** sketch-element, but you select more than one sketch-element:

1. Click the sketch-element in the graphics-area

   The element shows in the **SELECTION-WINDOW**.

2. Right-click the sketch-element you want to delete in the **SELECTION-WINDOW**

   A shortcut menu shows next to your pointer:

3. Click **Delete element** in the shortcut menu

To delete **MULTIPLE** sketch-elements:

1. Drag a window to select multiple sketch-elements in the graphics-area
2. Click the **Delete** key on your keyboard

1.5.12.4.1.4 ... delete Constraints

How to delete a sketch Constraint

You cannot see Geometric-Constraints in the graphics-area.

1. SHIFT + Click a sketch-element in the graphics-area

The sketch-element AND the constraints that you have added to it show in the **SELECTION-WINDOW**.

2. Right-click the constraint in the **SELECTION-WINDOW**
3. Click **Delete element** in the shortcut menu

Note:

If a Constraint has been added to a **Point** (a **POINT**, **START-POINT**, **END-POINT** or **CENTER-POINT**), then you must click the **Point** to see the constraint in the **SELECTION-WINDOW**.

1.5.12.4.1.5 ... add a Sketch-Loop/Sketch-Path

General definitions:

A **sketch-loop** is a closed, continuous 'string' of sketch-elements that you join end to end.

A **sketch-path** is an open, continuous 'string' of sketch-elements that you join end to end.

Merge-Points

You must **merge** the **START-POINT** or **END-POINT** of one sketch-element with the **START-POINT** or **END-POINT** of an adjacent sketch-element.

The Merge-Points command removes one **POINT** at each 'joint' between the adjacent sketch-elements.

There are two ways to merge two **POINTS**:

- Dynamically (recommended) - as you add the sketch-elements, with the Hover Technique 291
- Later - in the **PART-EDITOR** and use **Geometry toolbar** > Merge-Points 291

Why add a sketch-loop or sketch-path?

You can add a **PROFILE** to a sketch-loop.

You can add a **MOTION-PATH FB** (with a **MOTION-POINT**) to a sketch-path or sketch-loop.

Why sketch-loops fail?

Condition 1: Points are not Merged

Two **POINTS** are coincident, or just happen to be at the same position in a **PART**.

Condition 2: Branches

You CANNOT merge three or more **POINTS** into one **POINT** - for example, the ends of three **LINES** or **ARCS**.

Condition 3: Figures-of-Eight

A sketch-element cannot cross over another sketch-element in the same sketch-loop.

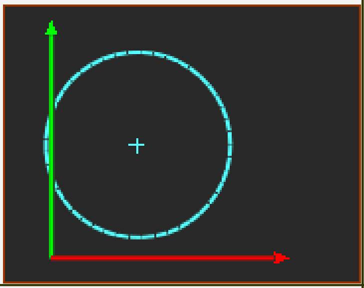
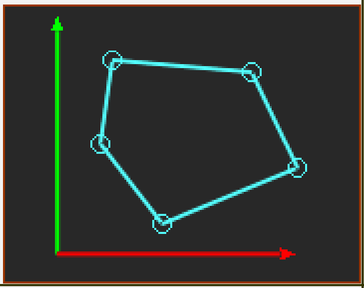
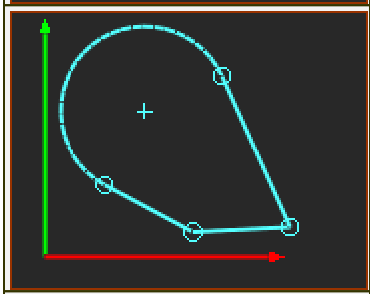
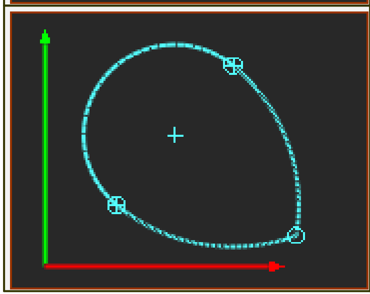
This condition does not apply to a sketch-path.

Condition 3: Zero thickness

Sketch-Loop: A sketch-element cannot touch another sketch-element in the same sketch-loop.

Sketch-Path: This condition does not apply to a sketch-path.

Example sketch-loops

	**Circle** The **CIRCLE** is a sketch-loop. After you add a **PROFILE** to the **CIRCLE**, you can use it as a **Follower-Roller**.
	**Lines** **LINES** joined, with Points merged.
	**Lines and Arcs** **LINES** and **ARCS**, with Points merged.
	**Arcs and Arcs** **ARCS** and **ARCS**, with Points merged.

1.5.12.4.2 FAQs

FAQs

How do I know I am using the Part-Editor? 676

1.5.12.4.2.1 How many Parts can I edit at one time?

How many Parts can I edit at a time?

You can edit **one** PART at a time.

To edit a different PART, you must:

1. Close the PART-EDITOR to return to the MECHANISM-EDITOR
2. Select a different PART to edit in the PART-EDITOR

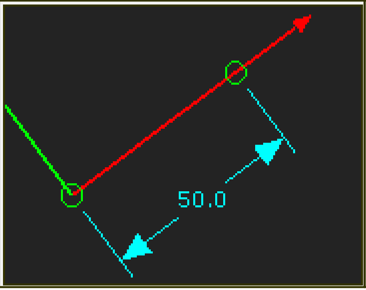
1.5.12.4.2.2 Why edit a Part?

Why edit a Part?

There are many reasons to edit a PART.

In all cases, use the PART-EDITOR to edit the PART.

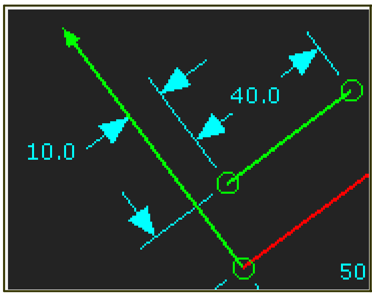
Edit the Length of a Part



Edit the PART to edit the length of the CAD-LINE, which is the length of the PART.

See also: Edit the Length of a Part 670

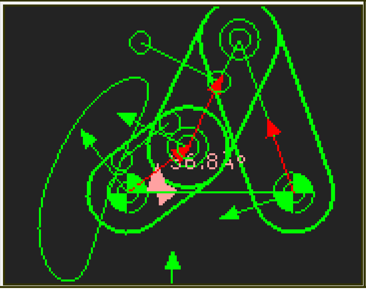
Add a Point and/or Line to locate Pin-Joints, Slide-Joints, and Ball-Joints



You can add new LINES, CAD-LINES, and POINTS to locate joints in the PART.

You MUST add a minimum of one sketch-element to the BASE-PART for a PIN-JOINT or SLIDE-JOINT between the BASE-PART and a PART you add to the model.

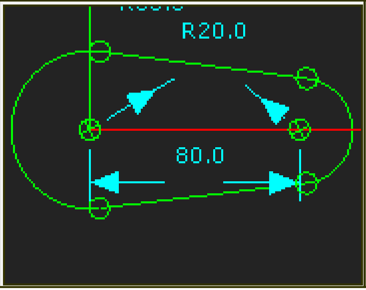
Trace Points



You can add a **POINT** to a **PART** and then view the trace of that **POINT** on the **MECHANISM-PLANE** during a machine-cycle.

See **Add Trace-Point** [122].

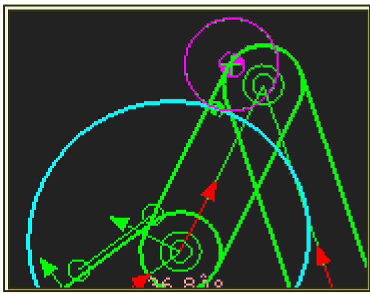
Sketch-Loops / Sketch-Paths



You must sketch a sketch-loop before you can add a **PROFILE / EXTRUSION**.

Use the **PART-EDITOR** to add the sketch-elements for the sketch-loop.

Follower-Profiles

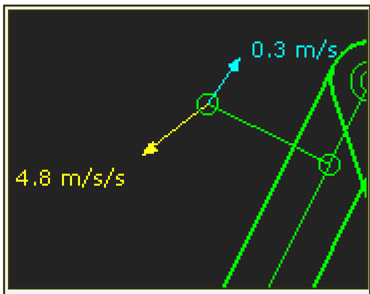


Each Cam needs a Follower-Profile.

Add a **sketch-loop** for the **Follower-Profile** - typically a **CIRCLE**.

You must also sketch the shape of the **Cam-Blank** when you add a **3D-CAM**.

Plot exact Kinematic Data



For any **POINT*** that you add to a **PART**, you can:

- Show the instantaneous kinematic vectors (Velocity and Acceleration) of the **POINT** with the POINT PROPERTIES DIALOG [543]
- Plot motion-values of Position, Velocity and Acceleration throughout the machine-cycle with the POINT-DATA FB [197] or MEASUREMENT FB [193] that you connect to a GRAPH FB [202]

---

* **POINT**, **START-POINT**, **END-POINT**, **CENTER-POINT**, and **MOTION-POINT**.

Add a CAD-Line

You can add **CAD-LINES** to any **PART**. You can use the **CAD-LINE** to import **DXF-Drawings**, SOLIDWORKS parts, or STL file-types.

CAD-LINES can be coincident with each other, or at different positions in the **PART**.

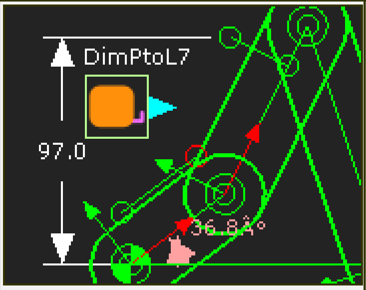
There is a **CAD-LINE** between the **START-POINT** and **END-POINT** of every **PART** you add to the model.

Constraint Based Editing Tools for Mechanism Synthesis

See Mechanism-Synthesis.

- Three, Four and Five Position Synthesis
- Coupler Curve and Coupler Point Synthesis
- Function Generation

To add sketch-elements for a Measurement FB dimension

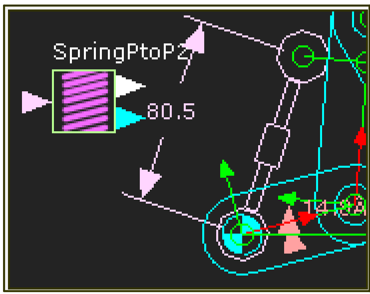


Occasionally, you must add sketch-elements to **PARTS** to measure the distance with a **MEASUREMENT FB**. See Add Measurement FB[193].

The output from a **POINT-DATA FB** is position, velocity and acceleration of a **POINT**.

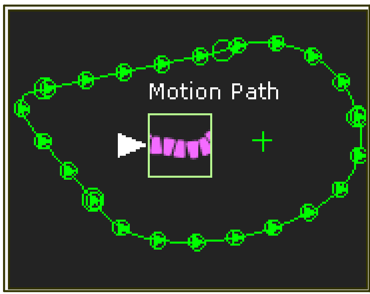
You can use the output of a **MEASUREMENT FB** or **POINT-DATA FB** as the independent variable (X-axis) of a different **FB**.

Add a Point or Line for a Spring FB



Add a **POINT** or **LINE** to anchor a **SPRING FB**.

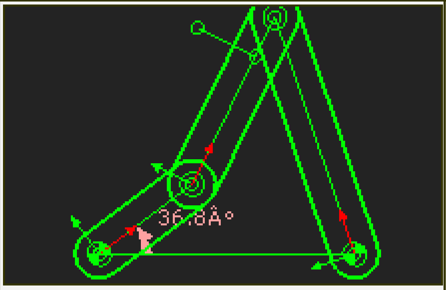
Add a sketch-loop for a Motion-Path and Motion-Point.



A **MOTION-PATH FB** adds a **MOTION-POINT** to a sketch-path in a **PART**.

1.5.12.4.2.3 How do I know I am using the Part-Editor?

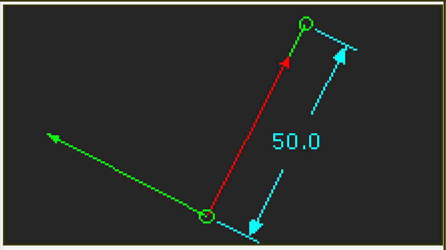
How do I know I am using the Part-Editor and not the Mechanism-Editor?



Part in Mechanism-Editor

Mechanism-Editor:

- The **Mechanism tab** should indicate the Mechanism-Editor is active.
- There is more than one PART - usually.
- There is a Part-Outline around each PART.
- The **XY-axes**, at the START-POINT of each PART, are relatively small.



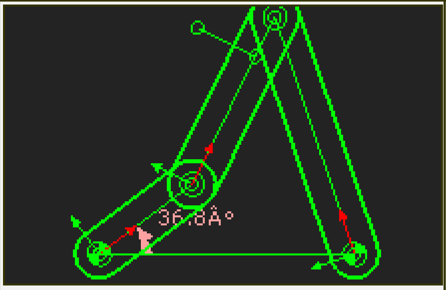
Part in Part-Editor

Part-Editor:

- The **Mechanism tab** changes to a **Part-Outline** when you start the **Part-Editor**.
- You cannot see the PART-OUTLINE.
- The **XY-axes** are relatively large.
- There is a DIMENSION for the length of the CAD-LINE of a PART that you have added to the model.

1.5.12.4.2.4 Can I edit (and other questions relating to) the Part-Outline?

Can I edit the Part-Outline? ... and other questions that relate to the Part-Outline.



Part-Outline of three Parts in the Graphics-Area

Can I edit the Part-Outline?

NO.

The PART-OUTLINE is the symbol for the PART element.

When do I need to click the Part-Outline?

You select the PART-OUTLINE to edit the PART.

You may need to click the PART-OUTLINE to select as the PART when you add more complex elements.

E.g.: Select the PART-OUTLINE as the **Cam-Part**, when you do Add 2D-Cam.

Can I change the size of the Part-Outline symbol?

YES. Use the Application Settings > Accessibility tab > Graphic > Symbol Display Size 347

Must I display Part-Outlines?

NO.

To hide PART-OUTLINES, see Display Filters > Show/Hide Part-Outlines 67 .

You can double-click the **Y-axis** to edit a PART.

You must display PART-OUTLINES to display **Force-Vectors** 237 .

Can I hide individual Part-Outlines?

No.

Can I change the color of a Part-Outline?

Only when you display **Force-Vectors**. You can use the CONFIGURE POWER SOURCE dialog to edit the color of individual PARTS.

When you do not display **Force-Vectors**, we recommend you use the default colors of PART-OUTLINES for PARTS that are kinematically-defined / solved (a type of Green), and for PARTS that are not kinematically-defined / not solved (a type of Blue).

1.5.12.4.2.5 Why is the dimension 'negative' in the Dimension dialog'?

Why is my dimension negative?

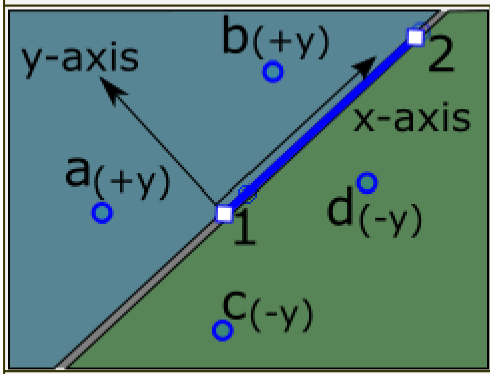
There is a **–ve sign** if the distance to a sketch-element is in a **negative** quadrant !!!

In practice, do NOT delete the **– sign**, but edit the dimension in the normal way.

However, to explain the negative dimension in the negative quadrant .... .

Each LINE has a X-Y coordinate-system. The coordinate-system's:

- 0,0 is its START-POINT
- +X-axis is from its START-POINT(1) to its END-POINT(2)
- +Y-axis is at +90º from the X-axis, on the **Mechanism-Plane**.

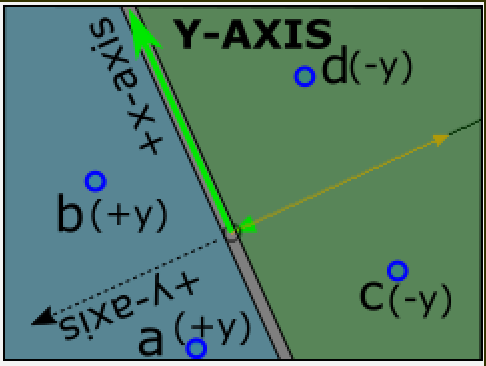


When you add a dimension that is a perpendicular distance from a LINE, the:

- dimension is +ve when the dimension is in the **+Y-axis** (blue area in the image).
- dimension is –ve when the dimension is in the **–Y-axis** (green area in the image).

In the top image there is a Blue LINE**(1 to 2)** on the **X-axis** of the PART. A:

- dimension from the LINE**(1 to 2)** to a POINT **a** or **b** is **positive**

• dimension from the LINE(1 to 2) to a POINT **c** or **d** is **negative**	
	A PART'S **X-axis AND Y-axis** also each have its own coordinate-system! Each axis is identical to that of a LINE. The bottom image shows the Coordinate-System of the **Y-axis** The **local +x-axis** of the **Y-axis** of a PART is along the **Y-axis**! In the bottom image: • dimensions from the **Y-axis** to POINTS **a** and **b** are **positive**. • dimensions from the **Y-axis** to POINTS **c** and **d** are **negative**.

1.5.12.4.2.6 Why do I need to add Geometry to the Base-Part?

Why do I need to add geometry to the Base-Part?

1. Why is there not a CAD-LINE in the BASE-PART?

   We do not want you to automatically add Joints to the Origin of the BASE-PART.
2. Why?

   For the BASE-PART, we have found it to be useful to add POINTS and LINES that are not at the Origin or along the X-axis or Y–axis.
3. Why?

   You can edit the dimensions later, and also add the dimensions to a DESIGN-SET 217.
4. Why edit POINTS and LINES in the BASE-PARTS?

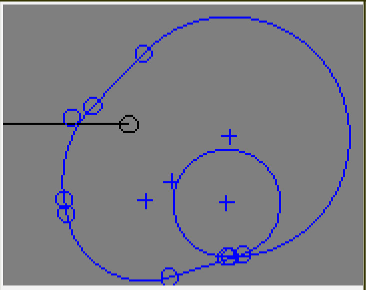
   a) Edit the dimension and move the Joints, if the POINTS or LINES are used for Joints

   b) Move the PLANE and **MECHANISM-EDITOR** in the Machine Frame, if a LINE is used for a new PLANE and **MECHANISM-EDITOR**.

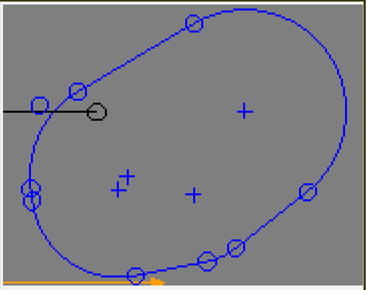
1.5.12.4.2.7 My sketch has disappeared. What do I do?

Trouble-shoot the sketch-editor.

Where is my Sketch?



Incorrect Arc



Correct Arc - After Undo

To recover a sketch that changes in an unexpected way:

Use Edit menu > Undo[55], or **CTRL + Z** on your keyboard.

Sometimes the Sketch collapses to a small dot.

Use Edit menu > Undo[55], or **CTRL + Z** on your keyboard.

Sometimes the Sketch expands to the size of a planet.

Use Edit menu > Undo[55], or **CTRL + Z** on your keyboard.

Note:

Below:

BLUE means the geometry is **Not Solved**.

BLACK means the geometry is **Fully Solved**.

Why is my sketch BLACK when it should be BLUE?

Sometimes, a sketch-element is **BLACK** but you know it should be **BLUE**. You should be able to add a dimension or constraint to it, but you cannot.

Or, a sketch-element is **BLUE** when it should be **BLACK**.

The best solution is to do one of these actions:

- Delete the sketch-element and add it again.
- Shift-Click the sketch-element so it and the constraints that you have added to it show in the **SELECTION-WINDOW**
- Right-click a constraint, or the sketch-element, and select **Delete Element** in the shortcut menu.

OR

- Use Edit menu > Undo[55] **or CTRL + Z**

Then add a different constraint.

You can add the same constraint again, or use a different constraint, to see if the sketch-element turns **BLACK**.

In our defense, the **PART-EDITOR** is continuously improved.

Why is my sketch Blue, and I cannot add any more constraints?'

Sometimes, a sketch-element is **BLUE** but you cannot add more constraints.

You might be able to drag a sketch-element that is blue, but when you come to add a new constraint, **MechDesigner** does not accept it.

In this case, a new constraint may remove two degrees-of-freedom, but the sketch has only one remaining degree-of-freedom.

Example:

Add Coincident Constraint between the center-Point of a Circle and a Point at the end of a Line.

If: the CENTER-POINT of the CIRCLE has a COINCIDENT CONSTRAINT with the LINE

Then: it is not possible to also add a COINCIDENT-CONSTRAINT with the START-POINT or END-POINT of the LINE

1. SHIFT + Click the LINE or the CENTER-POINT of the CIRCLE so the COINCIDENT-CONSTRAINT shows in the SELECTION-WINDOW
2. Delete the COINCIDENT CONSTRAINT using the SELECTION-WINDOW

1.5.12.4.2.8 What are the color codes of the Part-Editor?

Color-codes of Elements in the Part-Editor

You can control the Color for the two states of Geometry.

- **Geometry Under Defined** - typically, near to Blue
- **Geometry Fully Defined** - typically, near to Green

See Application-Settings > Graphics tab > DISPLAY COLORS

A dimension is Gray if it:

- has been added to a DESIGN-SET
- is the length of the LINE between the center of two gears in a GEAR-PAIR
- is the radius of a PULLEY
- controls the length of a MOTION-PATH

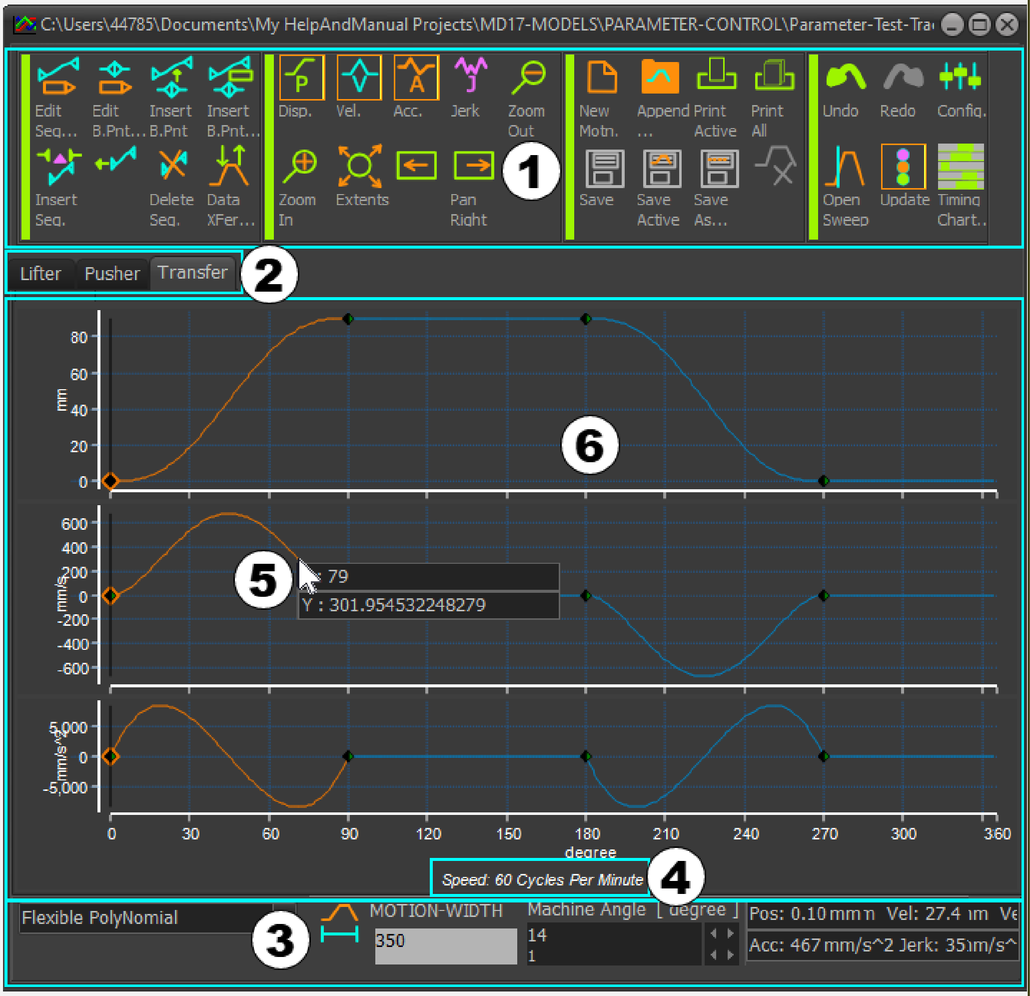
Other Colors

- Reference Geometry is Orange

1.6 MotionDesigner Reference & User Interface

MotionDesigner: Main User Interface

We update the MechDesigner model for you immediately as you use edit a motion in **MotionDesigner**.



MotionDesigner (Click to Expand or Collapse)

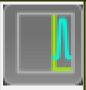
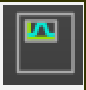
MotionDesigner :

1. [Blend-Point and Segment, Edit, File, and View toolbars](683)
2. [Motion name-tabs](683) - see also [Rename Motion](683)
3. [Motion-toolbar](741)
4. Machine Speed - edit in **Mech****Designer** > [Edit menu > Machine-Settings](56)
5. [Motion Values at Pointer](684)
6. Position, Velocity, Acceleration, Jerk (P.V.A.J) Motion-Graphs.

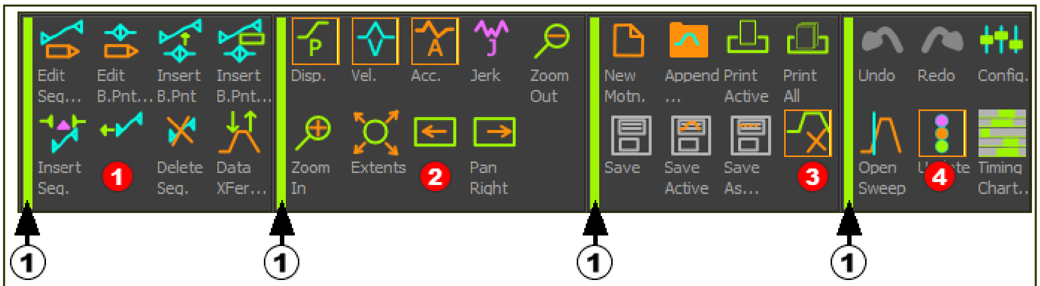
MotionDesigner: Float or Dock

MECH-Designer -Visibility toolbar > Float or Dock

MotionDesigner is docked to the right of the application-window when you start **MechDesigner**.

	**To Float MotionDesigner :** 1. Click MechDesigner > Visibility menu / toolbar > Dock / Float MotionDesigner **MotionDesigner** is now floating. 2. Re-size and re-position **MotionDesigner**. We remember the size and position for you when you float **MotionDesigner** again.
	**To Dock MotionDesigner :** 1. Click MechDesigner > Visibility toolbar > Dock / Float MotionDesigner **MotionDesigner** is now docked again to the right of the application-window.

① MotionDesigner: Toolbars



MotionDesigner toolbars

①	Toolbar Expand / Collapse bar (x4)
1	Blend-Point & Segment toolbar [716]
2	View toolbar [738]
3	File toolbar [723]
4	Edit toolbar [730]

Motion toolbar [741] is below the graphs

② MotionDesigner: Motion name-tabs

4 x Motion name-tabs

In the image, there are four **Motion name-tabs** - to give four motions.

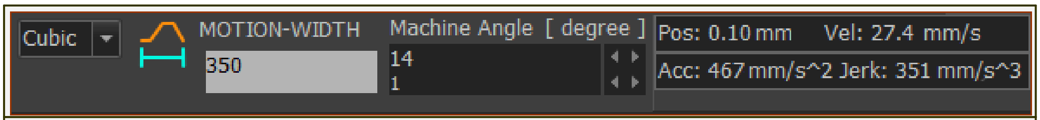
Motion0 - the name of the default motion.

Motion1, Motion2, Motion3, Motion4, ... the default names for motions that add with Add Motion [723] .

Y Axis and **X Axis** - two motions have been renamed from the default name.

See Add Motion 723 **and Open and Append** 724
See also: How to Rename a Motion 846

3 MotionDesigner: Motion toolbar

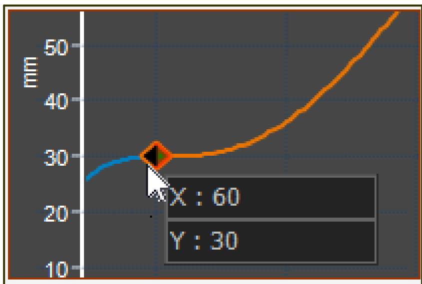


Use to :

- Select a **Motion-Law** for a segment
- Confirm the width of a Motion - MOTION-WIDTH
- Evaluate the Motion values as a function of the X-axis value.

See more: Motion toolbar 741

5 MotionDesigner: Motion-Values at Pointer



Motion-values at your pointer

1. Move your mouse-pointer above a motion graph plot-line, or to a BLEND-POINT.

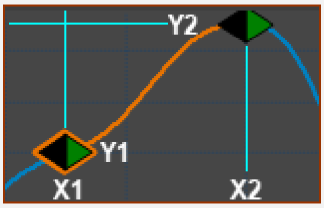
The X and Y motion-values show near to your pointer.

See also: Motion-Value Evaluator 743

1.6.1 Terminology and Symbols

MotionDesigner Terminology:

Segments



A Segment: from X1 to X2

Motions are split into SEGMENTS.

Each SEGMENT has a SEGMENT-WIDTH.

SEGMENTS join together, end-to-end (they concatenate), to create a motion, usually over one machine-cycle of 360º

You must select a MOTION-LAW for each SEGMENT with the Motion-Law Selector [741] .

The mathematical-function of the MOTION-LAW, and its motion-values at its start and end, control the shape of the SEGMENT.

SEGMENT-EDITOR

The SEGMENT EDITOR edits the SELECTED-SEGMENT.

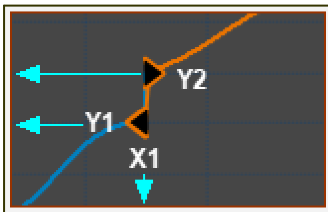
You can use the SEGMENT-EDITOR to edit the:

- SEGMENT-WIDTH (**X2 – X1**)
- motion-value **Y1** at **X1**
- motion-value **Y2** at **X2**
- MOTION-LAW

Depending on the MOTION-LAW, you may be able to control its:

- motion-values **Y1** and **Y2** of one or all of its motion-derivatives: **P, V, A, J.**
- SEGMENT-PARAMETERS (not all MOTION-LAWS)
- SEGMENT RANGE (not all MOTION-LAWS)

Blend-Points



A Blend-Point: at X1

Motions are split at BLEND-POINTS

A BLEND-POINT does NOT have a SEGMENT-WIDTH.

A **BLEND-POINT** has one **X-axis** value (**X1** in the image) and two **Y-axis** values (**Y1** at the end of the **PREVIOUS-SEGMENT**, and **Y2** at the start of the **SELECTED-SEGMENT**) - see image above

BLEND-POINT EDITOR

The **BLEND-POINT EDITOR** controls the motion-values of the **BLEND-POINT** at the start (beginning, left side) of the **SELECTED-SEGMENT**.

Use the **BLEND-POINT EDITOR** to edit the:

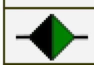
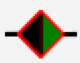
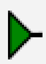
- value **X1**
- motion-value **Y1** at the **End of Previous-Segment** of one or all of its motion-derivatives: **P, V, A, J**
- motion-value **Y2** at the **Start of Selected-Segment** of one or all of its motion-derivatives: **P, V, A, J**

Other Terminology

MOTION-LAW : (CAM-LAW) :	You must select a **MOTION-LAW** for each **SEGMENT**. Each type of Motion-Law has a name. The **MOTION-LAW** should be able to satisfy the motion requirements for your design. Each **MOTION-LAW** is a mathematical function. The **MOTION-LAW**, together with the motion-values at its start and end, control the motion-values between each **BLEND-POINT.** We use the term **MOTION-LAW** rather than **Cam-Law** as you can also apply your motion-design to a Hydraulic or Air Cylinder, Servomotor, ...
Motion-Derivative :	**Velocity**, **Acceleration**, and **Jerk** the three motion-derivatives of **Position**.
SEGMENT EDITOR :	Use the **SEGMENT EDITOR** to edit the **SEGMENT-WIDTH**, to select the **MOTION-LAW**, to edit the **SEGMENT-PARAMETERS**, and to edit the motion-values at the **Start of the Selected-Segment** and at the **End of the Selected-Segment**.
BLEND-POINT EDITOR :	Use the **BLEND-POINT EDITOR** to edit motion-values of the **BLEND-POINT** that is at the start of the **SELECTED-SEGMENT**. Edit **X-axis value** and the **Y-axis** motion-values at the "**End of the Previous-Segment,**" **Y1,** and at the "**Start of the Selected-Segment,**" **Y2**.

SELECTED-SEGMENT :	The SEGMENT to which you apply the motion-values that are in the SEGMENT EDITOR. The BLEND-POINT EDITOR applies its motion-values to the BLEND-POINT that is at the start of the SELECTED-SEGMENT. In the motion graphs, the SELECTED-SEGMENT is a different color to the other segments.
PREVIOUS-SEGMENT :	The SEGMENT that precedes (is to the left of / is earlier than / is before) the SELECTED-SEGMENT. If the SELECTED-SEGMENT is the first SEGMENT, then the **PREVIOUS-SEGMENT** is the last SEGMENT.
NEXT-SEGMENT :	The SEGMENT that follows (is to the right of / is later than / is after) the SELECTED-SEGMENT. If the SELECTED-SEGMENT is the last SEGMENT, then the **NEXT-SEGMENT** is the first SEGMENT.
“End of the Previous-Segment” :	Refers to the last motion-value of the SEGMENT that is one SEGMENT earlier than the SELECTED-SEGMENT. If the SELECTED-SEGMENT is **Segment 1**, then **End of the Previous-Segment** is the motion-value at the end of the motion.
“Start of Selected-Segment” :	Refers to the first motion-value of the SELECTED-SEGMENT.
Match, Flow :	To force (with a Control-Button in the the motion-value at the start of a **SEGMENT** to be equal to the motion-value at the end of the **PREVIOUS-SEGMENT**. We can Match motion-values of any or all motion-derivatives.

Symbols

There are two triangles at each BLEND-POINT.	
	BLEND-POINT
	ACTIVE BLEND-POINT - has an outline. The BLEND-POINT that is at the start of the SELECTED-SEGMENT.
	The **Start of a Segment**. The symbol may be GREEN, **BLACK, CLEAR,** or **GREY**.

	The **End of a Segment**. The symbol may be **BLACK**, **CLEAR**, or **GREY**.

Note: To increase the size of the symbols, see: **Active-Motion-Settings > Accessibility tab > Line and Symbol Sizes > Symbol Size.**

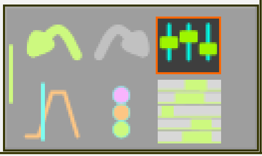
1.6.2 Program and Active Motion Settings

Th **Active Motion Settings dialog** is in the Edit toolbar[730]. It contains the settings that configure the active motion and also the **MotionDesigner** program in general.

We save the settings each time you save a **MechDesigner** model and each time you exit **MechDesigner**.

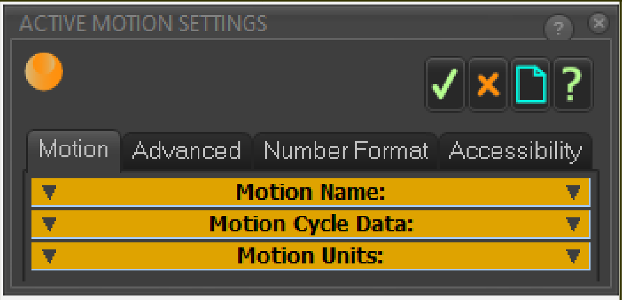
It is a good idea to check these settings before you start to design a motion.

Active Motion Settings



Edit toolbar > Active Motion Settings

Each motion has settings.



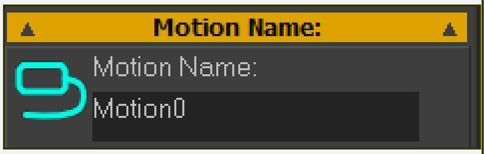
Active Motion Settings dialog

There are four tabs:

- **Motion**[688]
- **Advanced**[689]
- **Number-Format**[690]
- **Accessibility**[690]

Note: The settings become the default settings when you exit **MechDesigner**.

Motion tab



Motion name-tab (read-write)

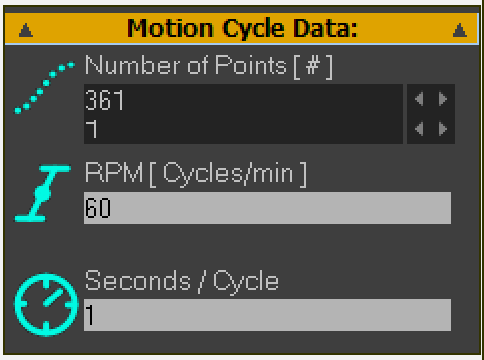
MOTION NAME

MOTION NAME **(read-write)** (default = Motion0, Motion1, ...)

Enter a new MOTION NAME with your keyboard.

Press the ENTER key on your keyboard.

The new Motion-Name is now the **Motion name-tab**.



MOTION CYCLE DATA

NUMBER-OF-POINTS **(read-write) (default = 360)**

The NUMBER-OF-POINTS along the active motion graph.

Note:

Enter NUMBER-OF-POINTS = 361 to put a Motion-Point exactly on each machine-degree in the Data Transfer Table[744] .

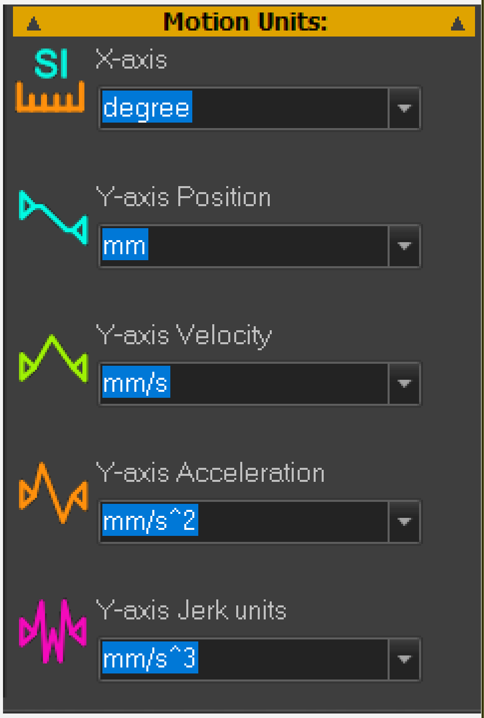
RPM [CYCLES/MIN] **(read-only)**

RPM **:** Machine cycles per minute.

See: MechDesigner - Edit menu>Machine Settings>Cycling Parameters>Cycles/Min

SECONDS / CYCLE **(read-only)**

SECONDS / CYCLE = 60 / CYCLES/MIN



MOTION UNITS

X–AXIS UNITS: **(default = degrees)**

Units available: **counts: sec, msec, cycle, degree, radian.**

Y–AXIS UNITS: **(default = degrees or mm)**

Units available: **mm, cm, m, inch, degree, radian, cycle, count**

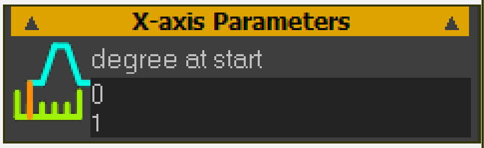
POSITION :	Units
VELOCITY :	Units/s
ACCELERATION :	Units/s^2
JERK :	Units/s^3

Note:

Change from Angular to Linear Units, or vice versa: If you change from Angular Units to Linear Units, then $1° = 1mm$

The motion does not have a different physical value when you select different Y-AXIS UNITS. E.g. 90mm becomes 0.090m, or 3.543inches.

Advanced tab

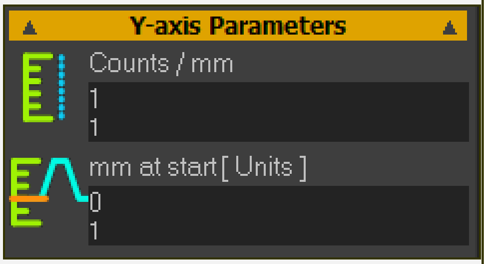


X-AXIS PARAMETERS

[UNITS] AT START (**default = 0**)

Edit **Unit** data-type in Motion tab

> 731 Motion Units



Y-AXIS PARAMETERS

COUNTS / DEGREE (**default =1**)

Edit **Unit** data-type in Motion tab

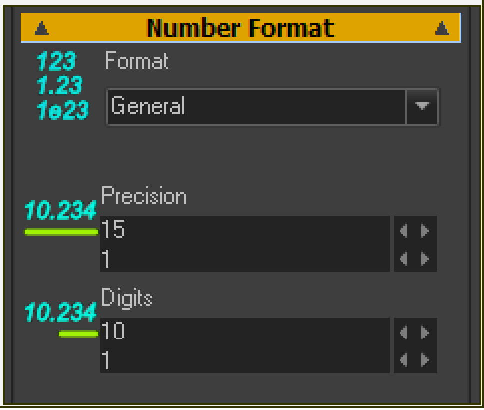
> 731 Motion Units

COUNTS AT START (**default = 0**)

Edit **Unit** data-type in Motion tab

> 731 Motion Units

Number Format tab



NUMBER FORMAT

FORMAT (**default : General**)

See Number Format

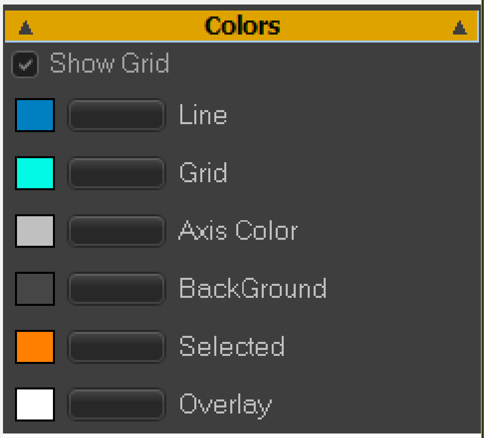
PRECISION (**default = 15**)

See Precision

DIGITS (**default = 10**)

See Digits

Accessibility tab

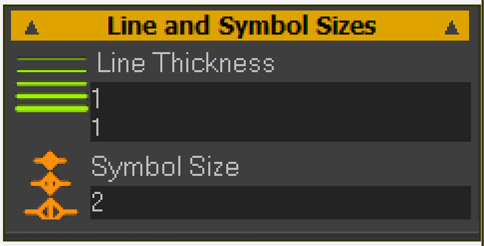


COLORS

☑ Show Grid : Enable to show the horizontal and vertical grid lines in the graph-plot area.

Colors : edit with **Windows Color Picker®** :

- **Line:** of all segments, but not the SELECTED-SEGMENT
- **Grid:** the horizontal and vertical Grid-Lines
- **Axis Color** : X and Y-axis text
- **Background:** the graph area
- **Selected:** the SELECTED-SEGMENT (typically Red)
- **Overlay:** see Overlay-Trace 751

	LINE AND SYMBOL SIZES LINE THICKNESS **(default = 1 ; Maximum = 8)** The plot thickness, in pixels, of the motion segments SYMBOL SIZE **(default = 2 ; Maximum = 8)** The scale/size of the **BLEND-POINT** symbols

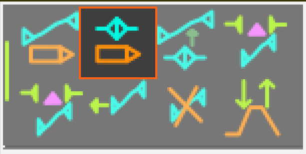
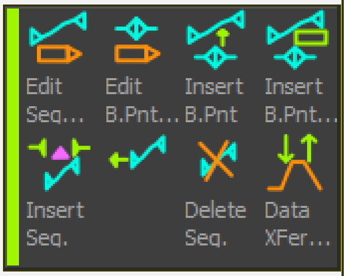
1.6.3 BLEND-POINT (NODE) EDITOR

BLEND-POINT (NODE) EDITOR

See also: SEGMENT EDITOR 704 .

How to open the BLEND-POINT EDITOR

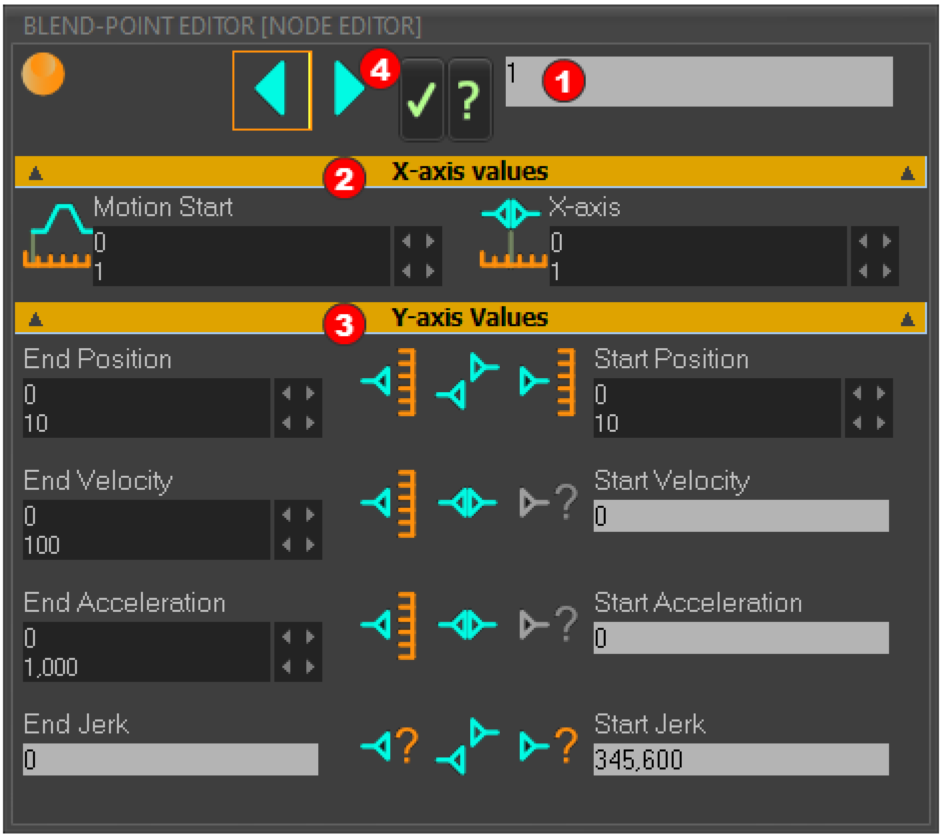
METHOD 1: Use the toolbar icon

 Blend-Point Editor icon	**MD16**  1. Click Blend-Point & Segment toolbar > Open Blend-Point Editor
 MD17-Blend-Point and Segment toolbar	**MD17**  1. Click Blend-Point & Segment toolbar > Open Blend-Point Editor
The BLEND-POINT EDITOR is now open.	

BLEND-POINT (NODE) EDITOR

The BLEND-POINT EDITOR edits the motion-values of the BLEND-POINT that is at the **start** of the SELECTED-SEGMENT.

You can change the BLEND-POINT (and SELECTED-SEGMENT) with the NEXT and PREVIOUS arrows❹ - see image below.



BLEND-POINT EDITOR

BLEND-POINT NUMBER ❶

Each BLEND-POINT and SEGMENT has a number. The BLEND-POINT at the start of the motion is BLEND-POINT # 1 - see X-AXIS VALUES > MOTION-START.

The BLEND-POINT NUMBER is the BLEND-POINT at the start of the SELECTED-SEGMENT.

The number of BLEND-POINTS is equal to the number of SEGMENTS.

X-AXIS VALUES ❷ - See Blend-Point - X-axis Controls [695]

Summary

MOTION START (default = 0)

Edit to move BLEND-POINT # 1 and the whole motion relative to **0** on the **X-axis.**

X-AXIS

Edit to move the active BLEND-POINT along the **X-axis**.

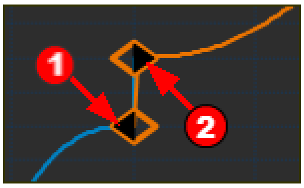
The active BLEND-POINT is at the start of the SELECTED-SEGMENT.

See also Warning [696] .

Units: **See Active-Motion-Settings > Motion tab > Motion Units [731]**

Y-AXIS VALUES ❸ - See Blend-Point - Y-axis Controls [698]

Summary



Use the **BLEND-POINT EDITOR** to edit the motion-values at the:

❶ **End of the** PREVIOUS-SEGMENT

AND / OR

❷ **Start of the** SELECTED-SEGMENT

The motion-derivatives (P V A J) that you can edit are a function of the:

- Motion-Law[709]
- Y-axis Control-Buttons settings[709]

To use the **BLEND-POINT EDITOR** efficiently, it is important to understand how to use the **Y-axis Control-Buttons**[700].

PREVIOUS / NEXT / OK / HELP buttons ❹

PREVIOUS:

Make the **PREVIOUS-SEGMENT** the **SELECTED-SEGMENT**.

Change the **BLEND-POINT NUMBER** by **– 1**

NEXT:

Make the **NEXT-SEGMENT** the **SELECTED-SEGMENT**.

Change the **BLEND-POINT NUMBER** by **+ 1**

Close the **BLEND-POINT EDITOR**

Open the **MotionDesigner** contextual help

1.6.3.1 Blend-Point Editor: X-axis Values

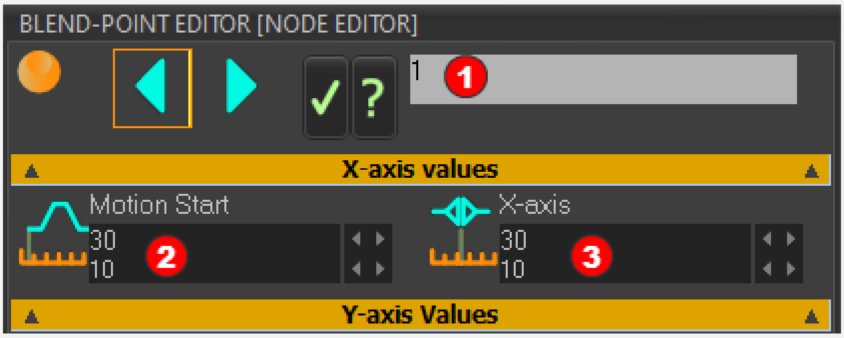
BLEND-POINT EDITOR : X-AXIS VALUES

When you edit the X-AXIS value of a BLEND-POINT, you change the SEGMENT-WIDTH of the PREVIOUS-SEGMENT AND the SELECTED-SEGMENT.

You do NOT change the MOTION-WIDTH.

However, please read the Warning - Bumping Blend-Points[696]

X-AXIS VALUES



X-axis values of Blend-Point #3

MOTION START ❷

Edit the MOTION-START❷ value to move the motion along the **X-axis**.

We make the X-AXIS❸ value of **Blend-Point #1** equal to the MOTION-START ❷ value.

We do not change the MOTION-WIDTH.

X-AXIS ❸

Edit to move the BLEND-POINT of BLEND-POINT #❶ along the X-AXIS - however, see SPECIAL CASE and WARNING

The other BLEND-POINTS do not move - however, see WARNING

Special Case

X-AXIS value of BLEND-POINT #1

BLEND-POINT #1

- You CANNOT edit the X-AXIS value of BLEND-POINT **#1**.
- we force the X-AXIS value of BLEND-POINT **#1** to be equal to the MOTION-START value.

However:

If you **attempt** to increase the X-AXIS value BLEND-POINT **#1** (move it to the right) ...

... you increase the SEGMENT-WIDTH[707] of the PREVIOUS-SEGMENT* and decrease the SEGMENT-WIDTH of the SELECTED-SEGMENT.

If you **attempt** to decrease the X-AXIS value of BLEND-POINT #1 (move it to the left) ...

... you decrease the SEGMENT-WIDTH of the PREVIOUS-SEGMENT* and increase the SEGMENT-WIDTH of the SELECTED-SEGMENT.

* : in this special-case, the PREVIOUS-SEGMENT is the segment to the left of SEGMENT #1.

WARNING

"**Bumping**" BLEND-POINTS !

If you edit the X-AXIS value of a BLEND-POINT and it **bumps** into an adjacent BLEND-POINT (left or right):

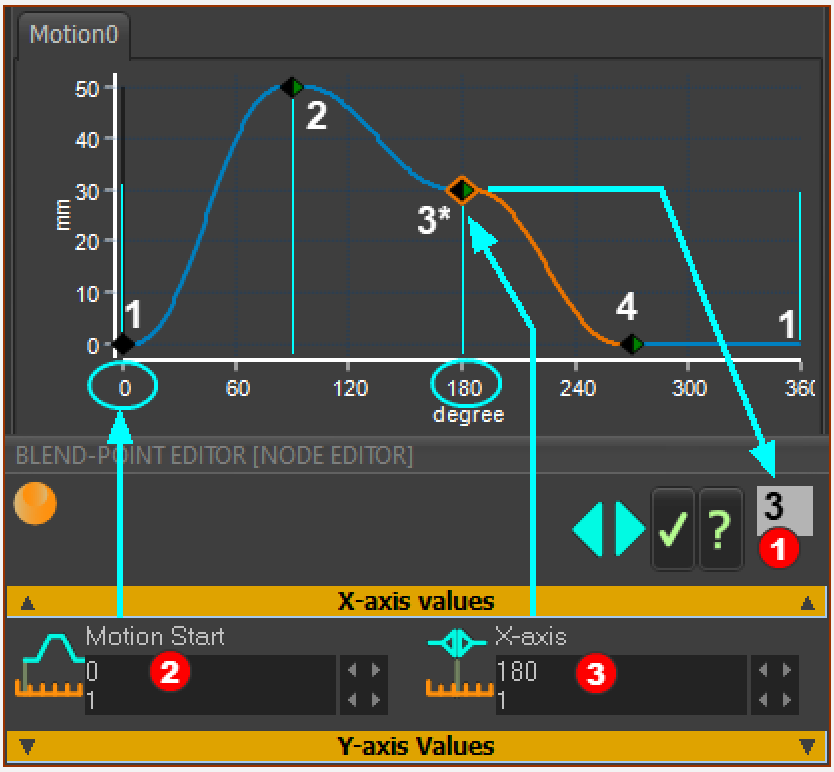
- the active BLEND-POINT AND the adjacent BLEND-POINT move together along the **X-axis**.
- AND the SEGMENT-WIDTH of the PREVIOUS-SEGMENT (or NEXT-SEGMENT) will be very short (e.g. 0.0000036 degrees) and invisible to you.
- AND the MOTION-WIDTH increases by a small amount (e.g. the MOTION-WIDTH increase to 360.0000036 degrees).

To separate the BLEND-POINTS, edit the X-AXIS value of the BLEND-POINT again.

The MOTION-WIDTH does NOT revert to 360 degrees.

To make the MOTION-WIDTH equal to 360 again, you must use the SEGMENT EDITOR [704] to edit the SEGMENT-WIDTH [707] of each segment.

EXAMPLE:



Motion-Start and X-axis Value of Blend-Point #3

BLEND-POINT NUMBER ❶

The number of the BLEND-POINT at the start of the SELECTED-SEGMENT.

The **BLEND-POINT NUMBER** is # 3

Note:

We frequently use "#" as short-hand for "number".

X-AXIS VALUES

❷ **MOTION START** is the X-axis value of **BLEND-POINT NUMBER 1. MOTION START** is at 0 degrees.

❸ **X-AXIS** value of the **BLEND-POINT #3** is 180 degrees.

As you edit the **X-AXIS** value **BLEND-POINT #3,** it moves to the left(<) or to the right(>).

To avoid "bumping" **BLEND-POINT #3** into **BLEND-POINT #2** or **#4**, the **X-AXIS** value of **BLEND-POINT #3** should be:

- Always more than the **X-AXIS** value of **BLEND-POINT NUMBER #2**. Minimum > 90 degrees.
- Always less than the **X-AXIS** value of **BLEND-POINT NUMBER#4**. Maximum < 270 degrees.

For "bumping", see WARNING 696, above.

See also: **How to edit a value in a data-box 850** **.**

1.6.3.2 Blend-Point Editor: Y-axis Values

Blend-Point Editor: Y-AXIS VALUES

It is important to know that each BLEND-POINT has two **Y-axis motion-values**❶ ❷ .

There is a motion-value at the:

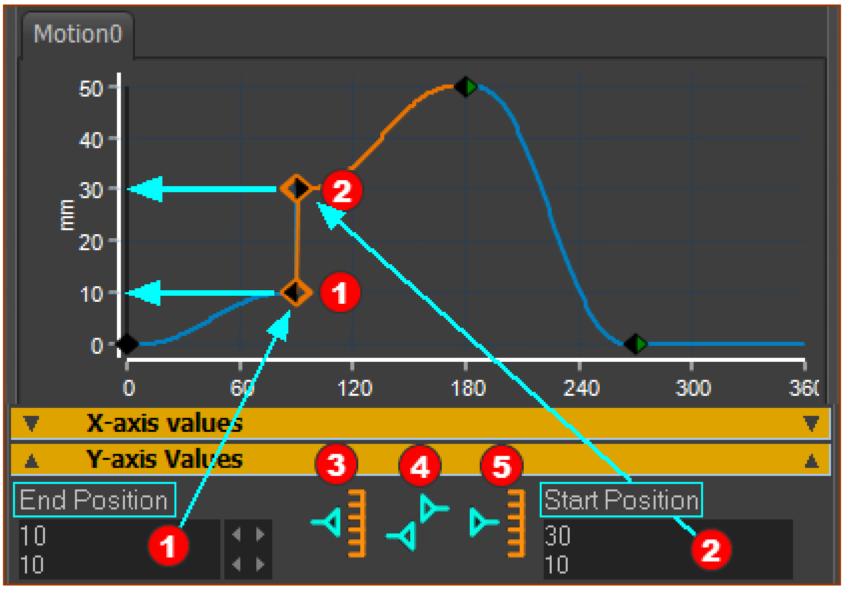
- **End of the Previous-Segment** ❶

AND at the:

- **Start of the Selected-Segment** ❷

Also, because there are four motion-derivatives, there are eight (8) motion-values at each BLEND-POINT.

Example



Position graph, Position motion-values, Position Control-Buttons

The image shows the:

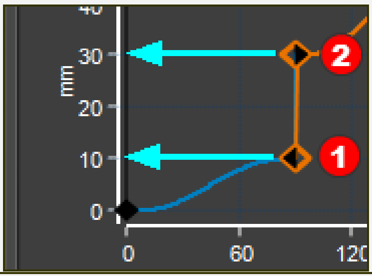
- Position motion-graph
- Position Y-axis motion-value and data-boxes ❶❷
- Position Control-Buttons ❸❹❺

The image does not show the:

- Velocity, Acceleration, and Jerk motion-graphs
- Velocity, Acceleration, and Jerk motion-value data-boxes
- Velocity, Acceleration, and Jerk Control-Buttons

Y-AXIS VALUES

Position Motion-Graph

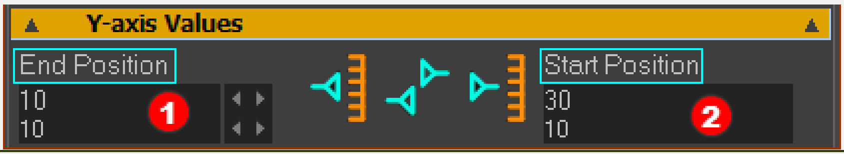


The **Position motion-graph** shows the Blend-Point with two motion-values.

❶ END POSITION (of the PREVIOUS-SEGMENT) = **10mm**

❷ START POSITION (of the SELECTED-SEGMENT) = **30mm**

Position Motion-Values



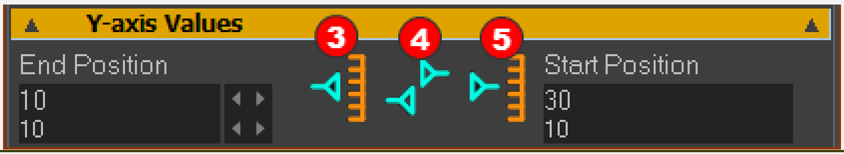
The **Position motion-derivative** has two motion-values and data-boxes

❶ END POSITION (of the PREVIOUS-SEGMENT) = **10mm**

❷ START POSITION (of the SELECTED-SEGMENT) = **30mm**

Position Control Buttons

See more at Control Buttons: States and Patterns 700



The **Control-Buttons** for the **Position motion-derivative** allows you to edit the two motion-values.

❸ END CONTROL BUTTON in the **Do Edit** state.

You can edit the motion-value at the END OF THE PREVIOUS-SEGMENT.

This control-button has three(3) states - **Do Edit**, **Do Not Edit**, and **Can Not Edit**

❹ MATCH CONTROL **button** in the **Do Not Match** state

The END-POSITION and the START-POSITION motion-values can be different.

This control-button has two(2) states - **Do Match** and **Do NOT Match**

❺ START CONTROL **button -** in the **Do Edit** state.

You can edit the motion-value at the START OF THE SELECTED-SEGMENT.

This control-button has three(3) states - **Do Edit**, **Do Not Edit**, and **Can Not Edit**

1.6.3.3 Blend-Point Editor: Control-Button States

Blend-Point Editor Control-buttons

Whether you can control the motion-values of a **BLEND-POINT** is a function of the:

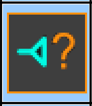
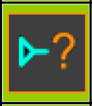
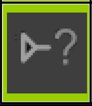
A. Motion-Law
B. Motion-Derivative
C. **Control-Buttons states**

You must understand how to use the **Control-Buttons** in the **BLEND-POINT EDITOR** (and the SEGMENT EDITOR[709]).

CONTROL-BUTTONS

EACH motion-derivative (**P V A J**) has **THREE Control-Buttons**.

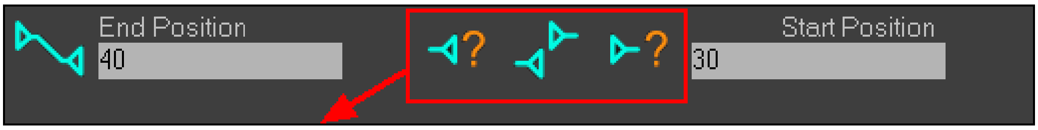
Each **Control-Button** has different states. Please read carefully the definitions in this table.

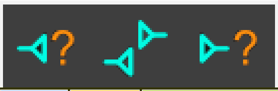
	Definition:
	DO **edit End (motion-value) of Previous-Segment** : It **IS** possible and **DO** control the motion value
	DO NOT **edit End (motion-value) of Previous-Segment** : It **IS** possible, bu **DO NOT** control the motion value
	CAN NOT **edit End (motion-value) of Previous-Segment** : It **IS NOT** possible to control the motion-value
	DO NOT **Match : DO NOT FORCE** the **Start (motion-value) of the Selected-Segment TO EQUAL** the **End (motion-value) of the Previous-Segment**
	DO MATCH **: DO FORCE** the **Start (motion-value) of the Selected-Segment TO EQUAL** the **End (motion-value) of the Previous-Segment**
	DO **edit Start (motion-value) of Selected-Segment** : It **IS** possible and **DO** control the motion value
	DO NOT **edit Start (motion-value) of Selected-Segment** : It **IS** possible, but **DO NOT** control the motion value
	CAN NOT **edit Start (motion-value) of Selected-Segment** : It **IS NOT** possible to control the motion-value

Control-Button States: Patterns: 1- 9

The **Control-Buttons** can have nine different patterns.

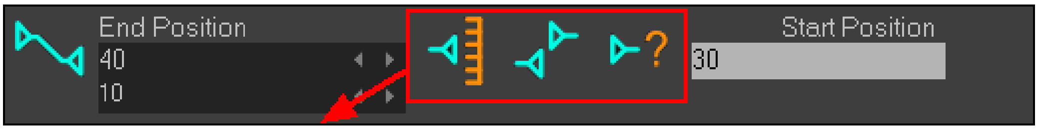
Pattern 1

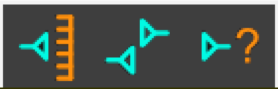




▼ ▼ ▼	▼ ▼	▶ Start of Selected-Segment : Possible but DO NOT control the value
	▶	End of the Previous-Segment ≠ Start of the Selected-Segment
▶		End of Previous-Segment : Possible but DO NOT control a value

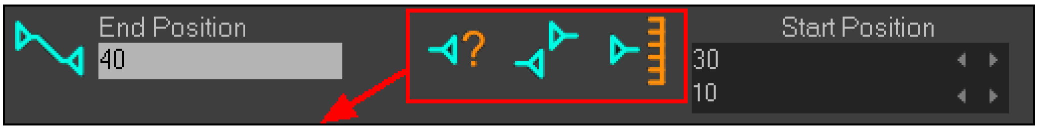
Pattern 2

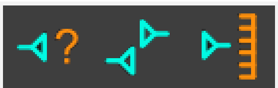




▼ ▼ ▼	▼ ▼	▶ Start of Selected-Segment : Possible but DO NOT control the value
	▶	End of the Previous-Segment ≠ Start of the Selected-Segment
▶		End of Previous-Segment : Possible and DO control the value

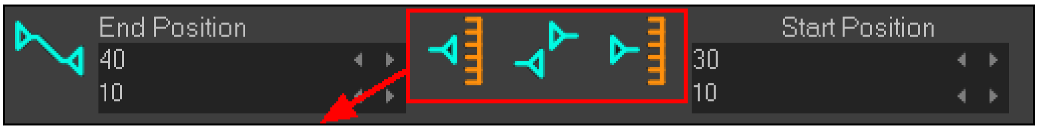
Pattern 3

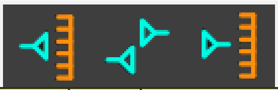




▼ ▼ ▼	▼ ▼	▶ Start of Selected-Segment : Possible and DO control the value
	▶	End of the Previous-Segment ≠ Start of the Selected-Segment
▶		End of Previous-Segment : Possible but DO NOT control the value

Pattern 4



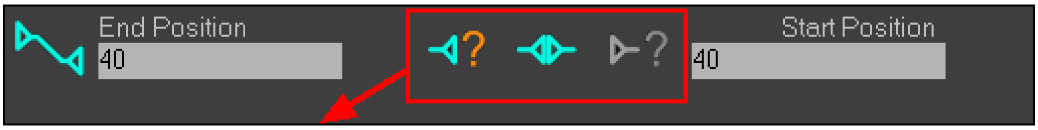


Start of Selected-Segment : Possible and DO control the value

End of the Previous-Segment ≠ Start of the Selected-Segment

End of Previous-Segment : Possible and DO control the value

Pattern 5

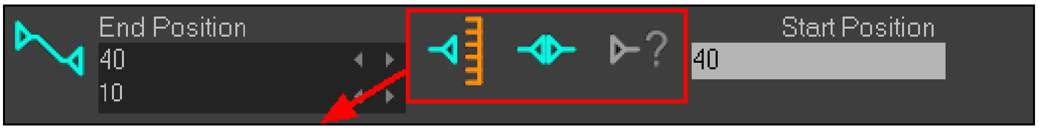


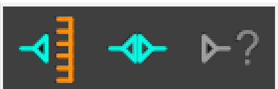
Start of Selected-Segment : NOT possible to control the value

End of the Previous-Segment = Start of the Selected-Segment

End of Previous-Segment : Possible but DO NOT control the value

Pattern 6



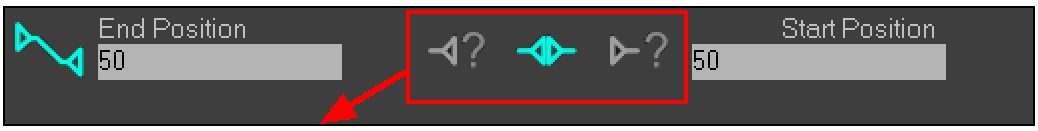


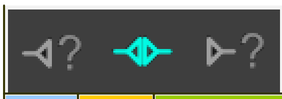
Start of Selected-Segment : NOT possible to control the value

End of the Previous-Segment = Start of the Selected-Segment

End of Previous-Segment : Possible and DO control the value

Pattern 7



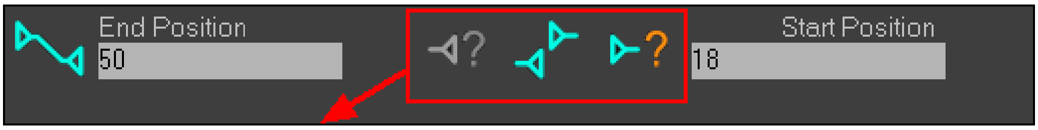


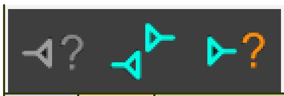
▼ ▼ ▼ ▶ Start of Selected-Segment : NOT possible to control the value

▶ End of the Previous-Segment = Start of the Selected-Segment

▶ End of Previous-Segment : NOT possible to control the value

Pattern 8



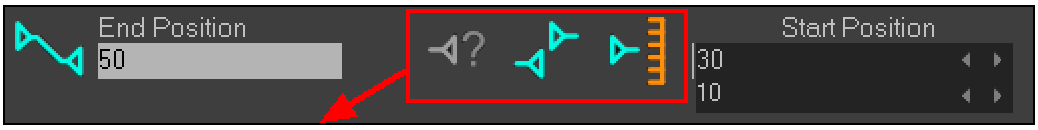


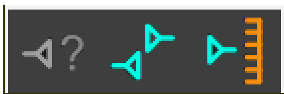
▼ ▼ ▼ ▶ Start of Selected-Segment : Possible but DO NOT control the value

▶ End of the Previous-Segment ≠ Start of the Selected-Segment

▶ End of Previous-Segment : NOT possible to control the value

Pattern 9





▼ ▼ ▼ ▶ Start of Selected-Segment : Possible and DO control the value

▶ End of the Previous-Segment ≠ Start of the Selected-Segment

▶ End of Previous-Segment : NOT possible to control the value

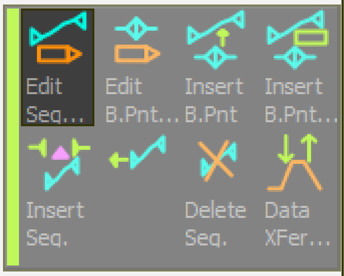
1.6.4 SEGMENT EDITOR

SEGMENT EDITOR

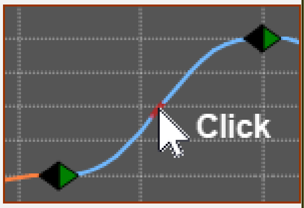
See also : BLEND-POINT (NODE) EDITOR 692 .

How to open the SEGMENT EDITOR

METHOD 1: Use the toolbar icon

 MD16-Segment-Editor command	**MD16**  1. Click Blend-Point & Segment toolbar > Open Segment Editor
 MD17-Blend-Point and Segment toolbar	**MD17**  1. Click Blend-Point & Segment toolbar > Open Segment Editor
The SEGMENT EDITOR is now open.	

METHOD 2: Click the Segment in the motion-graph

	1. Move your mouse-pointer over the graph line of a SEGMENT. A short section of the segment becomes red 2. Click your mouse-button
The SEGMENT EDITOR is now open.	

SEGMENT EDITOR

We immediately update the model for you as you edit motion-values with the SEGMENT EDITOR.

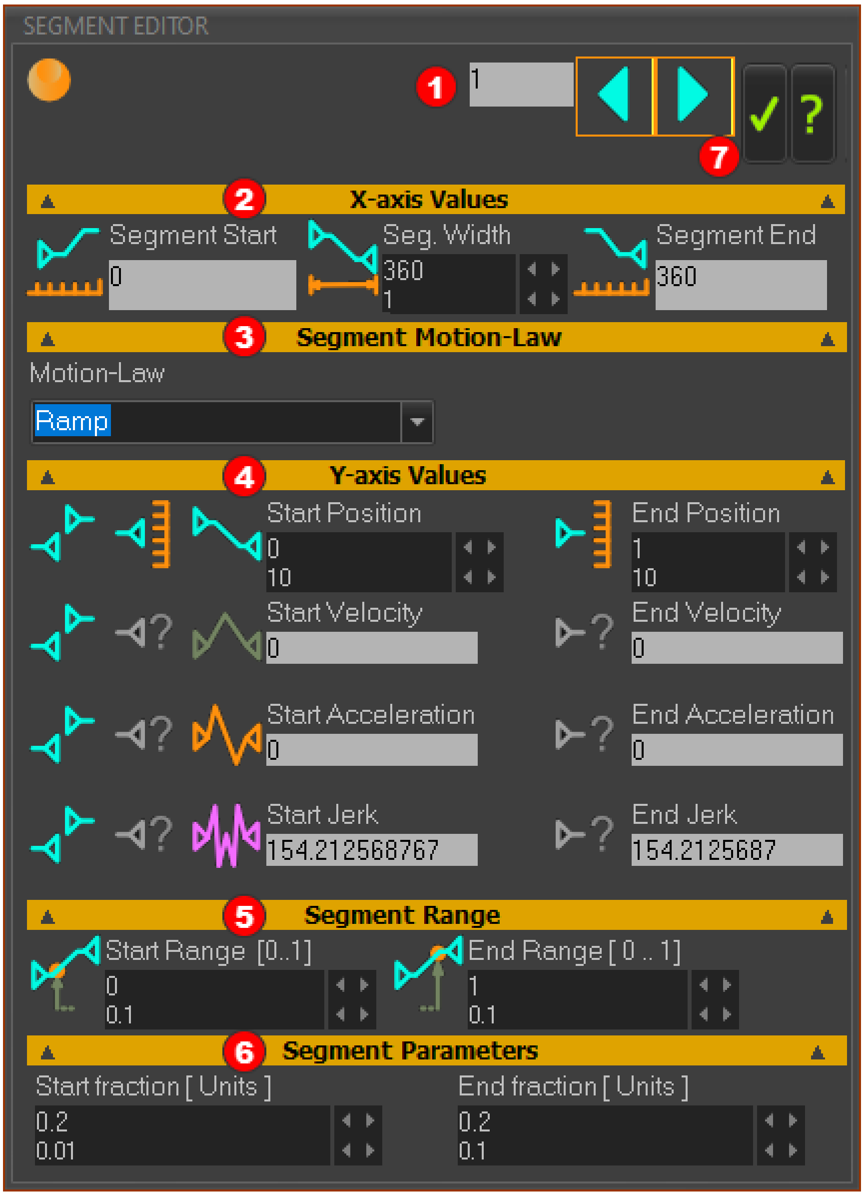
You can change the SELECTED-SEGMENT and BLEND-POINT with the NEXT and PREVIOUS arrows7 - see below.

Note:

If you can see all of the ORANGE SEPARATORS that should be available for the Motion-Law:

1. Click one of the ORANGE SEPARATORS two times to collapse and expand it.

You should then see all of the ORANGE SEPARATORS that are available with that **Motion-Law**.



SEGMENT-EDITOR

SEGMENT NUMBER ❶

The SEGMENT NUMBER is the number of the SELECTED-SEGMENT.
The motion and parameter values in the SEGMENT-EDITOR apply to the BLEND-POINTS at the start and end of the SELECTED-SEGMENT.

X-AXIS VALUES ❷

Summary

SEGMENT START (**read-only**) - the **X-axis** value at the start of the SELECTED-SEGMENT

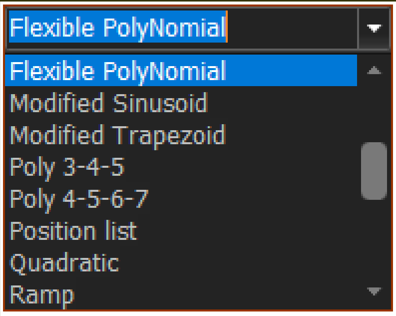
SEGMENT-WIDTH - the duration - in **X-axis units** - of the SELECTED-SEGMENT - **See more** here

707

SEGMENT END (**read-only**) - the **X-axis** value at the end of the SELECTED-SEGMENT

SEGMENT MOTION-LAW ❸

Summary



Motion-Law Selector

Use the drop-down box to select the MOTION-LAW for the SELECTED-SEGMENT.

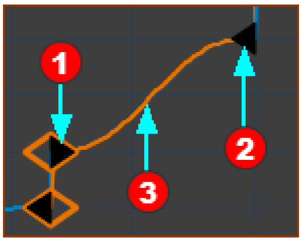
WARNING

After you select a MOTION-LAW, click somewhere in the motion graph area to remove the focus from the **Motion-Law Selector** list-box.

See more: Segment Motion-Laws [755]

Y-AXIS VALUES ❹

Summary



A Segment(3)

The **SEGMENT EDITOR** edits motion-values at the:

❶ Start of the SELECTED-SEGMENT ❸, and the

❷ End of the SELECTED-SEGMENT ❸

Which of the motion-derivatives (P V A J) you can edit is a function of the:

- Motion-Law [709]
- Y-axis Control-Buttons settings [709]

See more Segment Y-axis Values / Control Buttons [709]

SEGMENT RANGE ❺

Not available with all Traditional Motion-Laws [755]

See more Segment-Range [712]

SEGMENT PARAMETERS ❻

Not available with all Traditional Motion-Laws [755]

See more: Segment-Parameters [715]

PREVIOUS / NEXT / OK / HELP buttons ❼

Make the PREVIOUS-SEGMENT be the SELECTED-SEGMENT

Make the NEXT-SEGMENT be the SELECTED-SEGMENT

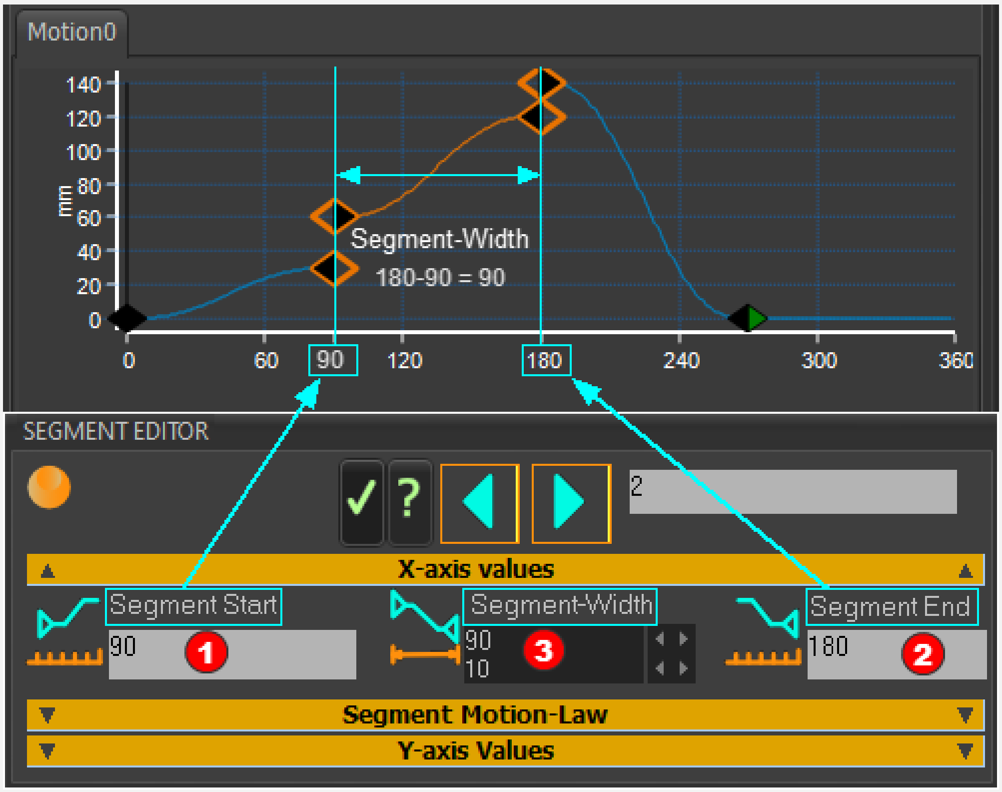
Close the **SEGMENT EDITOR** and apply the new motion-values and parameter settings to the SELECTED-SEGMENT.

Open the contextual help for the **SEGMENT-EDITOR**.

1.6.4.1 Segment Editor: X-axis Values / Segment-Width

Segment Editor : X-AXIS VALUES

Edit the period of a segment with the **SEGMENT-WIDTH** parameter.



SEGMENT-EDITOR - X-axis Values - Segment-Width Parameter

X-AXIS VALUES

❶ **SEGMENT START** (read-only)

E.g. SEGMENT START❶ = **90 degrees**

❸ **SEGMENT-WIDTH**

The duration, in X-axis Units 707, of the **SELECTED-SEGMENT**.

E.g. SEGMENT-WIDTH❸ = **90 degrees**

❷ **SEGMENT END** (read-only)

E.g. SEGMENT END❷ = SEGMENT-START❶ + SEGMENT-WIDTH❸ = 90+90 = **180 degrees**

WARNING:

When you edit the **SEGMENT-WIDTH** you also change the **MOTION-WIDTH**.

If you do **not** want the **MOTION-WIDTH** to change, you must edit the **SEGMENT-WIDTH** of a minimum of two segments.

X-axis Units

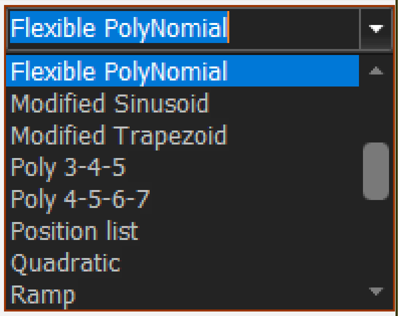
Control the **X-axis units** with Active-Motion-Settings > Motion tab > Motion Units > X-axis 731

The default **X-axis Units** are **degrees**.
See also: **Segment-Range** [712] , **Segment-Parameters** [715] , Y-AXIS VALUES

1.6.4.2 Segment-Editor: Segment Motion-Law

Segment Editor : SEGMENT MOTION-LAW

All segments have a motion-law - see Motion-Laws[755]



Motion-Law Selector

Use the drop-down list-box to select the **Motion-Law** for the SELECTED-SEGMENT.

WARNING

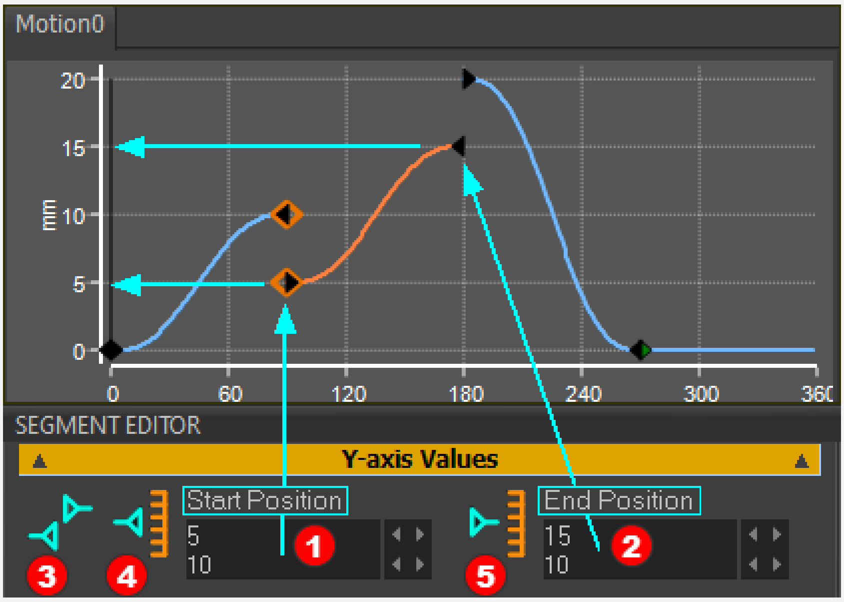
After you select a **Motion-Law**, click somewhere in the motion graph area to remove the focus from the **Motion-Law Selector** list-box.

See: Motion-Laws[755]

1.6.4.3 Segment Editor: Y-axis Values / Control-Buttons

Segment Editor : Y -AXIS VALUES

Edit the motion-values at the **Start of the Selected-Segment** and/or the **End of the Selected-Segment.**



SEGMENT-EDITOR - POSITION ONLY: Example Y-axis Values

Y-AXIS VALUES

Y-axis motion-values of **Position, Velocity, Acceleration, Jerk.**

❶ START **(motion-value of motion-derivative):**

E.g. : START POSITION❶ = **5mm** (see image above)

❷ END **(motion-value of motion-derivative):**

E.g. : END POSITION❷ = **15mm** (see image above)

CONTROL BUTTONS ❸❹❺ for Position, Velocity, Acceleration, Jerk.

See more at Control Buttons: States and Patterns 700

❸ **MATCH CONTROL button** - to control the motion continuity from the PREVIOUS-SEGMENT to the SELECTED-SEGMENT.

This button has two possible states:

Do Force the motion-value at START OF THE SELECTED-SEGMENT to equal the motion-value at the END OF THE PREVIOUS-SEGMENT

Do NOT Force the motion-value at START OF THE SELECTED-SEGMENT = motion-value at the **End of the Previous-Segment**

❹ **START CONTROL button** - to control the motion-value at the START OF THE SELECTED-SEGMENT.

This button has three possible states:

Do control (the motion-value at the) START OF THE SELECTED-SEGMENT

Do NOT control (the motion-value at the) START OF THE SELECTED-SEGMENT

Not possible to control (the motion-value at the) START OF THE SELECTED-SEGMENT

❺ **END CONTROL button -** to control the motion-value at the END OF THE SELECTED-SEGMENT.

It has three possible states:

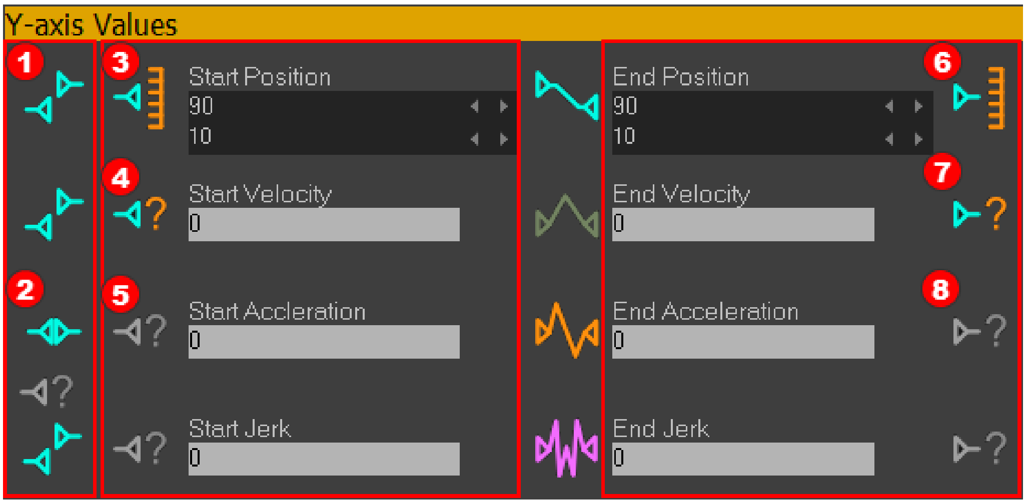
Do control (the motion-value at the) END OF THE SELECTED-SEGMENT

Do NOT control (the motion-value at the) END OF THE SELECTED-SEGMENT

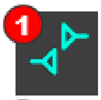
Not possible to control (the motion-value at the) END OF THE SELECTED-SEGMENT

See also BLEND-POINT EDITOR CONTROL BUTTONS 700

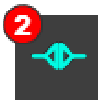
Segment Editor: Possible Control-Button Settings



MATCH from Previous-Segment



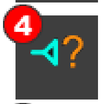
Do NOT FORCE
Start of Selected-Segment = End of **Previous**-Segment



Do FORCE
Start of Selected-Segment = End of **Previous**-Segment

Motion-value at START of Selected-Segment

Do Control



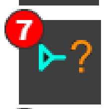
Allow MotionDesigner to Control

NOT possible to Control

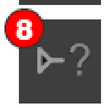
Motion-value at END of Selected-Segment

Do Control

Allow MotionDesigner to Control



NOT possible to Control



1.6.4.4 Segment Editor: Segment-Range

Segment Editor : SEGMENT-RANGE

The SEGMENT RANGE separator is available with many (not all) Traditional Motion-Laws 755.

Parameters:

START-RANGE: default = 0

END-RANGE: default = 1

The SEGMENT-RANGE parameters control the phases at which to start and end the mathematical-function of the motion-law.

One application of SEGMENT-RANGE the parameters is to design **Asymmetrical Motions - see** below 713.

Default Segment Ranges

START-RANGE ≥ 0 END-RANGE ≤ 1

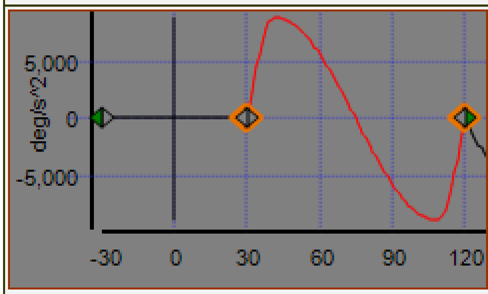
0 ≤ START RANGE < END RANGE ≤ 1

START-RANGE and END-RANGE parameters do NOT change the SEGMENT-WIDTH.

Example:

The images below show the acceleration graph of a **MODIFIED SINUSOID** motion-law with different SEGMENT-RANGE parameter values.

Note: the SEGMENT-WIDTH does NOT change when you edit the SEGMENT-RANGE parameter.

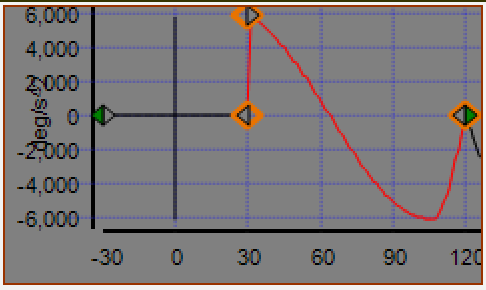


1) Standard Mod Sine

STANDARD Modified Sinusoid.

SEGMENT-WIDTH = 120º-30º = 90º

- START-RANGE = 0.0
- END-RANGE = 1.0

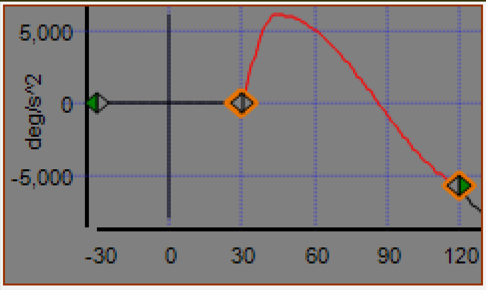


2) Start Range = 0.2 ; End-Range = 1

Modified-Sinusoid with 20% clipped from its Start.

SEGMENT-WIDTH = 120º-30º = 90º

- START-RANGE = 0.2 - to remove **20%** from the start of the **MODIFIED-SINUSOID** mathematical function
- END-RANGE = 1.0



Start Range = 0.0 ; End-Range = 0.8

Modified-Sinusoid with 20% clipped from its End.

SEGMENT-WIDTH = 120º-30º = 90º

- START-RANGE = 0.0
- END-RANGE = 0.8 - to remove the **20%** from the end of the **MODIFIED-SINUSOID** mathematical function

See also: Segment Editor: Segment-Width 707, Segment Editor: Parameters 715

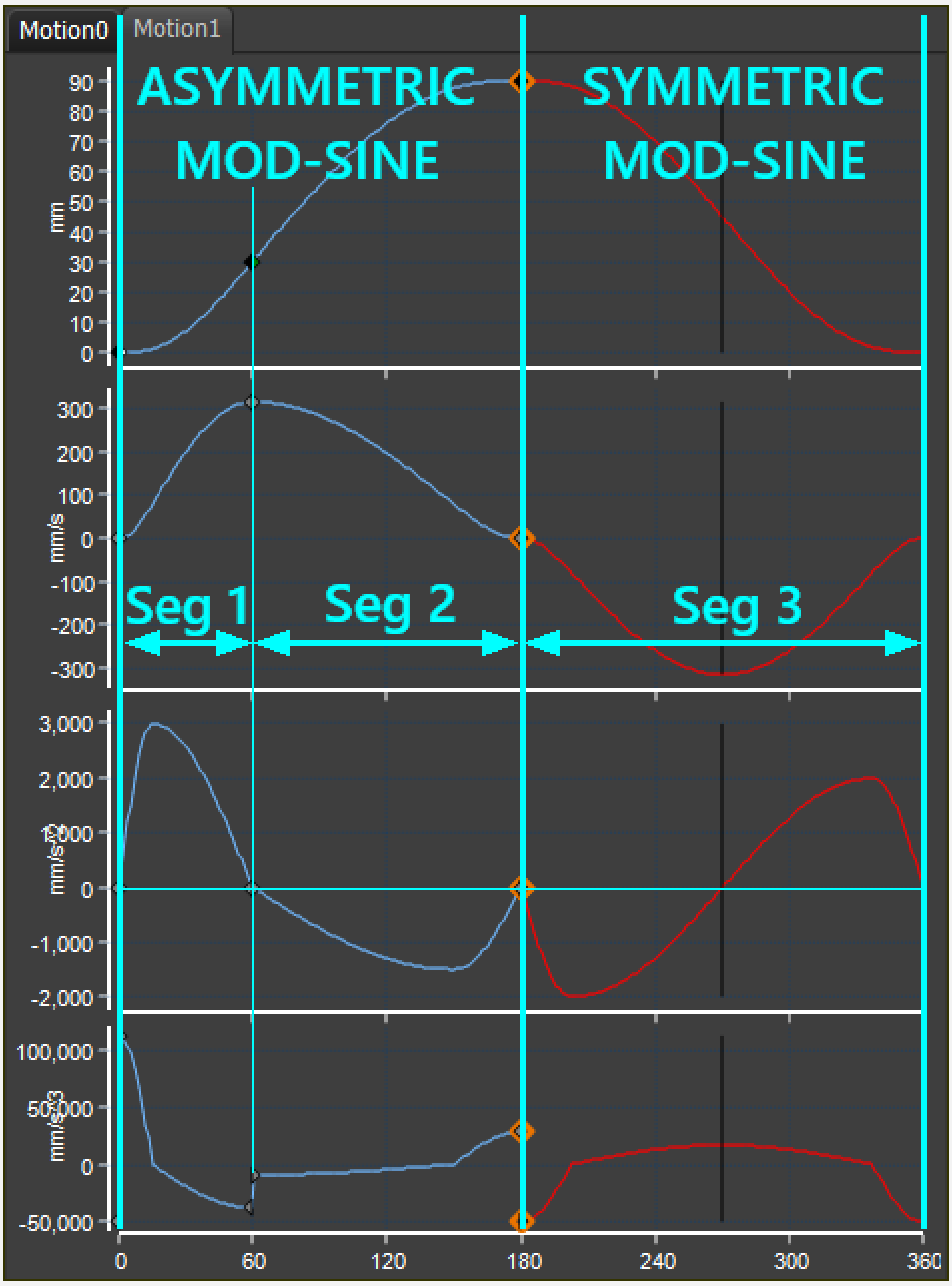
Asymmetric Motion - Example

For example: use an **Asymmetric Modified-Sinusoid** to accelerate rapidly and decelerate more gradually, or **vice versa**.

You split a **symmetric Modified-Sinusoid** segment into two segments, and then use the SEGMENT-RANGE parameters to change the phase of the crossover to design the **Asymmetric Modified-Sinusoid**.

In the image below there is a Rise and Return motion.

- The Rise is an **Asymmetric Modified Sinusoid** (0 - 180º). The crossover is at 60º.
- The Return is a **Symmetric Modified Sinusoid** (180 - 360º). The crossover is at 270º.



Asymmetric Mod-Sine | Symmetric Mod-Sine

Asymmetrical Mod-Sine Segments :

$X - axis\ : 0 - 180°$

$Crossover\ at\ 60°$

$\therefore \lambda = 60/180 = 1/3$

SEGMENT 1

Machine angle : $X - axis\ : 0 - 60°$ ($1/3$ of total Asymmetric motion-law)

Displacement : $Y - axis\ : 0 - 30mm$ ($1/3$ of total Asymmetric Displacement)

START-RANGE = 0 ; END RANGE = 0.5

SEGMENT 2

Machine angle : $X - axis \;\; : 60 - 180°$ ($2/3$ of total Asymmetric motion-law)

Displacement : $Y - axis \;\; : 30 - 90mm$ ($2/3$ of total Asymmetric Displacement)

START-RANGE = 0.5 ; END RANGE = 1.0

Characteristics Values: Asymmetric and Symmetric Compared.

Velocity Coefficient :	$Cv_{asym} = Cv_{sym}$
Acceleration Coefficient :	$Ca_{asym} = Ca_{sym}/2\lambda$
Deceleration Coefficient :	$Ca_{asym} = Ca_{sym}/2(1 - \lambda)$

1.6.4.5 Segment Editor: Segment-Parameters

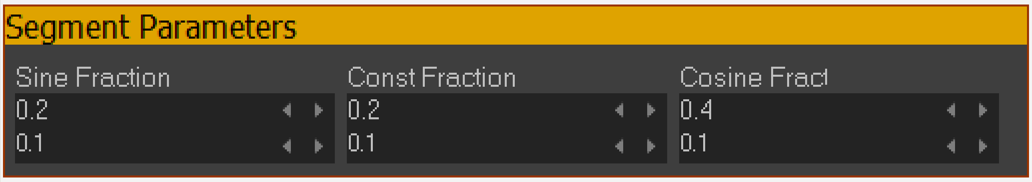
Segment Editor : SEGMENT PARAMETERS

The SEGMENT PARAMETERS separator is available with many (not all) Traditional Motion-Laws[755].

The actual SEGMENT-PARAMETERS are unique to the Motion-Law.

Their details are described with each Motion-Law.

The best way to learn about the different SEGMENT PARAMETERS is to experiment with their values.



Segment-Parameters with the Sine-Constant Acceleration-Cosine motion-law

The image above shows the three SEGMENT-PARAMETERS for the SINE-CONSTANT-ACCELERATION-COSINE[814] motion-law.

The CONSTANT-FRACTION parameter, refers to the **Non-Zero Constant Acceleration**, and not the **Zero Constant-Acceleration**.

Note:

Commercial Indexers frequently use a **Modified-Sine with** motion-law with **20%, 33%, 50%, or 66% Constant-Velocity** of the index-period.

A period of Constant-Velocity:

- reduces the maximum velocity and a
- reduces a Cam's Pressure-Angle.
- increases the minimum width between the cam-tracks of a Globoidal-Cam, to increase the width of the rib.

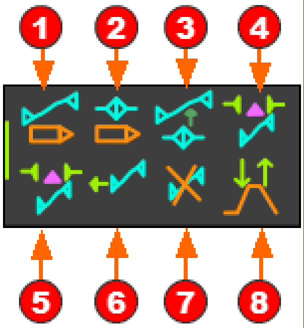
In **MotionDesigner**, you can enter any percentage of **Constant Velocity**.

See also: Segment-Range[712], Segment-Width[707]

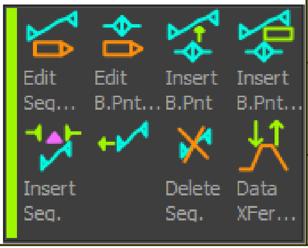
1.6.5 Blend-Point & Segment toolbar

Blend-Point & Segment toolbar

MD16

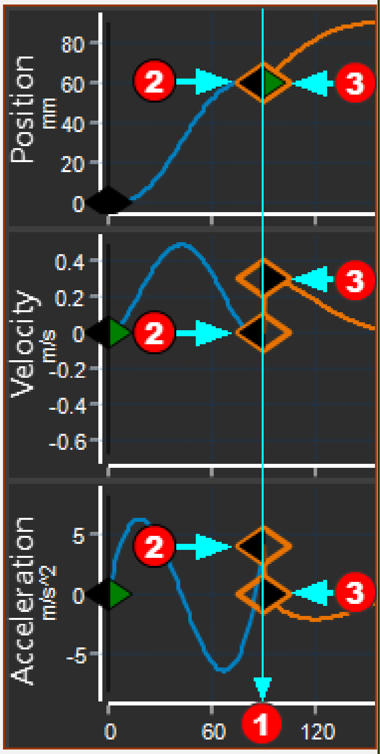


MD17



1	SEGMENT EDITOR [704]
2	BLEND-POINT EDITOR [692]
3	Insert Blend-Point [720]
4	Insert Blend-Point At [720]
5	Insert Segment [718]
6	Append Segment [718]
7	Delete Segment [719]
8	Data Transfer Table [744]

About Blend-Points (Nodes) and Motion-Values



Each **BLEND-POINT** has:

- **ONE X-axis** value(1) for **all** motion-derivatives
- **TWO Y-axis** values(23) for **each** motion-derivative
- 2 is a **Y-axis value** at the **END** of the **Previous-Segment**
- **AND**
- 3 is a **Y-axis value** at the **START** of the **SELECTED-SEGMENT**

The two **Y-axis values** can be:

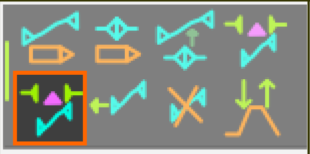
- forced to be equal, or
- forced to be different, or
- not specified, or
- one is specified and the other not specified
- one or the other is not possible to be specified

	To control the **X-axis value** and the **Y-axis-values** of **each** **BLEND-POINT**, use the: • BLEND-POINT EDITOR 692 AND / OR • SEGMENT EDITOR 704

1.6.5.1 Segment: Insert

Insert Segment

Use **Insert-Segment** to add a new SEGMENT that immediately to the left of the SELECTED-SEGMENT.



Insert Segment

1. Click **Blend-Point & Segment toolbar > Insert Segment**

A new SEGMENT is now immediately to the left of the SELECTED-SEGMENT.

The new SEGMENT is now the SELECTED-SEGMENT.

Notes:

The SEGMENT-WIDTH of the new segment is **90º** *

The new MOTION-WIDTH is **90º** wider *

Use the SEGMENT EDITOR[704] to reduce the SEGMENT-WIDTH of one or more segments, to reduce the MOTION-WIDTH again.

To add a new segment, but do NOT increase the MOTION-WIDTH, use

- Insert Blend-Point at[720] or
- Insert-Blend-Point[720].

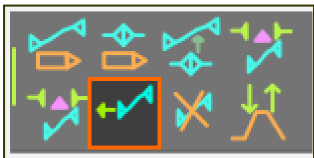
---

* 90º or an equivalent for other X–axis units[731]

1.6.5.2 Segment: Append

Append Segment

Use **Append-Segment** to add a new SEGMENT to the end of the motion, after the last SEGMENT.



Append Segment

1. Click **Blend-Point & Segment toolbar > Append Segment**

A new SEGMENT is now at the end of the motion, after the last SEGMENT.

The new SEGMENT is now the SELECTED-SEGMENT.

Notes:

The SEGMENT-WIDTH of the new segment is **90º** *.

The new MOTION-WIDTH is **90º** wider *.

Use the SEGMENT EDITOR[704] to reduce the SEGMENT-WIDTH of one or more segments, to reduce the MOTION-WIDTH again.

To add a new SEGMENT, and not change the MOTION-WIDTH, use:

- Insert Blend-Point at[720] or
- Insert-Blend-Point[720].

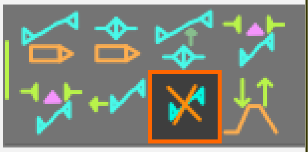
---

* 90º or an equivalent for other X–axis units[731]

1.6.5.3 Segment: Delete

Delete Segment

Use **Delete-Segment** to remove the SELECTED-SEGMENT.

 Delete Segment	Use your mouse to select a SEGMENT. It is now the SELECTED-SEGMENT. To delete the SELECTED-SEGMENT:  1. Click **Blend-Point & Segment toolbar > Delete Segment** The SELECTED-SEGMENT has been removed from the motion.

Notes:

The SEGMENT WIDTH of the **PREVIOUS-SEGMENT** increases by the SEGMENT-WIDTH of the SEGMENT that you delete.

The MOTION-WIDTH does not change.

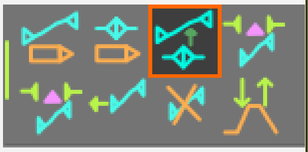
You do not get a warning.

1.6.5.4 Blend-Point: Insert

Insert Blend-Point (approximately)

Add a new **BLEND-POINT**, and to split one segment into two segments.

To add a **BLEND-POINT** at the **X-AXIS VALUE** that you click with your mouse.



Insert Blend-Point 'Approximately'

1. Click **Blend-Point & Segment toolbar > Insert Blend-Point**
2. Move your mouse-pointer to the place on motion-graph at which you want to Insert a new **BLEND-POINT**.
3. Click the motion-graph.

RESULT

A new **BLEND-POINT** splits the **SEGMENT** at the **X-axis** of your mouse-pointer. The **SEGMENT** becomes two **SEGMENTS**.

The two **SEGMENTS** have the same **motion-law**.

Recommended: Use the BLEND-POINT EDITOR 692 to move the **BLEND-POINT** to an exact X-axis value 695.

See also:

Insert Blend-Point at 720

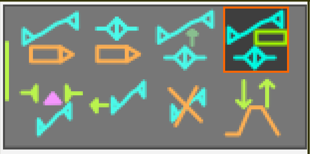
TOP-TIP: Motion Planning

1.6.5.5 Blend-Point: Insert at

Insert Blend-Point at (exactly)

Add a new **BLEND-POINT**, and to split one segment into two segments.

You must enter an **X-AXIS VALUE** for the new **BLEND-POINT** in the **INSERT BLEND-POINT AT... DIALOG**



Insert Blend-Point AT

STEP 1. **Do Insert Blend-Point at...**

1. Click **Blend-Point & Segment toolbar > Insert Blend-Point at ...**

The **INSERT BLEND-POINT AT... DIALOG** is open.

MD16

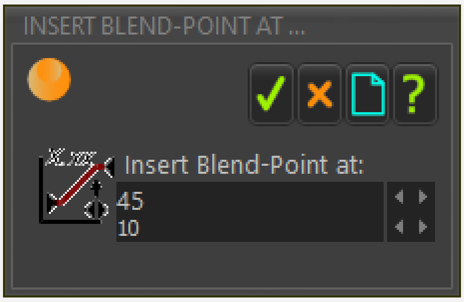
The default **X-AXIS VALUE** in the dialog is at the mid-point of the **SELECTED-SEGMENT**.

However, to add a new **BLEND-POINT**, you **must** edit the **X-AXIS VALUE** in the dialog.

STEP 2. **Edit the X-axis value for the new Blend-Point**

Do

1. Enter an **X-AXIS VALUE** with your keyboard



MD-16:
Insert Blend-Point at... dialog

2. Press the “Enter” key on your keyboard

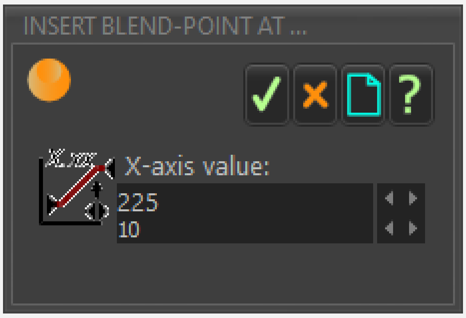
And/or do:

1. Use the **Spin-Box tool** to edit the **X-axis value**

When the **X-AXIS VALUE** for the new **BLEND-POINT** is correct:

2. Click ✓ to close the dialog

MD17



MD-17:
Insert Blend-Point at... dialog

Notes:

After you add a new **BLEND-POINT**, you can also edit its **X-AXIS VALUE** with the BLEND-POINT EDITOR [695]

You cannot enter an **X-AXIS VALUE** for the **BLEND-POINT** that is:

- Less than the MOTION-START [695]
- Greater than MOTION-WIDTH [742] + **MOTION-START**

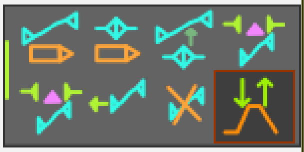
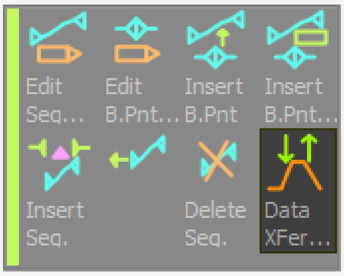
See-also: TOP-Tip: Motion Planning

1.6.5.6 Open Data-Transfer Table

Open Data Transfer Table

Use this command to open the **Data Transfer Table**

Use the **Data Transfer Table** to export and to import motion-files.

MD16	MD17
 MD16 Blend-Point and Segment toolbar	 MD17 Blend-Point and Segment toolbar

To open the **Data Transfer Table**:

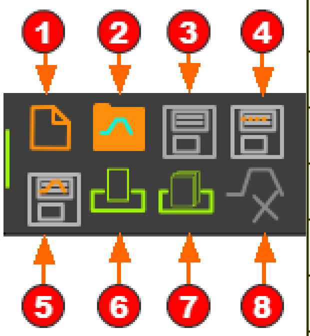
1. Click **Blend-Point & Segment toolbar > Data Transfer Table icon**.

The **Data Transfer Table** is now open - **see more:** Data Transfer Table 744

1.6.6 File toolbar

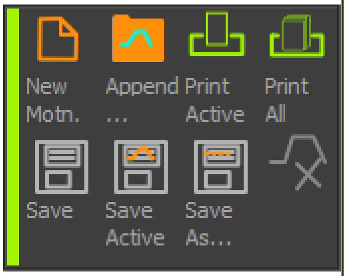
File toolbar

MD 16



MD16: File toolbar

MD 17



MD17: File toolbar

1	Add New Motion [723]
2	Open and Append Motion [724]
3	Save all [724] - See Note
4	Save all as... [725] - See Note
5	Save Active Motion as... [727] - See Note
6	Print Active Motion [729]
7	Print all Motions [729]
8	Delete Active Motion [729]

Notes:

When you save a model:

- we use the CXL file-extension for the MechDesigner model
- we use the MTD file-extension, with the same file-name as the MechDesigner model, for the motions in MotionDesigner

You can also save one or all motions with:

- MOTIONDesigner > File toolbar > Save all as [725] ... to save all of the motions to a different file-name.
- MOTIONDesigner > File toolbar > Save Active Motion [727] ... to save one motion to a different file-name.

Why save a motion to a different file-name?

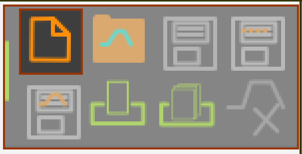
E.g. If a motion-design is complex you may want to save a motion, then re-import it to experiment with different motion-values.

You can use the motion you re-import as the basis for a different product, size, format, or machine.

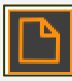
1.6.6.1 File: Add New Motion

Add New Motion

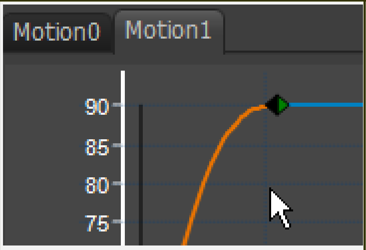
To add a new **Motion name-tab.**



Add New Motion



1. Click **File toolbar** > **Add New Motion**



Motion name-tabs

The new **Motion name-tab** is now the active **Motion name-tab.**

The new **Motion name-tab** is to the right of all other **Motion name-tabs.**

The new **Motion name-tab** is the default motion with four Flexible-Polynomial[777] segments.

See also:

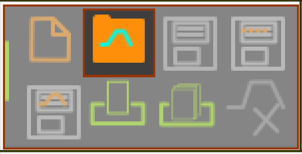
Motion name-tabs[683]

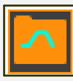
Open and Append[724]

1.6.6.2 File: Open and Append

Open and Append Motion

To open motion files you have saved to append to those existing **Motion name-tab(s).**





1. Click **File toolbar** > **Open and Append**

See also: Add Motion[723]

Open and Append Motion file-types

MTD: MotionDesigner file-type

The **MTD** file may include any number of motions. Each motion in the MTD file will add a **Motion name-tab.**

DA: Jetter file-type

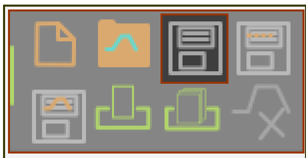
TXT: Logix 5000 Cam file (beta-testing) file-type

SHP: Camlinks & Motion file-type

1.6.6.3 File: Save All Motions

Save All

To save all motions to one file.



1. Click **File toolbar** > **Save All**

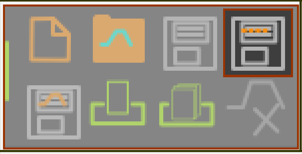
MotionDesigner files-types are **MTD** file-type.

	Note: We save for you all of your motions to the MTD file-type when you save the **MechDesigner** model.

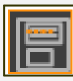
See also: Open And Append [724], Save All As [725], Add Motion [723], Save [727], Close [729]

1.6.6.4 File: Save All Motions As...

Save all as ...



To save all motions to one file with a new file-name:



1. Click **File toolbar > Save All as ...**

Note: When you save the **MechDesigner** model to a **CXL** file, we also save for you **all** of the motions in **MotionDesigner** to one **MTD** file with the same file-name as the CXL file.

See also: Save All [724], Save Active Motion [727], Delete/Remove [729], Add Motion [723], Open and Append [724]

Save as Motion file-types

MTD: MotionDesigner file-type

Save all of the Motions to one MTD file.

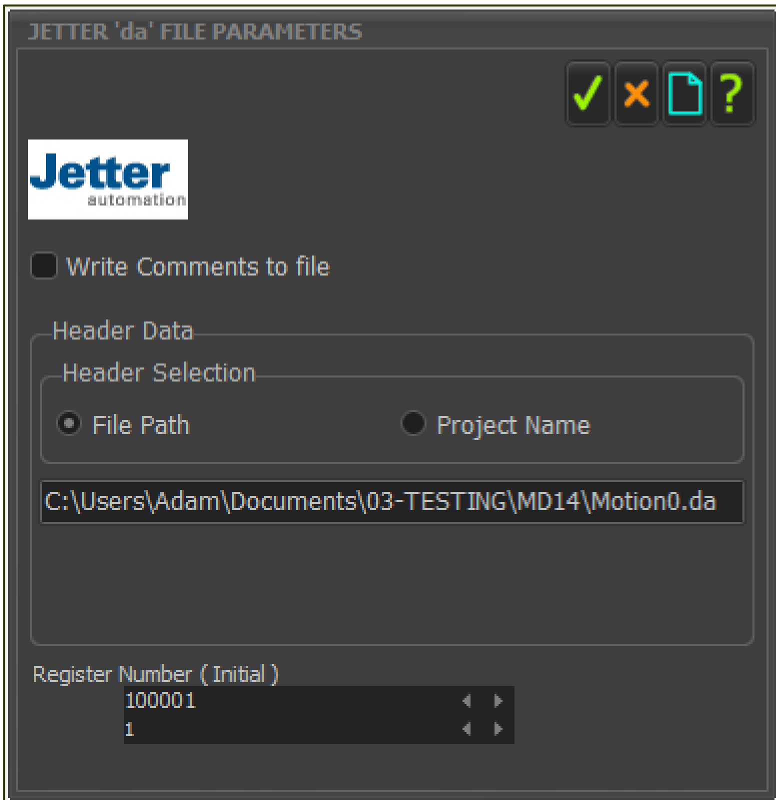
DA: Jetter file-type

Save as the Jetter Automation file-type - see below.

TXT: Logix 5000 Cam file (beta-testing) file-type

Save as the Allen-Bradley (Rockwell) Logix 5000 Cam file-type.

Jetter File-Type Dialog-box



WRITE COMMENTS TO FILE

Click the check-box if you want the DA file to explain the function and parameter of each line

HEADER DATA BOX

Use the check-box to write, as text, at the top of the DA file:

- **File Path** - the path is in the box- it is **read-only**.

- or -

- **Project Name** - you must write the Project Name in the box

REGISTER NUMBER AT START BOX

Enter a **Register Offset** in the box

OK, CLOSE, CANCEL OR HELP BUTTONS

MotionDesigner saves each motion to a different file. The file-name is the Motion name-tab.

Notes on the DA file

All motion-type are saved as the Polynomial file-type, with their coefficients.

If the segment is a **Traditional Motion-Law** of the **Harmonic Type**, for example **Modified-Sinusoid**, then:

1. The actual **Mod-Sine** segment is divided into sub-segments.

   The Blend-Points for the sub-segments are at the 'natural' positions within the Segment.

2. The sub-segments are saved as **Polynomials**.

   The Polynomial coefficients minimize the error between the actual Segment and the **Polynomial** Segment.

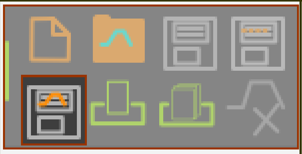
For example:

- **Modified-Sinusoid Motion-Law** has three sub-segments
- **Modified-Trapezoidal Motion-Law** has five sub-segments

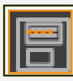
To review the BLEND-POINTS and the sub-segments, do Open and Append[724] and select the **DA** file-type after you save it.

1.6.6.5 File: Save Active Motion

Save Active Motion



To save the active Motion only:



1. Click **File toolbar > Save Active Motion**

See also: MOTION FILE-TYPES, below

See also: Save All[724] , Save[727]

Save Active Motion File-Types:

MTD: MotionDesigner File-Type.

The active motion is saved to the MTD file-type

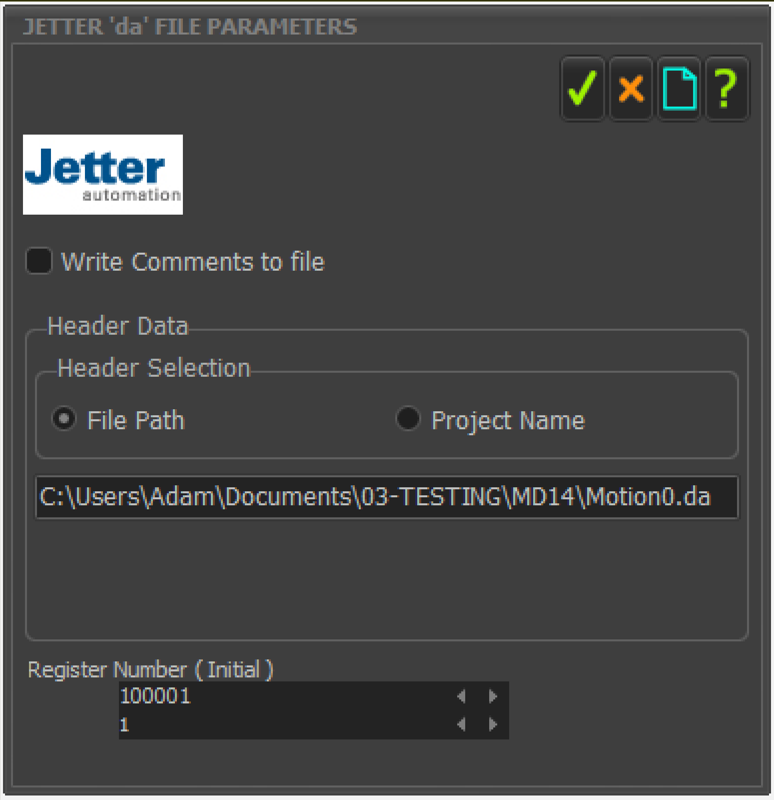
DA: Jetter File-Type

This is the Jetter Automation file-type - see below.

TXT: Logix 5000 Cam file (beta-testing)

This is the Allen-Bradley (Rockwell) Logix 5000 Cam file-type.

Jetter File-Type Dialog-box



Jetter .DA Save as interface

When you select DA as the file-type, this interface opens.

You have the option to enter these parameters:

WRITE COMMENTS TO FILE

Click the check-box if you want the DA file to explain the function and parameter of each line

HEADER DATA box

Use the check-box to write, as text, at the top of the DA file:

- **File Path** - the path is in the box- it is **read-only**.

  - or -

- **Project Name** - you must write the Project Name in the box

REGISTER NUMBER AT START BOX

Enter a **Register Offset** in the box

OK, Close, Cancel or Help buttons

MotionDesigner saves the motion as a .DA file-type. The file-name is the same as the Motion name-tab.

Notes on the DA file

All motion-types are saved as a polynomial file-type, with their coefficients.

If the segment is a **Traditional Motion-Law** of the **Harmonic Type**, for example **Modified-Sinusoid**, then:

1. The actual **Mod-Sine** segment is divided into sub-segments.

   The Blend-Points for the sub-segments are at the 'natural' positions within the Segment.

2. The sub-segments are saved as **Polynomials**.

   The Polynomial coefficients minimize the error between the actual Segment and the **Polynomial** Segment.

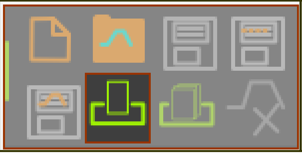
For example:

- **Modified-Sinusoid Motion-Law** has three sub-segments
- **Modified-Trapezoidal Motion-Law** has five sub-segments

To review the Blend-Points and the sub-segments, you can do: Open and Append 724 and select the **DA** file-type after you save it.

1.6.6.6 File: Print

Print Active Motion

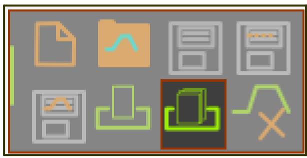


File toolbar > Print Motion

Prints the active Motion

1.6.6.7 File: Print All

Print All Motions



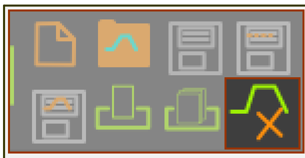
File toolbar > Print ALL Motions

Print **ALL** of the motions.

1.6.6.8 File: Delete Active Motion

Delete Active Motion

WARNING - there is **NO WARNING !!!**



There is no WARNING that you will **DELETE** the **Motion name-tab**

and

You cannot undo **DELETE ACTIVE MOTION!!!**

File toolbar > Delete Active Motion IMMEDIATELY

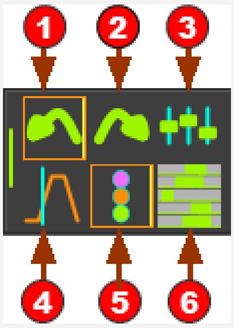
1. Click the name-tab of the motion that you want to delete
2. Click File toolbar > Delete Active Motion

Notes:

- You cannot delete all **Motions name-tabs** - one Motion name-tab must be available.
- You cannot delete a motion that has a link with a **MOTION FB** (in **MechDesigner**).

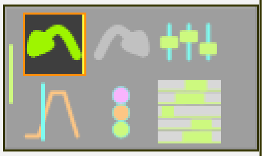
1.6.7 Edit toolbar

Edit toolbar

MD16  MD16: Edit toolbar **MD17**  MD17: Edit toolbar	1	Undo [730]
	2	Redo [730]
	3	Active Motion Settings [731] / Configure Motion / Re-name Motion [731]
	4	Sweep Display [733]
	5	Auto-Update [734]
	6	Display Motion Chart [735]

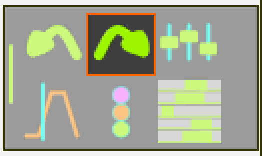
1.6.7.1 Edit: Undo

Undo

	Edit toolbar > Undo ... to **undo** the previous motion edit. You can continue to **undo** more edits. **Note:** You may need to click in the **MotionDesigner** application window before you can use Undo.
See also: Redo [730]	

1.6.7.2 Edit: Redo

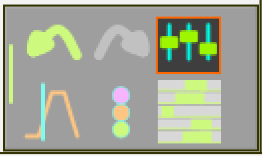
Redo

	Edit toolbar > Redo 1. Click **Edit toolbar** > **Redo** to **redo** the last undone command. You can continue to **redo** all undone commands. **Note:**

	Each **Motion name-tab** has its own stack you can Redo.
See also: Undo 730, Command History 730	

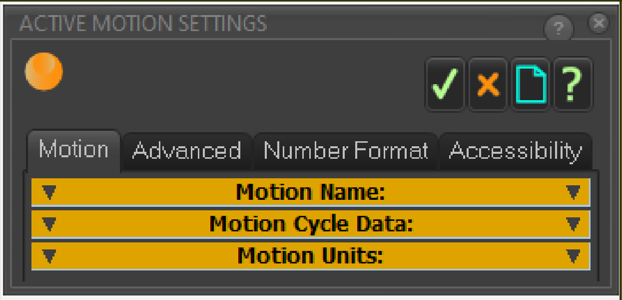
1.6.7.3 Edit: Active Motion Settings

Active Motion Settings



Edit toolbar > Active Motion Settings

Each motion has settings.



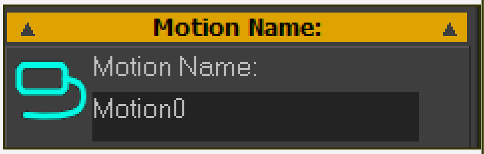
Active Motion Settings dialog

There are four tabs:

- **Motion**
- **Advanced**
- **Number-Format**
- **Accessibility**

Note: The settings become the default settings when you exit MechDesigner.

Motion tab



Motion name-tab (read-write)

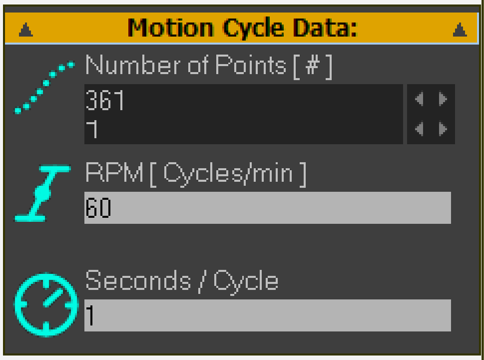
MOTION NAME

MOTION NAME **(read-write)** (default = Motion0, Motion1, ...)

Enter a new MOTION NAME with your keyboard.

Press the ENTER key on your keyboard.

The new Motion-Name is now the **Motion name-tab**.



MOTION CYCLE DATA

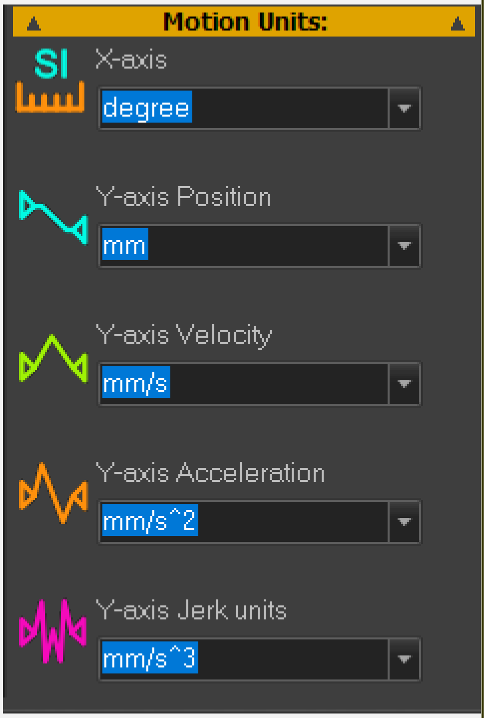
NUMBER-OF-POINTS **(read-write) (default = 360)**

The NUMBER-OF-POINTS along the active motion graph.

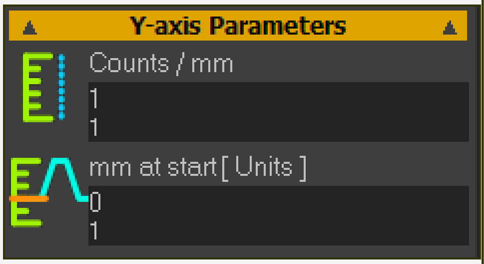
Note:

Enter NUMBER-OF-POINTS = 361 to put a Motion-Point exactly on each machine-degree as defined by the **MMA**.

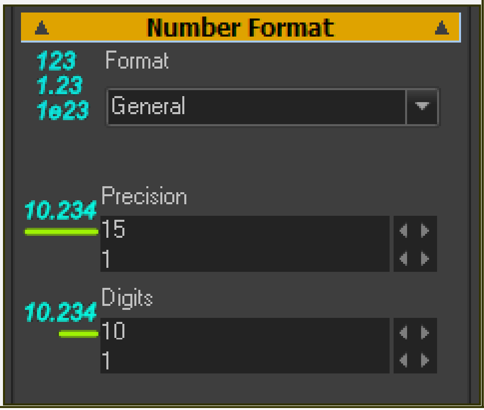
RPM [CYCLES/MIN] **(read-only)**

<table>
<tr><td></td><td>RPM : Machine cycles per minute.
See: MechDesigner - Edit menu>Machine Settings>Cycling Parameters>Cycles/Min
SECONDS / CYCLE (read-only)
SECONDS / CYCLE = 60 / CYCLES/MIN</td></tr>
<tr><td>
</td><td>MOTION UNITS
X–AXIS UNITS: (default = degrees)
Units available: counts: sec, msec, cycle, degree, radian.
Y–AXIS UNITS: (default = degrees or mm)
Units available: mm, cm, m, inch, degree, radian, cycle, count.
<table>
<tr><td>POSITION :</td><td>Units</td></tr>
<tr><td>VELOCITY :</td><td>Units/s</td></tr>
<tr><td>ACCELERATION :</td><td>Units/s^2</td></tr>
<tr><td>JERK :</td><td>Units/s^3</td></tr>
</table>
Note:
Change from Angular to Linear Units, or vice versa: If you change from Angular Units to Linear Units, then $1^\circ = 1\ mm$
The motion does not have a different physical value when you select different Y-AXIS UNITS. E.g. 90mm becomes 0.090m, or 3.543inches.</td></tr>
</table>

Advanced tab

<table>
<tr><td>
</td><td>X-AXIS PARAMETERS
[UNITS] AT START (default = 0)
Edit Unit data-type in Motion tab > 731 Motion Units</td></tr>
<tr><td>
</td><td>Y-AXIS PARAMETERS
COUNTS / DEGREE (default =1)
Edit Unit data-type in Motion tab > 731 Motion Units
COUNTS AT START (default = 0)
Edit Unit data-type in Motion tab > 731 Motion Units</td></tr>
</table>

Number Format tab



NUMBER FORMAT

FORMAT (**default : General**)

See Number Format

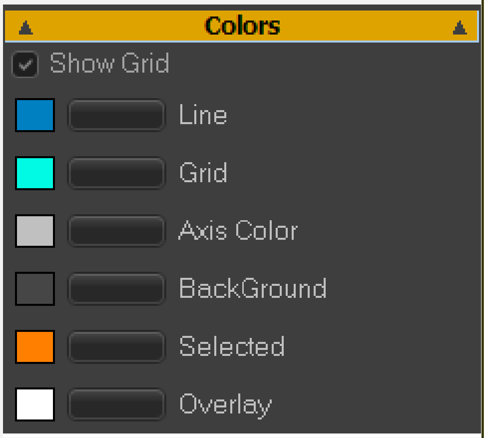
PRECISION **(default = 6)**

See Precision

DIGITS **(default = 3)**

See Digits

Accessibility tab

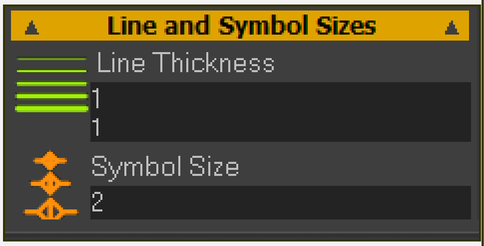


COLORS

☑ Show Grid : Enable to show the horizontal and vertical grid lines in the graph-plot area.

Colors : edit with **Windows Color Picker®** :

- **Line:** of all segments, but not the SELECTED-SEGMENT
- **Grid:** the vertical and horizontal Grid-Lines
- **Axis Color :** X and Y-axis text
- **Background:** the graph area
- **Selected:** the SELECTED-SEGMENT **(typically Red)**
- **Overlay:** see Overlay-Trace 751



LINE AND SYMBOL SIZES

LINE THICKNESS **(default = 1 ; Maximum = 8)**

The plot thickness, in pixels, of the motion segments

SYMBOL SIZE **(default = 2 ; Maximum = 8)**

The scale/size of the BLEND-POINT symbols

1.6.7.4 Edit: Sweep-Display

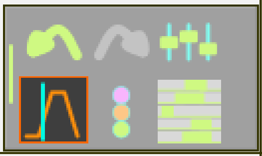
Sweep-Display

Use to evaluate exact P, V, A, J motion-values at any **X-axis value** as defined by the CURSOR-POSITION parameter.

As you edit the X-axis value with the **CURSOR-POSITION** parameter, a vertical cursor shows on the motion graphs at the **X-axis value.**

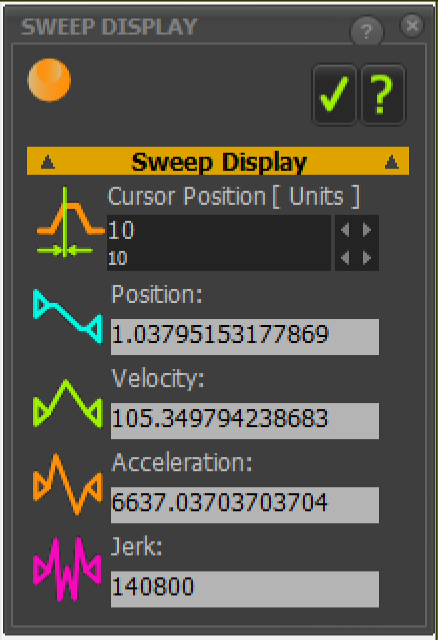
BUG: The Cursor does not sweep correctly when **MOTION-START ≠ 0**.

See Blend-Point Editor > X-axis Values > Motion-Start [695] **.**



To open the **Sweep-Display dialog**:

1. Click **Edit toolbar > Sweep-Display icon**



Sweep-Display dialog

SWEEP-DISPLAY

CURSOR POSITION

The **X-axis value** at which to evaluate exact motion-values.

POSITION, VELOCITY, ACCELERATION, JERK (read-only)

The exact **POSITION, VELOCITY, ACCELERATION**, and **JERK** motion-values at the **X-axis value** as defined by the **CURSOR-POSITION**.

The advantage of the **Sweep Display** is that you can see a vertical cursor on the motion graphs at the **X-axis value**.

The advantage of the **Motion-Value Evaluator** is that you can enter an X-axis value greater than the last X-axis point - see **Notes** below.

See also: Motion-Width [742] **, Number of Steps** [731] **, Motion-Value Evaluator** [684]

Notes:

Edit **DIGITS** and **PRECISION** of the motion-values with:

Edit toolbar > Active Motion Settings > Number Format tab | Number-Format separator [732] .

Maximum CURSOR POSITION = MOTION-WIDTH – NUMBER OF STEPS / MOTION-WIDTH.

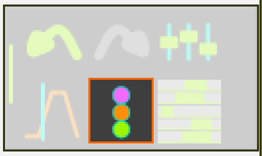
For example: If **MOTION-WIDTH = 360. and:**

NUMBER-OF-STEPS = 360; Maximum **CURSOR POSITION ≤ 359**

NUMBER-OF-STEPS = 3600; Maximum **CURSOR POSITION ≤ 359.9**

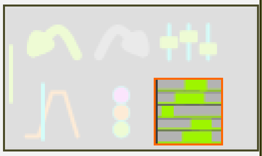
1.6.7.5 Edit: Rebuild Motions

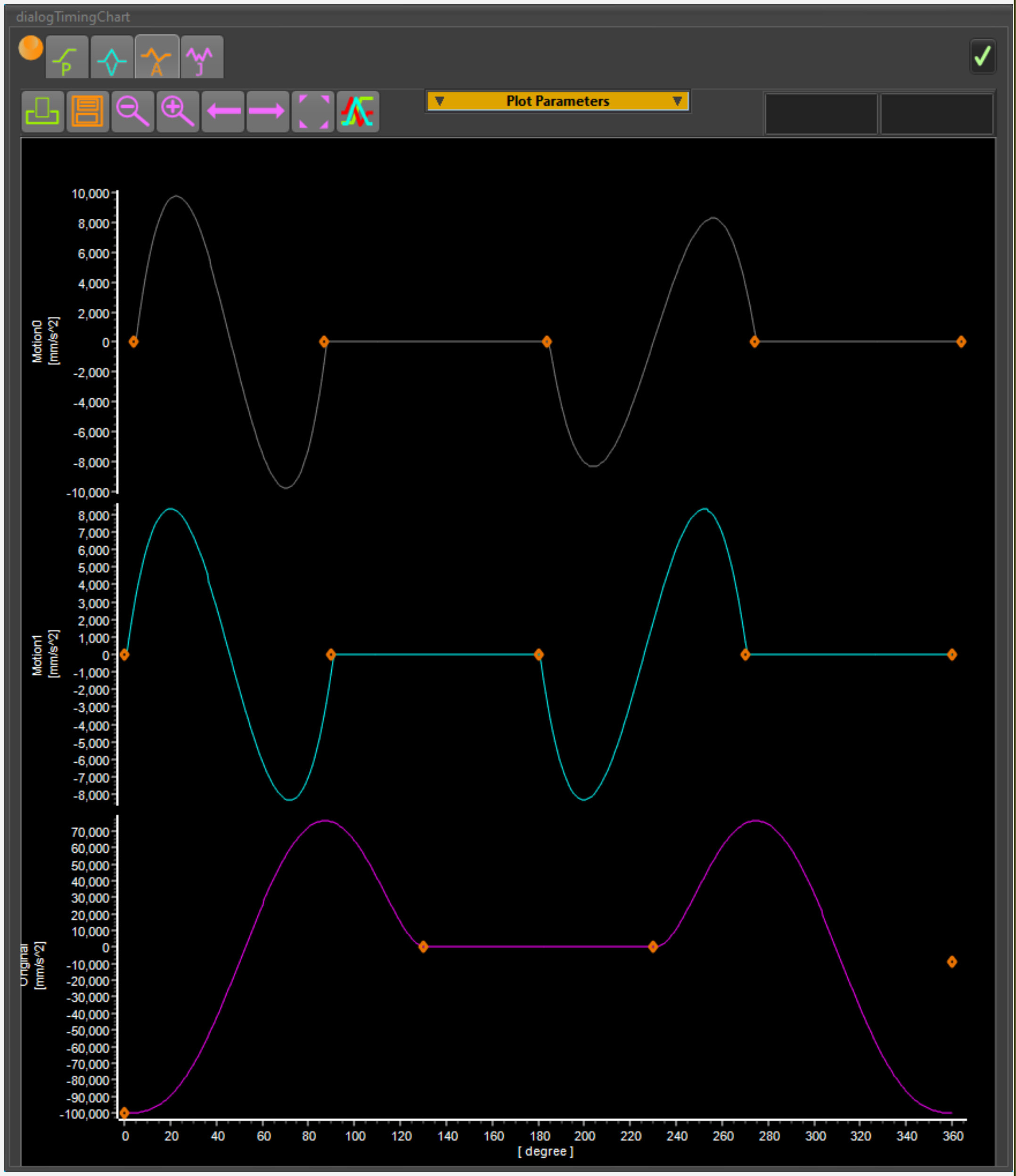
Auto-Update Motion

	Edit toolbar > Rebuild icon **Enable** - to rebuild the model as you edit a motion-value. or **Disabled** - to edit motion-values quickly. The model may not update to the new motion-value after each edit.

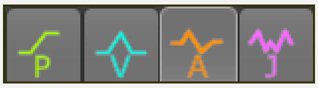
1.6.7.6 Edit: Display Motion Chart

Motion Chart

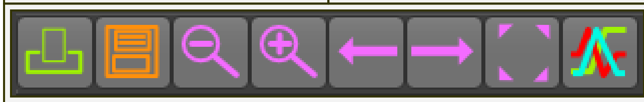
	Edit toolbar > Display Motion-Chart Display all of the motions in a chart. You can choose to display all of the P, V, A, or J charts for each motion. You can choose to display the motions above or over each other. You also Print the chart.



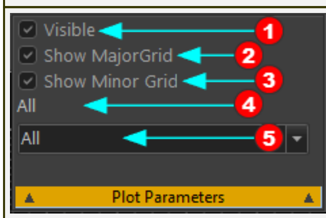
Click to Expand and Collapse
Motion Charts shown "above" each other.



Select which motion-derivative to display in the Motion Timing Chart.



Print, Save as, Zoom-Out, Zoom-In, Pan Left, Pan Right, Zoom Extents, Toggle: Display across each other or Display above each other.



Plot Parameters

PLOT PARAMETERS: - click to show these options:

❶ Enable to show the Motion as indicated in ❹

❷ Enable the Major Grid for the Motion in ❹

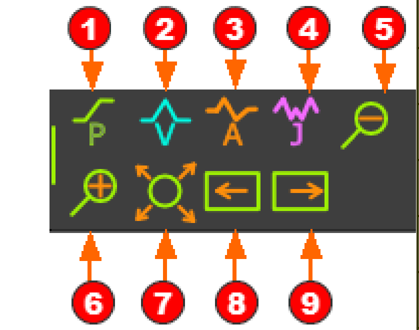
❸ Enable the Minor Grid for the Motion in ❹

	❹ The Motion (in this case “All” of the Motions) to apply the setting ❶❷❸. ❺ Drop-down to select which motion, or All, to apply the settings ❶❷❸.

1.6.8 View toolbar

View Toolbar

MD16



MD16: View toolbar

MD17

MD17: View toolbar

1	Show/Hide Position Graph [738]
2	Show/Hide Velocity Graph [739]
3	Show/Hide Acceleration Graph [739]
4	Show/Hide Jerk Graph [739]
5	Zoom Out [739]
6	Zoom In [739]
7	Zoom Extents [739]
8	Pan Left [740]
9	Pan Right [740]

Notes on Motion Graphs

You must show a minimum of one motion-derivative graph.

If you show more than one graph:

- the Position graph is above all other graphs
- the Velocity graph is below the Position graph, and/or above the Acceleration, and/or Jerk graph
- the Acceleration graph is below the Velocity graph, and/or above the Jerk graph
- the Jerk graph is below all other graphs

1.6.8.1 View: Show Position Graph

Show Position

View toolbar > Show POSITION Graph

Show or Hide the **POSITION** graph.

Terminology:

- **POSITION** is the location relative to a datum, similar to an X, Y, Z co-ordinate.
- **DISPLACEMENT** is the movement from one position to a different position.

See also: Show Velocity [739], Show Acceleration [739], Show Jerk [739]

1.6.8.2 View: Show Velocity Graph

Show Velocity

View toolbar > Show VELOCITY Graph

Show or Hide the **VELOCITY** graph.

Note:

VELOCITY is the rate-of-change of **POSITION** with respect to time.

See also: Show Position [738], Show Acceleration [739], Show Jerk [739]

1.6.8.3 View: Show Acceleration Graph

Show Acceleration

View toolbar > Show ACCELERATION Graph

Show or Hide the **ACCELERATION** graph.

Note:

ACCELERATION is the rate-of-change of **VELOCITY** with respect to time.

See also: Show Position [738], Show Velocity [739], Show Jerk [739]

1.6.8.4 View: Show Jerk Graph

Show Jerk

View toolbar > Show JERK Graph

Show or Hide the **JERK** graph.

Note:

JERK is the rate-of-change of **ACCELERATION** with respect to time.

See also: Show Position [738], Show Velocity [739], Show Acceleration [739]

1.6.8.5 View: Zoom-In

Zoom-In

View toolbar > Zoom-In

Expand the **X–axis** (NOT the Y-axis) to see less of the motion.

See also: Zoom-Out [740], Zoom Extents [739], Pan Left [740], Pan Right [740]

1.6.8.6 View: Zoom-Extents

Zoom-Extents

View toolbar > Zoom Extents

	Scale the **X-axis** to equal the Motion-Width.
See also: Zoom-In[739], Zoom-Out[740], Pan Left[740], Pan Right[740]	

1.6.8.7 View: Pan Left

Pan-Left

	View toolbar > Pan Left Move the **X-axis** of the motion graph to the right. This tool does **not** change the timing of the motion. To change the timing of the motion, see: Blend-Point Editor > X-axis values > Motion-Start.
See also: Zoom-In[739], Zoom-Out[740], Zoom Extents[739], Pan Right[740]	

1.6.8.8 View: Pan Right

Par Right

	View toolbar > Pan Right Move the **X-axis** of the motion graph to the left. This tool does **not** change the timing of the motion. To change the timing of the motion, see: Blend-Point Editor > X-axis values > Motion-Start.
See also: Zoom-In[739], Zoom-Out[740], Zoom Extents[739], Pan Right[740]	

1.6.8.9 View: Zoom-Out

Zoom-Out

	View toolbar > Zoom-Out Contract the **X–axis** (NOT the Y-axis) to see more of the motion.
See also: Zoom-In[739], Zoom Extents[739], Pan Left[740], Pan Right[740]	

1.6.9 Motion toolbar

Motion toolbar

The Motion toolbar is below the graphs.

To see all of the Motion toolbar, you may need to increase the width of **MotionDesigner**.

You can do one of the following:

- Drag the left edge of the **MotionDesigner** graphs, to the left.
- Float (undock) **MotionDesigner** - see MechDesigner > Visibility menu > Float or Dock MotionDesigner.

MD16

MD16: Motion toolbar

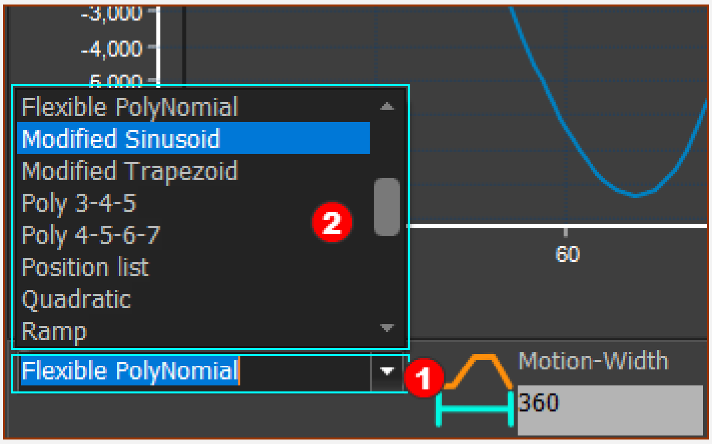
MD17

MD17: Motion-toolbar

1. Motion-Law Selector 741
2. Motion-Width 742 (read-only)
3. Motion Value Evaluator 743 (read-write)

1.6.9.1 Motion Law Selector

Motion-Law Selector



Motion-Law Selector list box

It is below the **Motion** graphs, at the left side of the **Motion toolbar**.

Before you can use the **Motion-Law Selector**:

1. Click a above or below a segment to move the program focus to **MotionDesigner.**
2. Click above or below a segment to make it the SELECTED-SEGMENT

Now, use the **Motion-Law Selector** to:

- Identify the MOTION-LAW of the SELECTED-SEGMENT

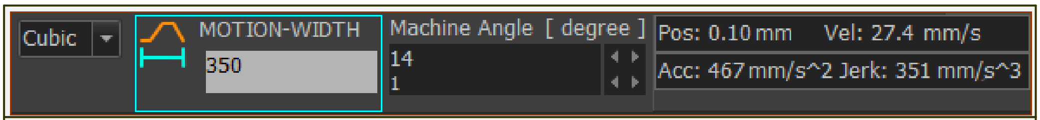
AND/OR

- Use the drop-down to select a different MOTION-LAW for the SELECTED-SEGMENT

See also Motion-Laws [755]

1.6.9.2 Motion-Width

Motion-Width (read-only)



MOTION-WIDTH = ∑ SEGMENT-WIDTHS [707]

IMPORTANT

Most typically, the MOTION-WIDTH = 360. Then, the timing of the motion will equal the timing of the **Master-Machine-Angle (MMA)**

To edit the MOTION-WIDTH, you must use the SEGMENT EDITOR [704] to edit the SEGMENT-WIDTH of one or more segments.

If MOTION-WIDTH is to equal one machine-cycle.

And the X-AXIS UNITS are:

Degrees: MOTION-WIDTH =360

Radians: MOTION-WIDTH $=2.\pi$

Seconds: MOTION-WIDTH = 60 / (CYCLES / MINUTE)

Milliseconds: MOTION-WIDTH = 60 000 / (CYCLES / MINUTE)

CYCLE/MINUTE

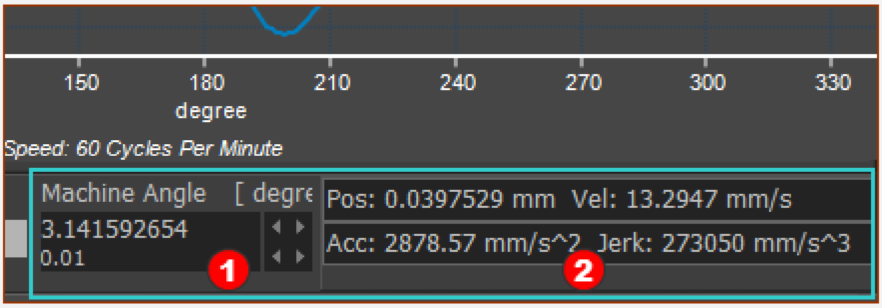
See MechDesigner: Edit menu > Machine-Settings > Cycling Parameters.

To edit the X-axis Units:

Active Motion-Settings > Motion tab > Motion Units > X-axis [731]

1.6.9.3 Motion-Value Evaluator

Motion-Values Evaluator



Machine-Angle(1) : Evaluate Motion-Values(2)

For any real number you enter as a **MACHINE-ANGLE**❶, we evaluate for you the exact **motion-values**❷ (**P**, **V**, **A**, **J**).

See also: Motion-Values at Pointer 684 , Sweep-Display 733

1.6.10 Data Transfer Table

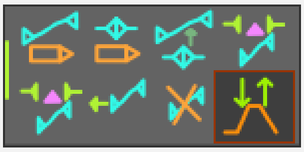
Data Transfer Table

Use the **Data Transfer Table** to:

- **Import data** from a **GRAPH FB**, or from a different application, e.g. NotePad, Excel, to the table and then to a **List segment-type**
- **Export motion data** from a motion-graph to the table and then save or copy the data.
- **Display data** in the table as a dumb-graph over a motion-graph - **see** Overlay Trace 751

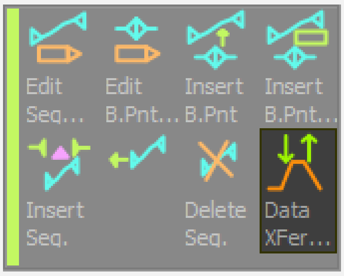
Open the Data Transfer Table

MD16



MD16
Blend-Point and
Segment toolbar

MD17



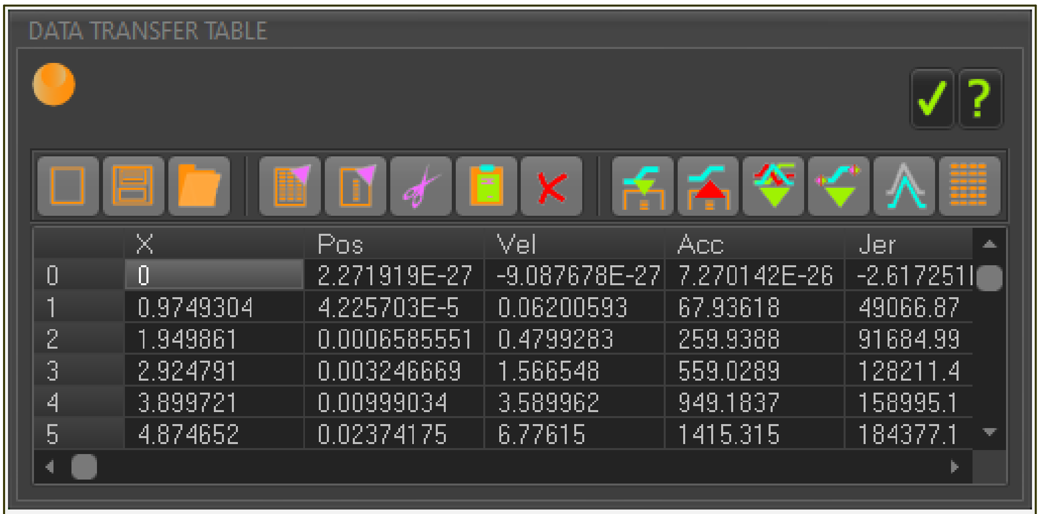
MD17-
Blend-Point and
Segment toolbar

To open the **Data Transfer Table**:

1. Click **Blend-Point & Segment toolbar** > **Data Transfer Table** icon.

The **Data Transfer Table** is now open.

Data Transfer Table



	X	Pos	Vel	Acc	Jer
0	0	2.271919E-27	-9.087678E-27	7.270142E-26	-2.617251
1	0.9749304	4.225703E-5	0.06200593	67.93618	49066.87
2	1.949861	0.0006585551	0.4799283	259.9388	91684.99
3	2.924791	0.003246669	1.566548	559.0289	128211.4
4	3.899721	0.00999034	3.589962	949.1837	158995.1
5	4.874652	0.02374175	6.77615	1415.315	184377.1

Data Transfer Table

Note: X-axis, Row 0 is at the Motion-Start 695.

Data Transfer Table toolbar

	Clear all data from the table[747] : Remove all the data from the **Data Transfer Table**.
	Save data to a CSV, TXT, or DAT file-type[747] : Save all of the data in the motion-graphs to a **CSV**, **TXT**, or a **DAT** file-type.
	Open and load data from a CSV, TXT, DAT file-type[747] : Load data in a **CSV**, **TXT**, or **DAT** file-type, and paste into the table.
	Copy all data to clipboard[748] : Copy **all** data in the **Data Transfer Table** to the Windows© clipboard.
	Copy selected data to clipboard[748] : Copy the selected data to the Windows© clipboard.
	Cut selected data to clipboard[748] : Remove selected data from the **Data Transfer Table** and copy to the Windows© clipboard.
	Paste clipboard to table[749] : Paste data in the Windows© clipboard to the **Data Transfer Table**, starting at the active cell.
	Delete selected data from table[749] : Delete the selected data from the **Data Transfer Table**.
	Get data from List segment-type[749] : The SELECTED-SEGMENT must be a **List Segment-Type**.
	Put data to a List segment-type[750] : The SELECTED-SEGMENT must be a **List Segment-Type**.
	Get all displayed P,V,A,J motion-data[750] : Transfer to the Data Transfer Table the motion-values of the motion graphs in the active motion - see also: **Note 1**, below.
	Get all displayed P,V,A,J segment-data[751] : Transfer to the Data Transfer Table the motion-values of the motion-derivative graphs that show, for the SELECTED-SEGMENT only - see also **Note 1**, below.
	Show data as an Overlay-Trace[751] : Display the motion-values that are in the **Data Transfer Table** as an OVERLAY-TRACE. You can toggle this icon to show or hide the OVERLAY-TRACE. An OVERLAY-TRACE is a **dumb graph** that shows with the active motion graph.
	Toggle: Include/Ignore last value in Data Transfer Table[754] Often you want to transfer the motion-values that are in the **Data Transfer Table** to another application - see also **Note 2**, below. With a non-progressive motion, your application may need: • the last and first data points to be equal, or

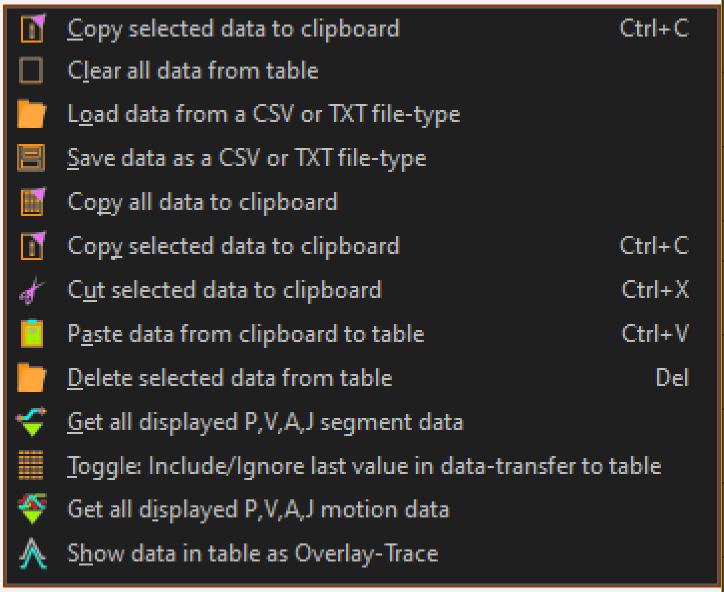
- the last and first data points to be not equal.

Notes:

1. Only data from those motion-derivatives that are showing as graphs.
2. You may need to increase or decrease the Number of Points[731] in the motion by 1 to get a motion-value exactly at each machine degree or millisecond - e.g. from 360 to 361 Points

Data Transfer Table: Shortcut menu

Right-click in the **Data Transfer Table** to show the shortcut menu.



- Copy Selected Data to the Clipboard[748]
- Clear all data from table[747]
- Load data from a CSV or TXT file-type[747]
- Save to Text File[747]
- Copy all data to clipboard[748]
- Copy selected data to clipboard[748]
- Cut selected data from table[748]
- Paste data from clipboard to table[749]
- Delete selected data from table[749]
- Get all displayed P,V,A,J segment data[751]
- Toggle: include/ignore last value in Data Transfer Table[754]
- Get all displayed P,V,A,J motion data[750]
- Show Data as an Overlay Trace[751]

What happens when you PUT data to a List segment-type

When you **PUT data** to a **List segment-type:**

- **MotionDesigner** recalculates for you the data in your list to put the correct number of points, which are proportional to the SEGMENT-WIDTH of the **List Segment-Type**.
- **MotionDesigner** numerically calculates for you all motion-derivatives from the data.

The minimum number-of-points (rows) you can transfer to a **List Segment-Type** is 6. We recommend many more than 6 points.

Get data from Motion / Segment

When you **GET data** from the motion or a segment:

NUMBER-OF-COLUMNS: X-axis + each displayed motion-derivative

NUMBER-OF-ROWS (**Motion**): = NUMBER-OF-STEPS in ACTIVE MOTION SETTINGS [731]

NUMBER-OF-ROWS (**Segment**): = NUMBER-OF-STEPS × SEGMENT-WIDTH / MOTION-WIDTH

1.6.10.1 Clear all data from the table

Clear All data from the Data Transfer Table

Click to clear, or remove, all data from the **Data Transfer Table**.

1.6.10.2 Save data to a CSV or TXT file-type

Save All Data or Save Selected Data to a Text File

Click to Save all data in the table to a file.

You can save the data as these file-types: CSV, TXT, or DAT.

The data does not need to be in the **Data Transfer Table**.

File-type	Description	Data
CSV	Comma Separated Values Numbers separated with the List separator	Index Number, X-axis value, Motion-Value at X-axis value for each graph.
TXT	Numbers separated with List Separator	Index Number, X-axis value, Motion-Value at X-axis value for each graph.
DAT	Compatible with Camlinks DAT file-type	Index Number, X-axis value, Motion-Value at X-axis value for each graph.

1.6.10.3 Load a CSV or TXT file-type

Open a Text File

Open a file that is a CSV, TXT, or DAT file-type.

The data in the file fills the table from the active cell in the **Data Transfer Table**

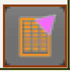
Usually, use the data in a segment that is a **List Segment-Type** or an Overlay Trace [751].

List Segments-Types are:

- Position List [803] : **MotionDesigner** numerically differentiates the data to create Velocity, Acceleration, and Jerk.
- Acceleration List [758] : **MotionDesigner** numerically integrates the data to create Velocity and Displacement.
- Z Raw-Data [834] : **MotionDesigner** numerically differentiates the data to create Velocity, Acceleration, and Jerk.

1.6.10.4 Copy all data to clipboard

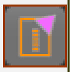
Copy all Data



Copy all data in the **Data Transfer Table** to the Windows® Clipboard.

1.6.10.5 Copy selected data to clipboard

Copy Selected Data



Save data to the Windows® Clipboard.

Select the Data:

1. Click a cell in the table
2. SHIFT+Click a different cell

The data is now **selected.**

3. Click this icon in the Data Transfer toolbar.

The **selected data** is now on your Clipboard.

1.6.10.6 Cut selected data from table

Cut Selected Data from Table to Clipboard

Use to cut the **Selected Data*** from the table and place on your Windows Clipboard.

You can:

- Paste the data to a computer application, such as Notepad®, WordPad®, Word®, Excel®, etc.
- Paste the data back into the Data Transfer Table.

*** Selected Data:**

1. Click a cell in the table
2. SHIFT+Click a different cell

The highlighted data is now the **Selected Data.**

See also:

Data Transfer: Copy [748],
Data Transfer: Paste [749]

1.6.10.7 Paste data from clipboard to table

Paste Data to Table

	Paste data from your clipboard to the **Data Transfer Table**. 1. Click a cell in the table 2. Click the icon to paste the data The data is now in the Data Transfer Table.

See also:

Data Transfer: Cut 748

Data Transfer: Copy 748

1.6.10.8 Delete selected data from table

Delete Selected Data from Data Transfer Table

	Delete **selected data*** from table. * **To select data:** 1. Click a cell in the table 2. SHIFT+Click a different cell The Selected Data is now the **Selected Data.**

See also:

Data Transfer: Copy 748

Data Transfer: Paste 749

1.6.10.9 Get data from List Segment-Type

Get Data from a List Segment-Type

Note: This icon is in the toolbar **only** when the SELECTED-SEGMENT is a **List Segment-Type**.	
	Get List Data : to get the data that you originally put to the **List Segment-Type** with the **Put List Data** 750 icon. **List Segment-Types** are: • Position-List 803 • Acceleration-List 758 • Z-Raw-Data 834

See also:

Put List Data 749

Get Segment Data 751

1.6.10.10 Put data to List Segment-Type

Put Data to a List Segment-Type

This icon is in the toolbar **only** when the SELECTED-SEGMENT is a **List Segment-Type**.

Put List Data : to put **data*** that you select from the **Data Transfer Table** to a **List Segment-Type.**

To Select data:

1. Click a Header to select all of the data under that header that column
2. Click **Put Data to List Segment**

OR

1. Click a cell in the table
2. SHIFT + Click a different cell* in the table

The highlighted data is now the **Selected-Data.**

3. Click **Put Data to List Segment**

After you put the data-points to the **List Segment-Type**, :

1. **MotionDesigner** re-samples your data to allocate the number of motion-points that are proportionate to the SEGMENT-WIDTH and Number-of-Points in the Motion [731]
2. Calculates all motion-derivatives

* The minimum number-of-points you can select in the **Data Transfer Table** is **6**.

You should usually put many more than 6 points to the **List Segment-Type**.

List Segment-Type are

- Position-List [803]
- Acceleration-List [758]
- Z-Raw-Data [834]

See also:

Get List Data [749]

Get Motion Data [750]

Get Selected-Segment Data [751]

Overlay-Trace [751]

1.6.10.11 Get motion data from displayed graphs

Get Motion Data from displayed Graphs

Get Motion Data

Transfer to the **Data Transfer Table** the **motion-values** of the **complete motion** and of the **displayed** graphs.

- **# Columns**: X-axis + each motion-derivative that is displayed as a graph.
- **# Rows** : Number-of-Steps

See Active Motion Settings > Motion tab > Motion Cycle Data[731] > Number-of-Steps

---

Number Format : **see** Active Motion Settings > Number-Format tab > NUMBER-FORMAT[731] > Precision / Digits

Units : **see** Active Motion Settings > Motion tab > MOTION-UNITS[731] > X-Axis / Y-Axis units

1.6.10.12 Get Segment Motion Data

Get Segment Data from Graphs

Get Segment Motion-Data

Transfer to the **Data Transfer Table** the motion-values of each motion-derivative for the **SELECTED-SEGMENT**.

- **# Columns** : X-axis + each motion-derivative that is displayed as a graph.
- **# Rows** : NUMBER-OF-STEPS[731] × SEGMENT-WIDTH(DEGREES) / 360

Number Format : **see** Active Motion Settings > Number-Format tab > NUMBER-FORMAT[731] > PRECISION / DIGITS

Units : **see** Active Motion Settings > Motion tab > MOTION-UNITS[731] > X-AXIS / Y-AXIS UNITS

1.6.10.13 Show data as Overlay-Trace

Overlay-Trace

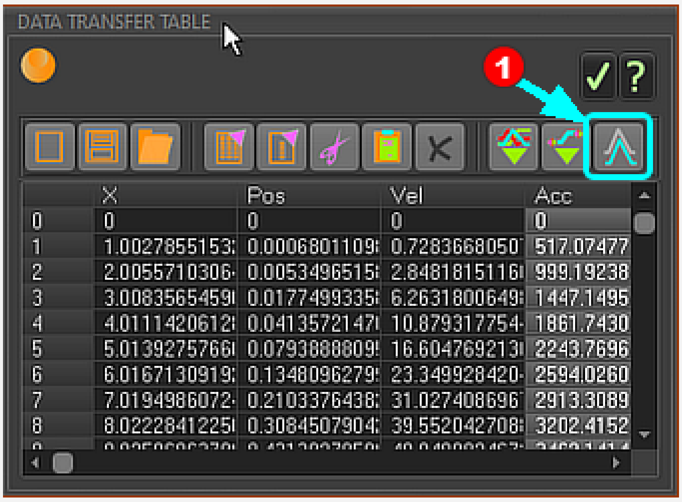
Show the data that is in the **Data Transfer Table** as a dumb graph together with the active **Motion**.

The dumb graph is the **Overlay-Trace**.

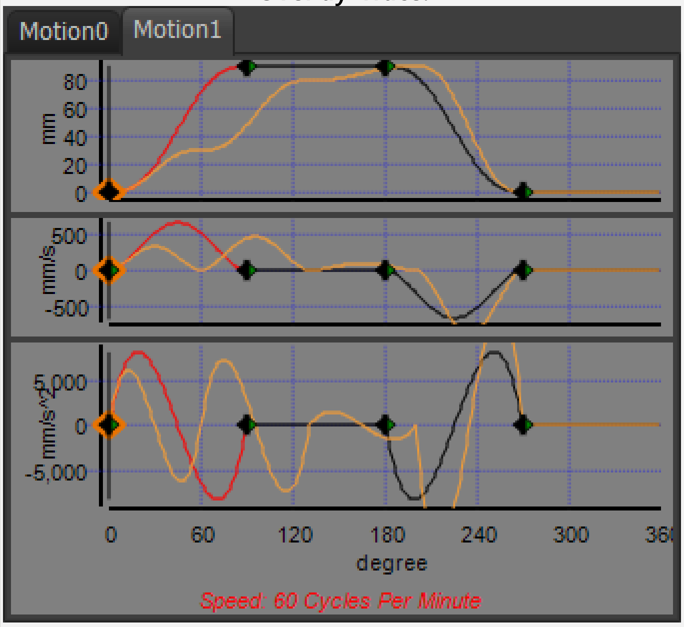
Note:

The MTD or ZXL file-types do not save the **Overlay-Trace** or the data in the **Data Transfer Table**.

If the data is important, and the data is not available from a Motion graph or a **GRAPH FB** (**MechDesigner**) then we recommend that you put the data[750] to a new Motion of one segment that is a List Segment-Type[756]. Also, rename the new Motion to **Overlay-Trace**, or a name to remind you that the data is intended for an Overlay-Trace in a different motion.

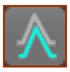


Position, Velocity, Acceleration motion-values for Overlay-Trace.



Overlay-Trace (in Orange) and the active Motion

To show an Overlay-Trace

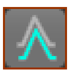


1. Make sure there is data in the **Data Transfer Table** (see Prepare the Data for an Overlay Trace 753, below)
2. Click the **Overlay-Trace** icon in the toolbar.

   The data shows as the **Overlay-Trace** together with the active motion.
3. Click in the graph to scale the graphs correctly.

   The active-motion and the **Overlay-Trace** rescale to their maximum and minimum values.

To hide the Overlay-Trace:



1. Click the **Overlay-Trace** icon again

   We disable the plot of the Overlay-Trace.

To edit the color of the Overlay-Trace

> MotionDesigner > Edit toolbar > Active Motion Settings [733] > Accessibility tab > Overlay Trace color button.

Prepare the Data for an Overlay Trace

The data in the **Data Transfer Table should be arranged as follows:**

- Data in Column 2, from Row 0, displays in the **Position** graph.
- Data in Column 3, from Row 0, displays in the **Velocity** graph.
- Data in Column 4, from Row 0, displays in the **Acceleration** graph.
- Data in Column 5, from Row 0, displays in the **Jerk** graph.

Note:

- The **Overlay-Trace** shows even if the data in Columns 2,3,4,5 are not motion-derivatives of each other.
- The **Overlay Trace** shows only for each column of data in the **Data Transfer Table** - we do not calculate other motion-derivatives for you.

Overlay-Trace example:

To show the motion-values of **Motion0** as an **Overlay Trace** in **Motion1.**

If necessary:

1. Click File toolbar > Add Motion [723] to add a **Motion1** as a new motion name-tab
2. Click View toolbar [738] > **P, V, A, J** buttons to show all motion-derivatives in **Motion1**
3. Click **Motion0 name-tab** to make it the active motion
4. Click **View toolbar** > **P, V, A, J** buttons to show all motion-derivatives in **Motion0**

Open the Data Transfer Table.

5. Click Blend-Point and Segment Editor toolbar > Data Transfer Table [744].

Get the motion-values from Motion0 into the Data Transfer Table.

6. Click Data Transfer Table > Get Motion Data [750].

   The **Data Transfer Table** fills with the motion-values for each motion-derivative in **Motion0.**

Make Motion1 the active motion.

7. Click **Motion1 name-tab** to make it the active motion

Show the data that is in the Data Transfer Table as the Overlay-Trace in Motion1.

8. Click **Data Transfer Table** > **Overlay Trace** button

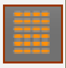
   The motion-values of **Motion0** are now an **Overlay Trace** in **Motion1**.

9. Click in the Graph of Motion1 to re-scale **Motion1** and the **Overlay Trace**.

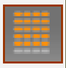
The graphs rescale to show the maximum and minimum of the **Motion1** and the **Overlay-Trace**.

1.6.10.14 Get Last Point

Toggle: Do Transfer or Do Not Transfer Last Motion Point



OR



A Toggle for when you **GET Motion-Data** 750 :

- Do transfer the last motion data point from the motion graphs to the **Data Transfer Table**.

OR

- Do **not** transfer the last motion data point from the motion graphs to the **Data Transfer Table**.

Example:

1. Edit the NUMBER OF POINTS = 361.

The NUMBER-OF-POINTS parameter is set in the Active Motion Settings > Motion tab.

2. Toggle IN the Get Last Point
3. Click Get Motion Data

The number of rows in the Data Transfer Table = 0 to 360, a total of 361 rows

4. Click Clear Data from the Table 747
5. Toggle OUT the Get Last Point
6. Click Get Motion Data

The number of Rows in the Data Transfer Table = 0 to 359, a total of 360 Rows

---

Frequently, when you want to transfer the motion-data in the **Data Transfer Table** to another application, your other application may need:

- the last row in the table to be equal to the first row in the table

or

- the last row in the table to be equal to the last point in the motion

---

See also:

See Active Motion Settings > Motion tab > Motion Cycle Data 731 > NUMBER-OF-POINTS

1.6.11 Motion Laws / Cam-Laws for Segments

Motion-Laws - also called Cam-Laws.

Select the **Motion-Law** for each segment with the Motion-Law Selector741 or the Segment-Editor704.

Each **Motion-Law** is a mathematical expression that defines how an **output variable** (Y-axis) changes as a function of an **input variable** (X-axis).

The mathematical expressions evaluate **EXACTLY** the **displacement**, **velocity**, **acceleration**, and **jerk** motion-values for all X-axis values. You do not need to know any mathematics.

For convenience, we can separate the motion-laws into three groups.

Traditional Motion-Laws

The **Traditional Motion-Laws** (also named **Standard Motion-Laws**) have been used for many years in cam mechanisms for **Rise** and **Return** segments, usually with a **Dwell** segment before and/or after.

The **Traditional Motion-Laws** are based on:

- Trigonometric Functions
- Polynomials Functions

Traditional Motion-Laws:

1. Constant-Acceleration & Deceleration759 **-** Polynomial Function
2. Constant-Velocity762 **-** Polynomial Function
3. Cubic767 **-** Polynomial Function
4. Cycloidal769 - Trigonometric Function
5. Cycloidal Constant-Velocity 50%772 -Trigonometric Function
6. Dwell775 **-** Polynomial Function
7. Modified-Sinusoid790 - Trigonometric Function
8. Modified-Trapezoidal793 - Trigonometric Function
9. Polynomial 2-3796 **-** Polynomial Function
10. Polynomial 3-4-5799 **-** Polynomial Function
11. Polynomial 4-5-6-7801 **-** Polynomial Function
12. Polynomial Low Impact Crossover788 - construct with two Flexible-Polynomial segments
13. Quadratic806 **-** Polynomial Function
14. Ramp808 - Trigonometric Function
15. Simple-Harmonic811 - Trigonometric Function
16. Sine-Constant-Cosine Acceleration814 - Trigonometric Function

    You can edit the **SEGMENT PARAMETERS** in the **SEGMENT EDITOR** to get:

    a. SCCA with Constant-Velocity 20%, 33%, 50%, 66%.... -
17. Sine-Squared818 - Trigonometric Function

18. Sinusoidal [820] - Trigonometric Function
19. Triple-Harmonic [822] - Trigonometric Function

    You can edit the **SEGMENT PARAMETERS** in the **SEGMENT EDITOR** to get a motion-law similar to:

    a. Triple Harmonic - Modified Trapezoidal [826]
    b. Triple Harmonic - Modified Sine [825]
    c. Triple Harmonic - Zero Jerk at Crossover [828]

---

20. **Flexible Polynomial**

    Use to design a Throw motion-law, in which a **return** segment follows **immediately** after a **rise** segment.

    YOU must design **Throw** motion-laws with two **Flexible Polynomial** [777] segments. These are examples:

    a. Throw: Quick-Return 1 - Finite Jerk @ Start / End [780]
    b. Throw: Quick-Return 2 - Zero Jerk @ Start / End [782]
    c. Throw: Rapid-Return 1: Finite-Jerk @ Start/End/Mid-Point [784]
    d. Throw: Rapid-Return 1: Zero Jerk @ Start/End, Finite Jerk @ Mid-Point [786]
    e. Low Impact at Crossover [788] **Low Impact at Crossover** uses two **Flex-ible-Polynomial** segments to give one Rise motion-law. The Jerk is zero when the Acceleration changes to Deceleration.

Special Motion-Laws

These meet the needs of specific applications.

25. Y–Inverse-Sinusoid [830] **:** when applied to the motion of a **crank**, it gives a constant **linear** velocity at the tip of a crank. Only one Y-Inverse-Sinusoid segment per crank rotation.
26. CV Inverse Crank [836] : similar to the Y-Inverse-Sinusoid, One or more Crank-Constant-Velocity segment per motion.
27. Flexible-Polynomial [777] - a VERY useful motion-law - see also **Motion-Laws 20 a-e**
28. Ramp [808] - also a useful motion-law - see also **Motion-Law 5, Cycloidal CV50**
29. **Asymmetric Motion-Laws**

List Segment-Types

You can import your own motion-values to a **List Segment-Type**:

29. Position-List [803]
30. Acceleration-List [758]
31. Z-Raw-Data [834]

When to use the Flexible Polynomial OR a Traditional, or the both Motion-Laws?

Flexible-Polynomial is the default motion-law. It is very powerful. We recommend that you learn how to use it effectively and efficiently.

Traditional Motion-Laws have advantages in some circumstances.

We recommend that you use:

- **All Flexible-Polynomials** - to give powerful and flexible motion-design possibilities

OR

- **All Traditional Motion-Laws** - the easiest to design a Rise and Return type motion

OR

- **A mixture of Flexible-Polynomial and Traditional Motion-Laws** - most difficult motion-design but may have advantages

German Technical VDI guidelines 2143 Parts 1 and 2

The **Motion-Laws** available in **MotionDesigner** exceed the German Technical VDI-guidelines 2143 Papers (Part) 1 and 2. Also bear in mind, that a motion at the Follower or Servomotor is usually found by **MechDesigner** with Inverse-Kinematics. When this is the case, the motion at the Follower or Servomotor is not the same as that of the motion-design that is given to the tooling, or Tool-Part.

1.6.11.1 Acceleration-List [Import Data]

Acceleration List

See also: Position-List 803 , Z-Raw Data 834

MOTION-DESCRIPTION

The **ACCELERATION LIST** is a List Segment-Type 756 .

Use it to import **Acceleration data**.

See Position-List 803 to learn how to Import data to a **List Segment-Type**.

MOTION-VALUES

We integrate (numerically) your data for you to calculate and show the **Velocity** and **Position** graphs.

We re-sample your data to give the correct number-of-points in the segment, such that:

Number-of-Points in the Acceleration List Segment = SEGMENT-WIDTH × NUMBER-OF-STEPS in Motion / 360

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None

SAMPLING ACCELERATION-DATA - RECOMMENDATIONS.

Acquire **acceleration-data** of a machine component with an **Accelerometer Sensor**.

- We recommend a **DC-Accelerometer Sensor** that gives an output from **0** to **1000Hz**.
- From **0Hz** is important. At **0Hz**, you can turn the accelerometer over to use **±g (gravity)** to calibrate it (g = ~9811mm/s/s).
- Import the data for one machine cycle. You can use an Encoder on a machine shaft to trigger the start and end the Acceleration Data acquisition.
- You get better results if you sample the data from a Dwell to a Dwell.
- Although there are mathematical techniques to compensate for any bias in the Acceleration Data, we do not use them when we integrate the your Acceleration data to get Velocity and Position.

1.6.11.2 Constant Acc and Dec Motion-Law [Parabolic]

Constant-Acceleration and Constant-Deceleration Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law [755]. Its name is often give **Constant-Acceleration**, or **Triangular Velocity**.

It has the lowest nominal maximum **Constant Acceleration** of the **Dwell-Rise-Dwell** type motion-laws. For this reason, historically, it was recommended for cam motion-design. It is still commonly used for Servo and Stepper motions.

However, it has many disadvantages - see **Application-Notes**, below.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY & END VELOCITY

START ACCELERATION & END ACCELERATION

START JERK & END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

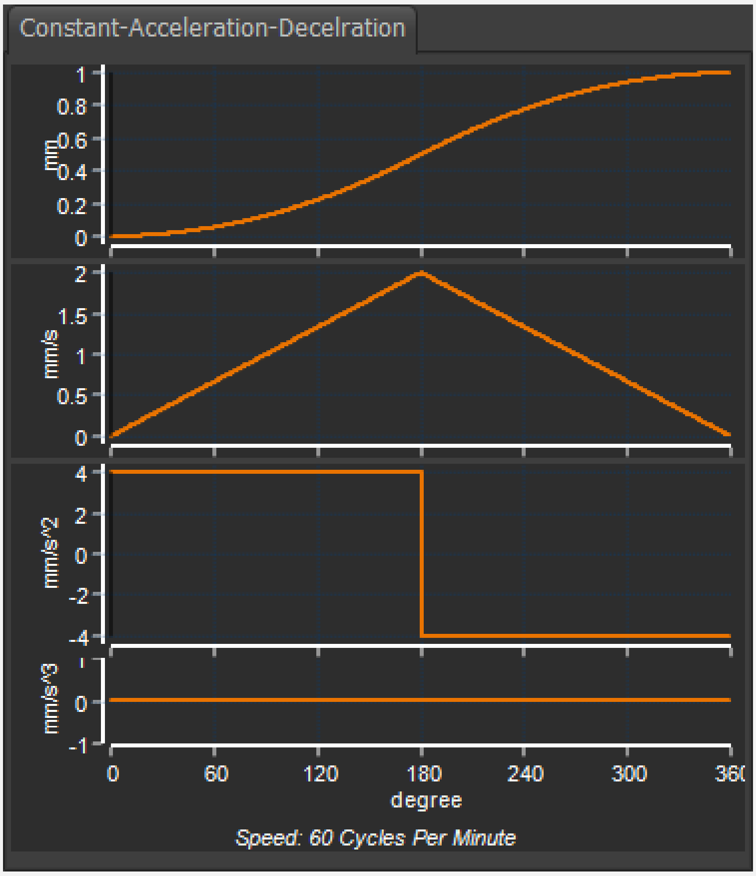
START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Constant-Acceleration - Constant-Deceleration Motion-Law - Parabolic Motion (Cam-Law)

Motion-Law Coefficients

Velocity Coefficient :	$C_v = 2.000$
Acceleration Coefficient :	$C_a = 4.000$
Jerk Coefficient :	$C_j = \infty$
Jerk at Crossover :	$C_{Jc} = 2 \times \infty$

APPLICATION NOTES

The Constant-Acceleration motion-law was used in the past because it has the lowest **nominal acceleration** of the **Traditional Motion-Laws**. However, it has infinite-jerk at three points: at its start, end, and at its crossover. This makes it a very poor choice form a dynamic-response viewpoint. Infinite-Jerk incites vibrations in any mechanical system. We do **not** recommend this motion-law if the **Period-Ratio** is less than 10, or even 20.

Dynamic Performance

The actual acceleration of a payload is significantly more than the nominal Constant-Acceleration value because of induced vibrations. For this reason, this motion-law should only be used in applications where inertia effects are insignificant.

Pressure-Angle Considerations

This motion-law produces a relatively large pressure-angle - and so might need a large cam for a given lift. The pressure-angle for this motion-I varies quite severely throughout this Motion-Law indicating that it is unsuitable for roller follower applications because of the severe accelerations imposed on the roller that induce roller slip.

Drive-Torques

This law performs badly in terms of drive torque considerations. This law has a discontinuity in Drive Torque, indicating shock loading and noise in operation. Particularly notable is the sudden reversal of the inertia torque factor, and hence of the torsional strain energy, at the cross-over of the motion segment. These reversals contribute to noise, shock loading, and vibration during operation.

1.6.11.3 Constant-Velocity

Constant-Velocity Cam-Law, Motion-Law

This is a Polynomial motion type.

See also : Constant-Velocity: Two Positions[765].

MOTION-DESCRIPTION

The Velocity is constant for the period of the SEGMENT-WIDTH.

MOTION-VALUES

You CAN control the:

START-POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

START-VELOCITY

The START-VELOCITY usually **flows** from the END-VELOCITY of the PREVIOUS-SEGMENT

You CANNOT control the:

END-POSITION

The END-POSITION is a calculated from the START-POSITION, START-VELOCITY, and SEGMENT-WIDTH[707]

END-VELOCITY

The END-VELOCITY is equal to its START-VELOCITY

START ACCELERATION = END-ACCELERATION = 0

START-JERK = END-JERK = 0

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None

Example - VELOCITY CONTINUITY

1. Use the Motion-Law Selector[741] to change the motion-law of a segment to a **CONSTANT-VELOCITY.**
2. Click above or below the segment in the motion-graphs.

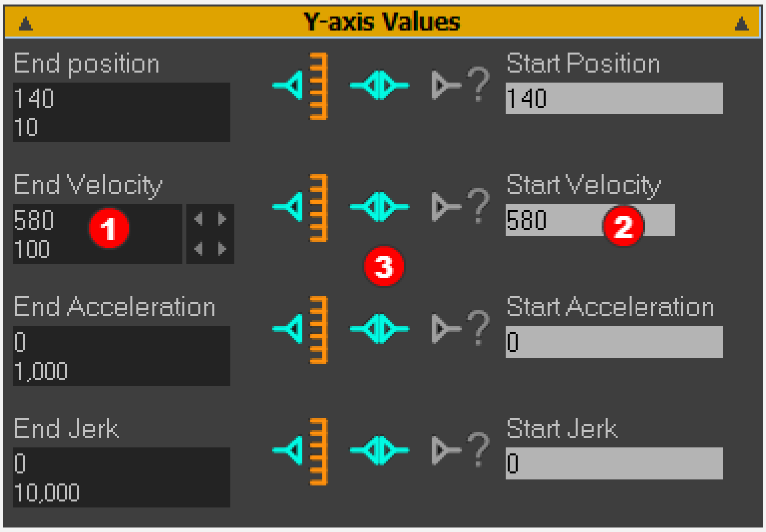
The **CONSTANT-VELOCITY** segment is now the SELECTED-SEGMENT.

3. Open the **BLEND-POINT EDITOR**

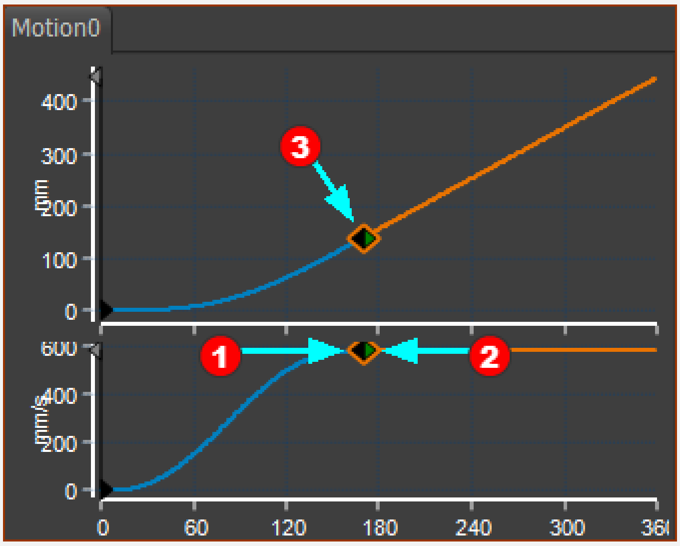
1. Set the **Match Control Button** to **Flow / Match** - see image ❸

The Velocity at the **Start of the Selected-Segment** is now forced to be equal to the Velocity at the **End of the Previous-Segment**.

	The Start Velocity becomes read-only. 2. Edit the **End Velocity** ❶ You should see that the **Start-Velocity** ❷ is equal to the **End-Velocity**.



Blend-Point Editor: Velocity Equal at Blend-Point.



Smooth Flow of Velocity at Blend-Point
Equal Gradients of Position Graph at Blend-Point

Example 2 - VELOCITY DIS-CONTINUITY

Definition of a Motion Dis-continuity:

The motion-values change instantly, such that there is a step between two adjacent motion-values. The motion-discontinuity is associated with a motion-derivative. E.g. A motion has a **Velocity discontinuity**

> A **Velocity discontinuity** is NOT recommended, of course. There is **infinite acceleration** at the **Velocity discontinuity** - which is mechanically not possible.
> A **Velocity discontinuity** puts a **kink** in the **Position** graph.

An example of a Velocity Dis-Continuity.

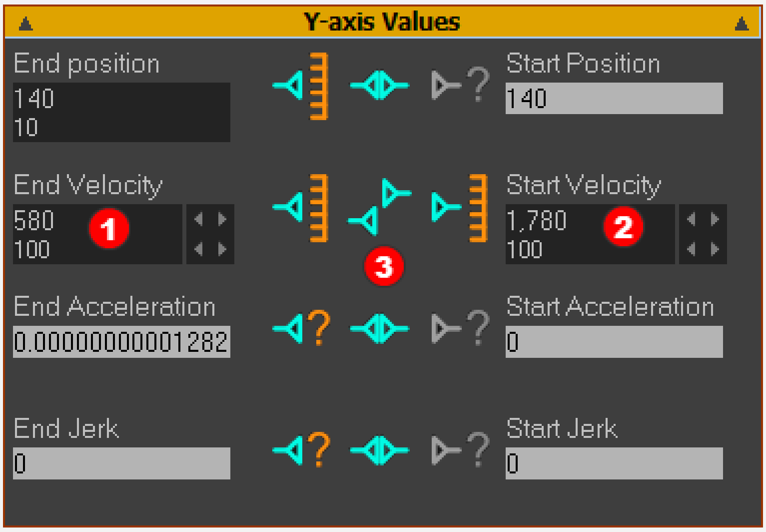
1. Use the Motion-Law Selector 741 to change a motion-law of a segment to a **CONSTANT-VELOCITY**.

2. Click above or below the segment in the motion-graphs.

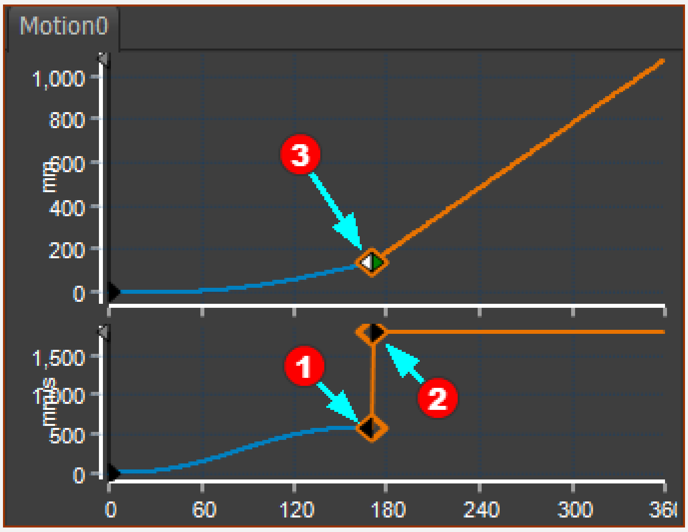
The **CONSTANT-VELOCITY** segment is now the SELECTED-SEGMENT.

3. Open the BLEND-POINT EDITOR

4. Set the **MATCH CONTROL-BUTTON** to **DO NOT MATCH**❸
5. Enter a **START-VELOCITY**❷ value that is not equal to the **END-VELOCITY**❶ value.



Blend-Point Editor: Velocities at Blend-Point are not Equal



Step in Velocity Graph, & Kink(corner) in Position Graph.
Step in gradient at Blend-Point in Position-Graph.

1.6.11.4 Constant-Velocity : Two Positions

Constant-Velocity | Two Position

See also : Constant-Velocity 762 .

MOTION-DESCRIPTION

Use the **Flexible-Polynomial** to define a segment that has Constant-Velocity between Two-Positions.

The Velocity is calculated from the SEGMENT-WIDTH and the difference between the END-POSITION and START-POSITION.

You must make sure the Velocity at the end of the PREVIOUS-SEGMENT is equal to the velocity of this segment.

The Acceleration and Jerk Values at the start and end of the segment are zero.

MOTION-VALUES

You CAN control the:

START-POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END-POSITION

You CANNOT control the:

START-VELOCITY & END-VELOCITY

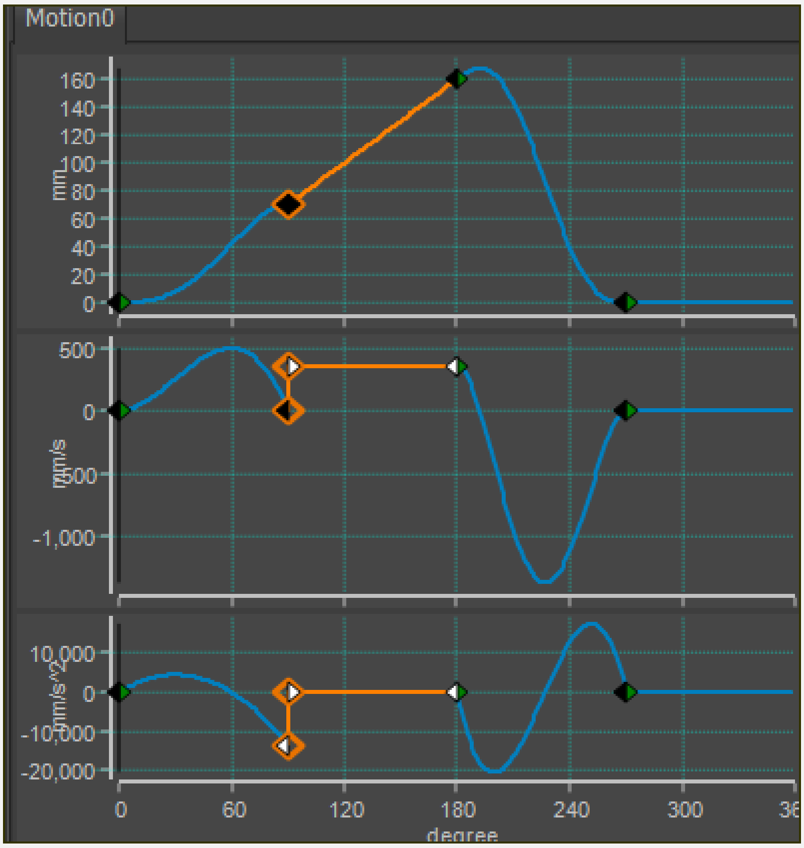
START-ACCELERATION & END-ACCELERATION

START-JERK & END-JERK

SEGMENT EDITOR: Control-Buttons for a 'Two Position | Constant-Velocity motion-law.

1. Use the Motion-Law Selector 741 to select a **Flexible-Polynomial** motion-law
2. Select the Segment
3. Open the SEGMENT EDITOR

4. Deselect **MATCH-VELOCITY**, **MATCH-ACCELERATION**, and **MATCH-JERK (FLOW)** **Control-Buttons**
5. Deselect **START VELOCITY**, **START ACCELERATION**, and **START JERK** **Control-Buttons**
6. Deselect **END-VELOCITY, END-ACCELERATION, AND END-JERK** **Control-Buttons**
7. Edit the **START-POSITION** and **END-POSITION** values
8. Edit the **X-AXIS** values.



2 Position, Constant-Velocity BUT Step Change in Velocity

Note:

When the **Constant-Velocity** segment is one segment of a complete machine-cycle use a **GEARING FB**, to replace a **MOTION FB** - assuming a **LINEAR-MOTION FB** is connected to the input of the **GEARING FB**.

When **GEARING-RATIO = 1** (in the **GEARING FB DIALOG**), the output equals its input, it increases steadily from 0 to 360.

If, for example, you enter **GEARING RATIO = 270/360**, the output increases steadily from 0 to 270, when its input increases steadily 0 to 360.

Thus, you can see it is easy to use a **GEARING FB** to output a **Constant-Velocity** for a complete a machine-cycle.

1.6.11.5 Cubic Motion-Law

Cubic Cam-Law, Motion-Law

MOTION-DESCRIPTION

A Traditional Motion-Law 755 . **The Jerk motion-values of this motion-law are constant.**

Use it when you want the Jerk to be a constant value, or the Acceleration to change linearly.

When the Velocity at its start and end are equal zero, it is the same as the Polynomial 2-3 796 .

MOTION-VALUES

You CAN control the:

START POSITION

The START POSITION usually **flows** from the END POSITION of the PREVIOUS-SEGMENT.

END POSITION

START VELOCITY

The START VELOCITY usually **flows** from the END VELOCITY of the PREVIOUS-SEGMENT

END VELOCITY

You CANNOT control the:

START ACCELERATION & END ACCELERATION

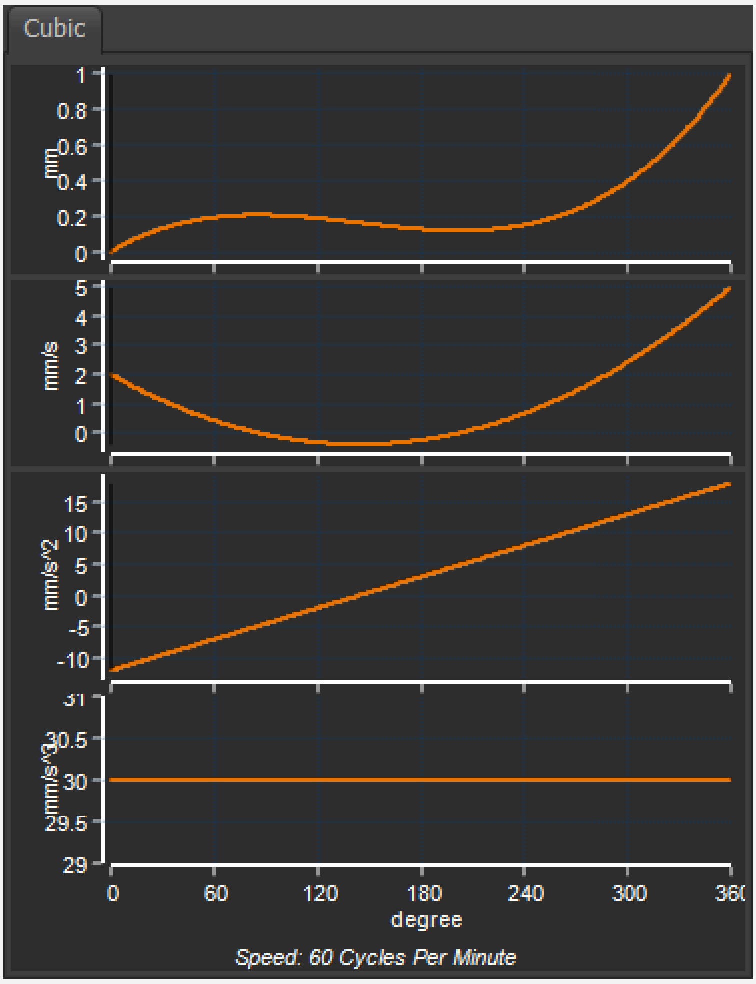
START JERK & END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None



Cubic Motion-Law

1.6.11.6 Cycloidal Motion-Law

Cycloidal Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law 755.

A motion with continuous Velocity and Acceleration from start to end. There is a Jerk discontinuity at its start and end.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY & END VELOCITY

START ACCELERATION & END ACCELERATION

START JERK & END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

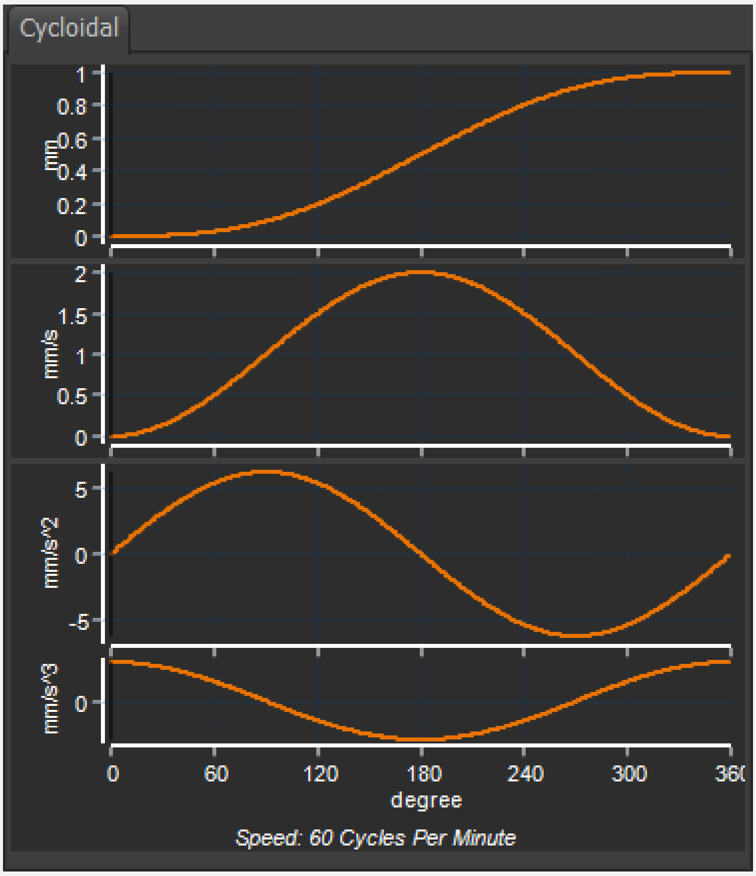
START-RANGE

END-RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Cycloidal Motion-Law (Cam-Law)

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 2.000$
Acceleration Coefficient :	$C_a = 6.28$
Jerk Coefficient :	$C_j = 39.48$
Jerk at Crossover :	$C_{Jc} = -39.48$

APPLICATION NOTES

Dynamic Performance

This Motion-Law is recommended in applications where the period ratio is near to 5, but the input drive is stiff and the shaft speed does not fluctuate significantly under load. It has a good acceleration characteristics at the load and should be used in systems where low residual vibration (vibration after the end of the motion segment) is desired.

Pressure Angle Considerations

It gives a relatively large pressure angle - and so might need a large cam for a given lift and predetermined pressure angle limits, to reduce it.

Drive Torques

This Motion-Law is recommended in applications where no sudden change of input torque is a requirement. Its torque characteristics are particularly good in relation to the other Traditional Motion-Laws when the period ratio is less than approximately 10.

1.6.11.7 Cycloidal-CV50 Motion-Law

Cycloidal-CV50 Cam-Law, Motion-Law

MOTION-DESCRIPTION

A Traditional Motion-Law [755]. Use the **Ramp** [808] **Motion-Law** to design a **CYCLOIDAL-CV50.**

The **Cycloidal-CV50** has three phases:

- **Phase 1**: Acceleration : first ½ wave of a Sine function : 25% of the Segment-Width.
- **Phase 2**: Zero Acceleration, Constant Velocity : 50% of the Segment-Width.
- **Phase 3**: Deceleration : last ½ wave of a Sine function : 25% of the Segment Width

A motion with continuous Velocity and Acceleration, from start to end, The Jerk is finite at its start and end.

Its peak Acceleration is quite high, but its peak Velocity is quite low.

MOTION-VALUES

You CAN control the:

Select the RAMP Motion-Law [808] :

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY & END VELOCITY - by definition, they are zero(0)

START ACCELERATION & END ACCELERATION - by definition, they are zero(0)

START JERK & END JERK - by definition, they are finite

SEGMENT PARAMETERS

The SEGMENT-PARAMETER values in the **Ramp** [808] motion-law to give the **Cycloidal CV50** motion-law.

START-FRACTION × 100 = % of SEGMENT-WIDTH

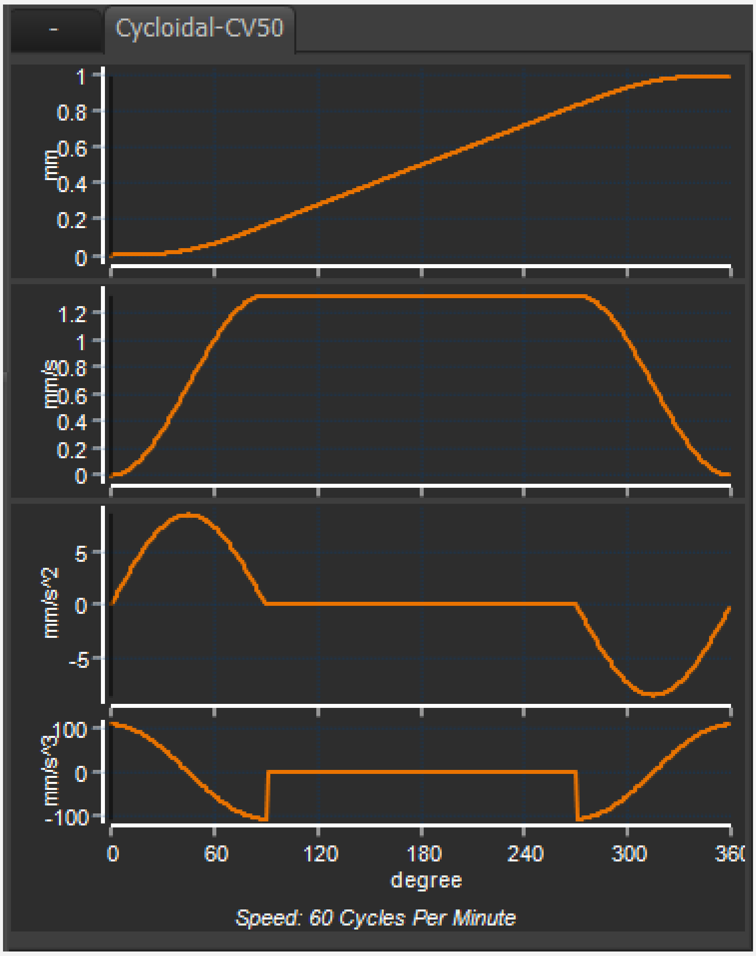
END-FRACTION × 100 = % of SEGMENT-WIDTH

SEGMENT-RANGE

START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1



Cycloidal-CV50 (50% is Constant-Velocity (with Ramp Motion-Law / Cam-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.333$
Acceleration Coefficient :	$C_a = 8.378$
Jerk Coefficient :	$C_j = 105.276$
Jerk at Crossover :	$C_{Jc} = 105.276$

APPLICATION NOTES:

Dynamic Performance

The **Cycloidal CV50 Motion-Law** is recommended in applications where you need the peak velocity to be low when compared to others. It has a large Peak Acceleration, with a short duration, thus more likely to induce vibrations.

Pressure Angle Considerations

It gives a relatively low pressure angle - because of its low peak velocity.

Drive Torques

This Motion-Law is not recommended in many applications as it gives a sudden change in torque. The input transmission rigidity would need to be high.

1.6.11.8 Dwell Motion-Law

Dwell Cam-Law, Motion-Law

MOTION DESCRIPTION

Dwell is a Traditional Motion-Law[755]. It is a **Polynomial Motion-Law.**

The **DWELL** motion-law has a constant **POSITION**, or zero displacement.

By definition, its motion-values for **VELOCITY, ACCELERATION,** and **JERK** are zero throughout the **SEGMENT-WIDTH**.

MOTION-VALUES

You CAN control the:

START POSITION

The **START POSITION** usually **flows** from the **POSITION** at the end of the **PREVIOUS-SEGMENT**

You CANNOT control the:

END POSITION - by definition, it is equal to the Position at its Start

START VELOCITY & **END VELOCITY** - by definition, they are zero(0)

START ACCELERATION & **END ACCELERATION** - by definition, they are zero(0)

START JERK & **END JERK** - by definition, they are zero(0)

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None

APPLICATION NOTES:

Use a **Dwell** when you want a tool to be stationary.

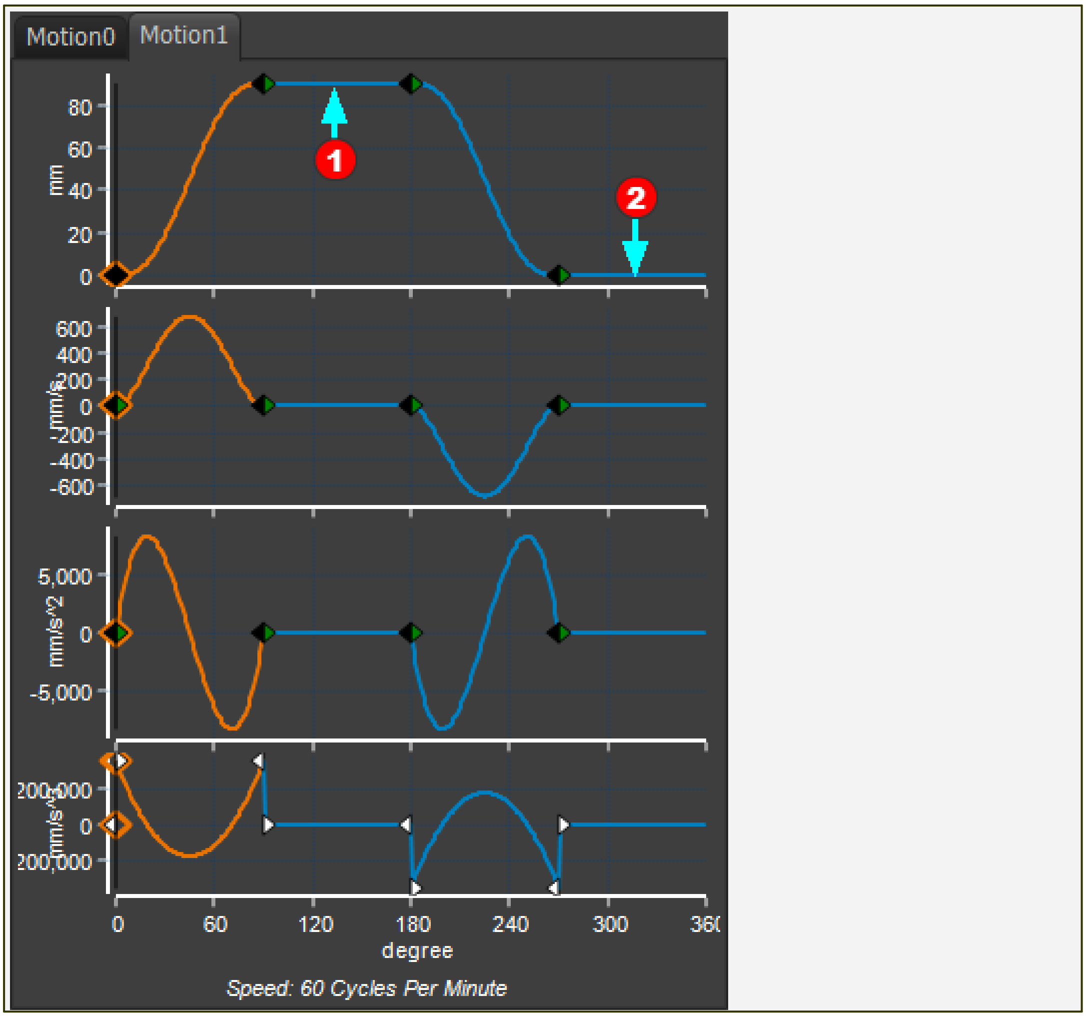
However, **Dwell** segments are used too frequently. Why?

The other segments become shorter in duration, and their peak accelerations also increase. Shorter segment are more likely to induce vibration in the mechanism. The Peak Torque of the drive-shaft also increases, and reverses from a positive to a negative torque more rapidly. This can lead to wind-up and over-run of the drive-shaft.

TOP-TIP

Try **not** to use a **Dwell** segment unless you need a tool to be absolutely stationary for at least 20° range of the X-axis.

If the dwell is less than 20°, then. as an alternative, try to delete the **Dwell** segment. Then, use segments that are before and after the 'dwell' that have zero jerk-values at the Blend-Point that replaces the Dwell segment.



Motion0
Motion1
80
60
mm
40
20
0
1
2
600
400
200
mm/s
0
-200
-400
-600
5,000
mm/s^2
0
-5,000
200,000
mm/s^3
0
-200,000
0
60
120
180
240
300
360
degree
Speed: 60 Cycles Per Minute

1.6.11.9 Flexible-Polynomial Motion-Law

Flexible-Polynomial Cam-Law, Motion-Law

MOTION DESCRIPTION

You can use the **FLEXIBLE-POLYNOMIAL** motion-law as a segment for most applications.

For each motion-derivative (P, V, A, J), you can use the **BLEND-POINT EDITOR** or the **SEGMENT EDITOR** to:

- **specify** the motion-value at the **start** and/or **end** of the Flexible-Polynomial segment.
- **not specify** the motion-value at the start and/or end of the Flexible-Polynomial segment.
- **match / force** the motion-value at the start of the Flexible-Polynomial segment to be equal to the motion-value at the end of the **PREVIOUS-SEGMENT**

You can use the **Flexible-Polynomial** to emulate a motion-law that is based on the other Polynomial Functions, which are:

- Dwell 775, Constant-Velocity 762, Cubic 767, Quadratic 806, Throw 780, Poly 345 799 and Poly 4567 801 motion-laws.

See **Tutorial: Introduction to the Flexible-Polynomial Motion-Law.**

MOTION-VALUES

You CAN control the:

START POSITION and END POSITION

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

You CANNOT control the:

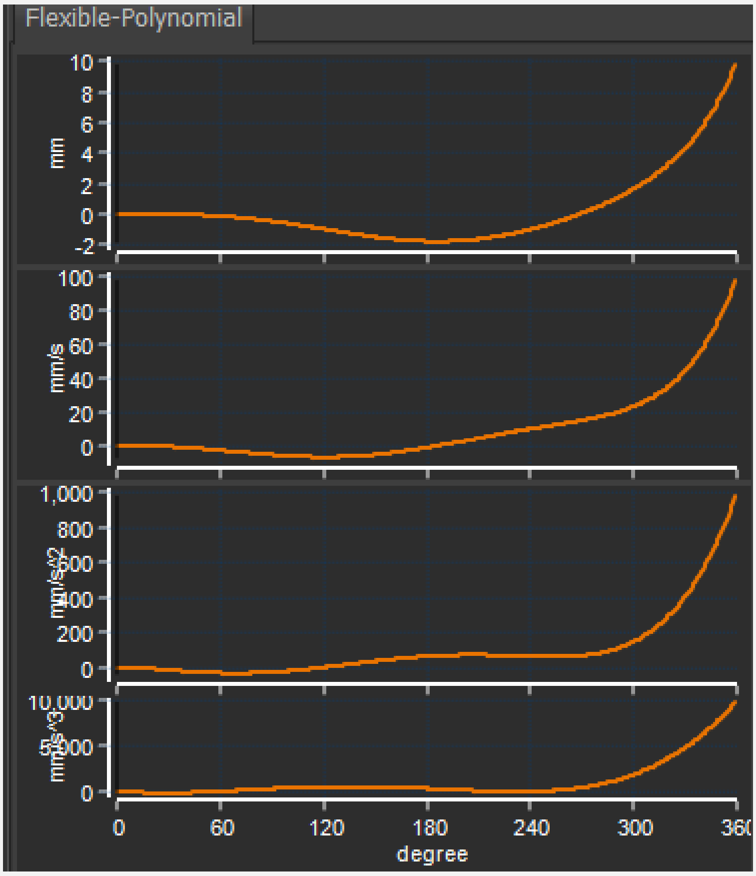
None

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None



Flexible-Polynomial

1.6.11.10 Throw Motion-Law

The Throw Motion-Law

Unlike other motion-laws, the **Throw motion-law** rises **AND** immediately returns.

To design a **Throw motion-law** we use two **Flexible Polynomial** segments. This provides you with many motion-design options.

Throw motion-laws:

- have zero velocity and acceleration at the start and end, and
- have continuous acceleration at the mid-point, and
- acceleration is usually not zero at the mid-point.

To give different motion characteristics, you can control the Jerk values at the start and end of the Rise and Return, and also Jerk continuity at its mid-point.

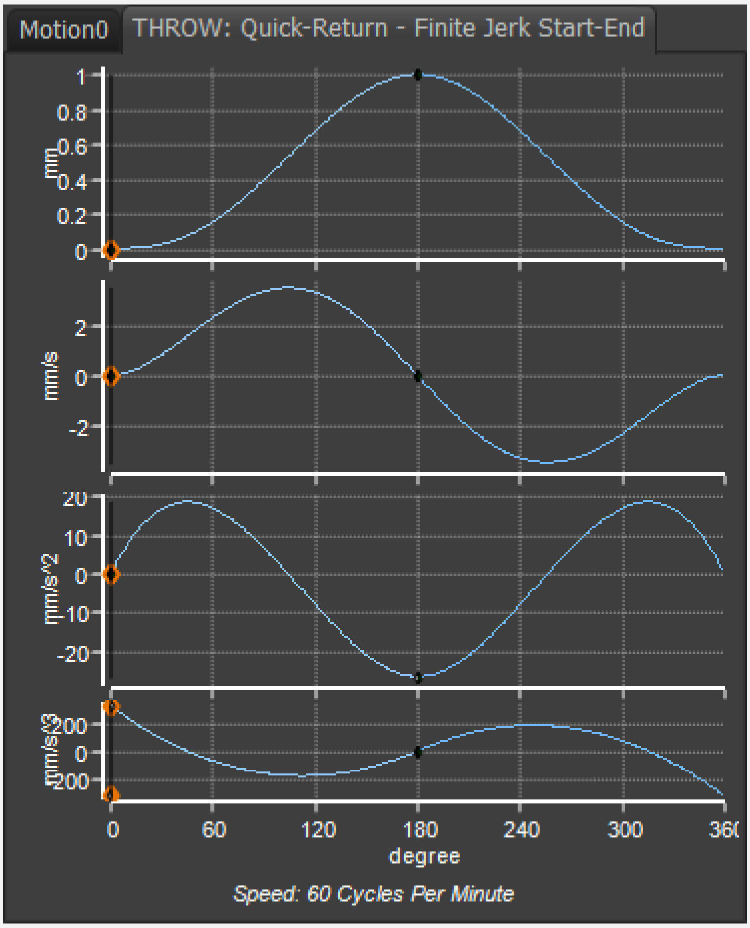
- Throw Quick-Return 1 780
- Throw Quick-Return 2 782
- Throw Rapid-Return 1 784
- Throw Rapid-Return 2 786
- Low Impact at Crossover 788

1.6.11.10.1 Throw Quick-Return: 1: Finite Jerk @ Start/End Motion-Law

Throw Quick-Return 1 - Finite Jerk at Start and End

Throw Quick-Return 1 - Finite Jerk at Start and End.

This **Throw Quick-Return 1** is the classic Rise-Return motion-law. It has a **Quick-Return** when compared to two **Polynomial 345** segments because it has a negative acceleration at its maximum displacement - at the transition from Rise to Return.



Throw Quick Return 1 - Finite-Jerk at Start and End

MOTION-VALUES OF EACH MOTION-DERIVATIVE

Start of rise segment 1 :

- Position = 0
- Velocity = 0
- Acceleration = 0
- Jerk = Unspecified (Actual value = 320 mm/s/s/s)

Mid-Point :

- Position = 1
- Velocity = 0
- Acceleration = Unspecified (Actual value = –26.666 mm/s/s)

OR Acceleration = –20 mm/s/s

- Jerk = 0

End of return Segment 2 :

- Position = 0
- Velocity =0
- Acceleration = 0
- Jerk = Unspecified (Actual value = –320 mm/s/s/s)

See also:

- Throw: Quick Return: Zero Jerk @ Start/End/Mid-Point 782
- Throw: Rapid Return: Finite Jerk @ Start/End/Mid-Point 784
- Throw: Rapid Return: Smooth-Start/End 786

1.6.11.10.2 Throw Quick-Return: 2: Zero Jerk @ Start/End/Mid-Point

Throw: Quick-Return with Zero Jerk at its Start and End

The Throw Motion-Law

Unlike the other motion-laws, the **Throw motion-law** rises from its **Start-Position** to its maximum displacement, and then returns to its **Start-Position**.

Use two **Flexible Polynomial** segments to design the **Throw motion-law**. Usually, the two segments have equal durations, but it is not necessary.

Throw: Quick-Return 1 - Zero Jerk at Start and End.

Because you use two **Flexible-Polynomial** segments to design the **Throw motion-law**, you can enter different motion-values and motion-constraints at its start, its maximum displacement, and at its end.

All **Throw motion-laws** have zero velocity and acceleration at their start and end.

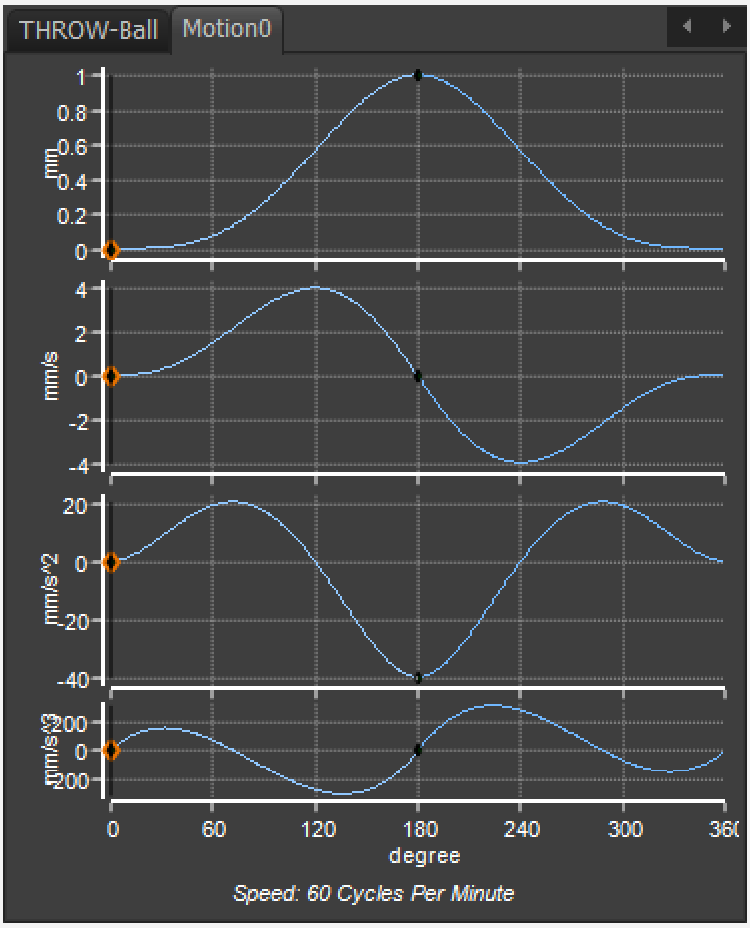
This **Throw motion-law** also has zero Jerk at its start and end.

This **Throw** has a **Quick-Return** because it has a negative acceleration at its maximum displacement - the transition from Rise to Return.

See also:

- Throw: Quick Return 1 Finite Jerk @ Start/End/Mid-Point 780
- Throw: Rapid Return: Finite Jerk @ Start/End/Mid-Point 784
- Throw: Rapid Return: Smooth-Start/End 786

Throw: Quick-Return - Zero Jerk at its Start-and End.



THROW: Quick-Return Zero Jerk Start, Middle, End

MOTION-VALUES OF EACH MOTION-DERIVATIVE

Start of rise segment 1 :

X =0

- Position = 0
- Velocity = 0
- Acceleration = 0
- Jerk = 0

Mid-Point :

X=180 (you can move the X-axis value of the mid-point)

- Position = 1
- Velocity = 0
- Acceleration = Unspecified (Actual value = -40.0mm/s/s)
- Jerk = 0

End of return Segment 2 :

X=360

- Position 2 = 0
- Velocity = 0
- Acceleration = 0
- Jerk = 0

1.6.11.10.3 Throw Rapid-Return 1: Finite-Jerk @ Start/End/Mid-Point Motion-Law

Throw: Rapid-Return Finite Jerk

The Throw Motion-Law

Unlike other motion-laws, the **Throw motion-law** rises from its **Start-Position** to its maximum displacement, and then returns to its **Start-Position**.

To give you maximum flexibility, use **two Flexible Polynomial** segments to design the **Throw motion-law**. Usually, the two segments have equal durations, but it is not necessary.

Throw: Rapid-Return 1 - Zero Jerk at Start and End.

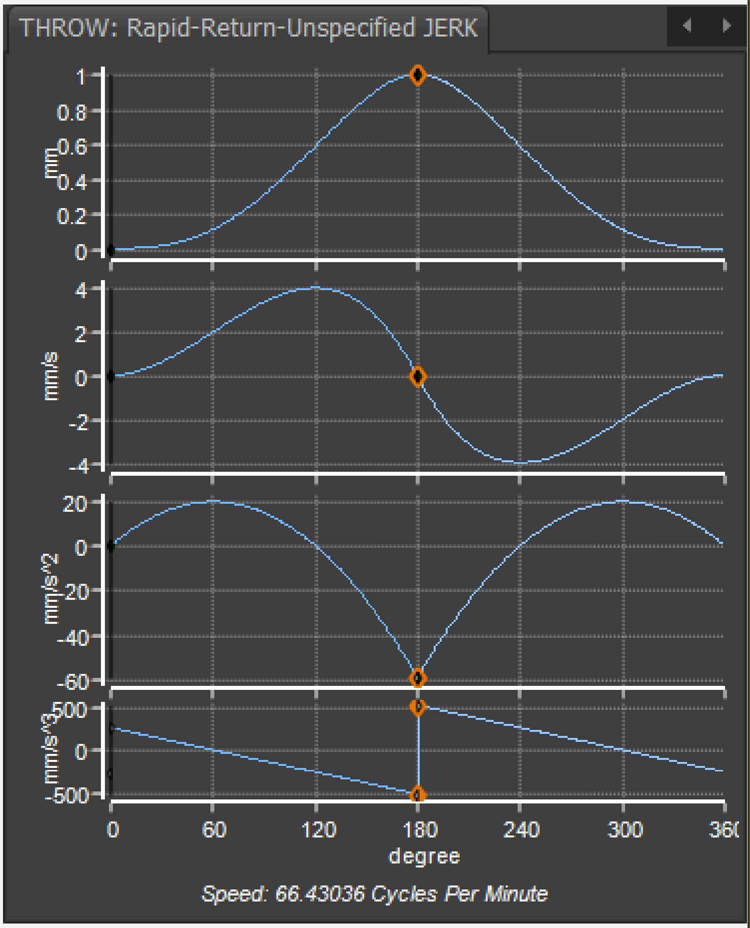
Because you use two **Flexible-Polynomial** segments to design the **Throw motion-law**, you can enter different motion-values and motion-constraints at its start, its maximum displacement, and at its end.

This **Throw** has a **Quick-Return** because it has a LARGE negative acceleration, and unspecified Jerk, at its maximum displacement - the transition from Rise to Return.

See also:

- Quick Return 1: Finite Jerk @ Start/End/Mid-Point 780
- Quick Return 2: Zero Jerk @ Start/End/Mid-Point 782
- Rapid Return 2: Smooth-Start/End 786

Two Segment 'Rapid-Return Motion 1



MOTION-VALUES OF EACH MOTION-DERIVATIVE

Start of Rise segment 1 :

- Position = 0
- Velocity = 0
- Acceleration = 0
- Jerk = Unspecified (Actual value = 260.6m/s/s/s)

Middle Blend-Point *:

- Position = 1
- Velocity = 0
- Acceleration = Unspecified (Actual value = -58.84mm/s/s)
- Jerk = Unspecified (Actual value = ±521.167mm/s/s/s)

End of Return segment 2 :

- Position 2 = 0
- Velocity = 0
- Acceleration = 0
- Jerk = Unspecified (Actual value = -260.6mm/s/s/s)

---

* Edit the X-axis value of the middle Blend-Point to give an asymmetrical motion.

1.6.11.10.4 Throw Rapid-Return 2: Zero-Jerk @ Start/End Motion-Law, Finite at Mid-Point

Throw: Rapid-Return with Zero Jerk

The Throw Motion-Law

Unlike other motion-laws, the **Throw motion-law** rises from its **Start-Position** to its maximum displacement, and then returns to its **Start-Position**.

To give you maximum flexibility, use two **Flexible Polynomial** segments to design the **Throw motion-law**. Usually, the two segments have equal durations, but it is not necessary.

Throw: Rapid-Return 2 - Zero Jerk at Start and End, unspecified at its mid-point.

Because you use two **Flexible-Polynomial** segments to design the **Throw motion-law**, you can enter different motion-values and motion-constraints at its start, its maximum displacement, and at its end.

All **Throw motion-laws** have zero velocity and acceleration at their start and end.

This **Throw motion-law** also has zero Jerk at its start and end.

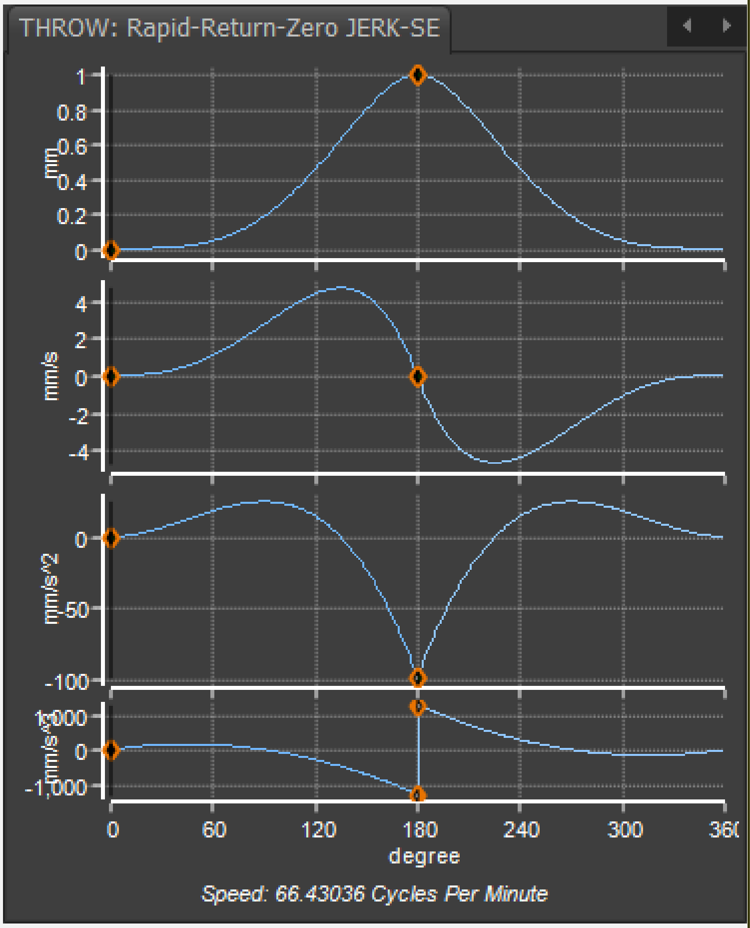
This **Throw** has a **Quick-Return** because it has a LARGE negative acceleration, and unspecified Jerk, at its maximum displacement - the transition from Rise to Return.

The **Throw type motion-law** it typically symmetrical. You can make it asymmetrical, if you move the X-axis value at its mid-point.

See also:

- Throw Quick Return 1: Finite Jerk @ Start/End/Mid-Point 780
- Throw Quick Return 2: Zero Jerk @ Start/End/Mid-Point 782
- Throw Rapid Return 1: Finite-Jerk @ Start/End/Mid-Point 784

Two Segment 'Rapid-Return with Zero Jerk at Start/End, 2'



MOTION-VALUES OF EACH MOTION-DERIVATIVE

Start of rise segment 1 :

- Position = 0
- Velocity = 0
- Acceleration = 0
- Jerk = 0

Mid-Point :

- Position = 1
- Velocity = 0
- Acceleration = Unspecified (Actual value = -98.mm/s/s)
- Jerk = Unspecified (Actual value = ±1303mm/s/s/s)

End of return Segment 2 :

- Position 2 = 0
- Velocity = 0
- Acceleration = 0
- Jerk = 0

1.6.11.11 Low Impact Crossover Motion-Law

Low Impact at Crossover.

Impact, Overrun, and Crossover.

Crossover is the timing at which acceleration becomes a deceleration, and vice versa.

At crossover, machine components traverse **backlash** to **impact** with each other.

As the Torque reverses, the application inertia may drive the motor. The motor may accelerate so that, for a short period, the motor rotates faster than intended. This is called **overrun**. As a result, the velocity and acceleration of the Follower may also be greater than intended.

A motion-law with **Low Jerk at Crossover** means the acceleration changes less rapidly at crossover - which means the Jerk is low at crossover. As the acceleration is low for a longer period, the velocity changes less rapidly, to reduce Impacts and Overrun.

Low Impact at Crossover.

Low or Zero Impact at Crossover motion-law is not available in the Motion-Law Selector741. Use two **Flexible Polynomial motion-laws**.

Velocity and Acceleration are zero at the start and end.

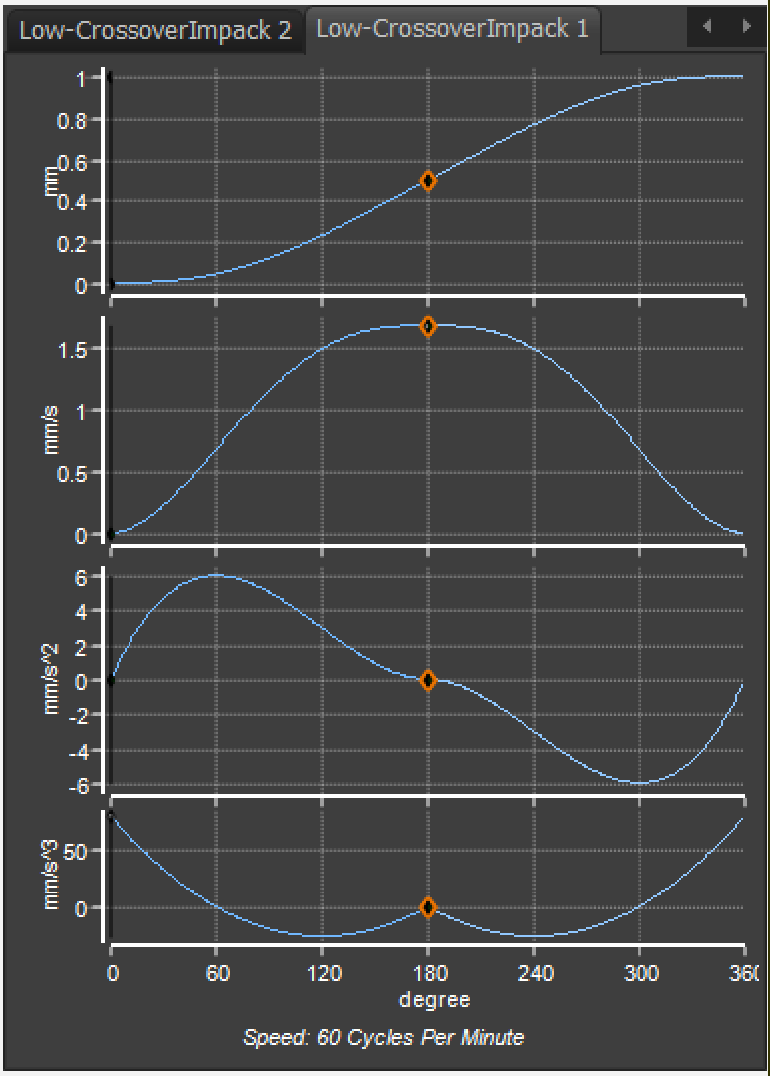
Acceleration and Jerk are zero at the mid-point.

The **Low Impact at Crossover** is typically symmetrical. You can make it asymmetrical if you move the X-axis and the Position at the mid-point. The maximum Velocity should not change, but the maximum Acceleration and Jerk values increase.

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.667$
Acceleration Coefficient :	$C_a = 5.926$
Jerk Coefficient :	$C_j = 80, -26.667$
Jerk at Crossover :	$C_{Jc} = 0.0$

Two Flexible Polynomial segments to give Low Jerk at Crossover motion-law.



Low Jerk at Crossover (with two Flexible-Polynomial Segments)

MOTION-VALUES OF EACH MOTION-DERIVATIVE - Normalized values

Start of rise segment 1 :

X = 0 (0°)

- Position = 0
- Velocity = 0
- Acceleration = 0
- Jerk = Unspecified (Actual value = 80 mm//s/s/s)

Mid-Point :

X = 0.5 (180°)

- Position = 0.5
- Velocity = Unspecified (Actual value = 1.6667 mm/s)
- Acceleration = 0
- Jerk = 0

End of return Segment 2 :

X = 1 (360°)

- Position = 1
- Velocity = 0
- Acceleration = 0
- Jerk = Unspecified (Actual value = 80 mm//s/s/s)

1.6.11.12 Modified-Sinusoid Motion-Law

Modified-Sinusoid Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law[755]. Its name is often reduced to **Mod-Sine.**

A motion with continuous **Velocity** and **Acceleration**, from start to end. The Jerk is finite at its start and end.

MOTION-VALUES

You CAN control the:

START POSITION -

The START POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

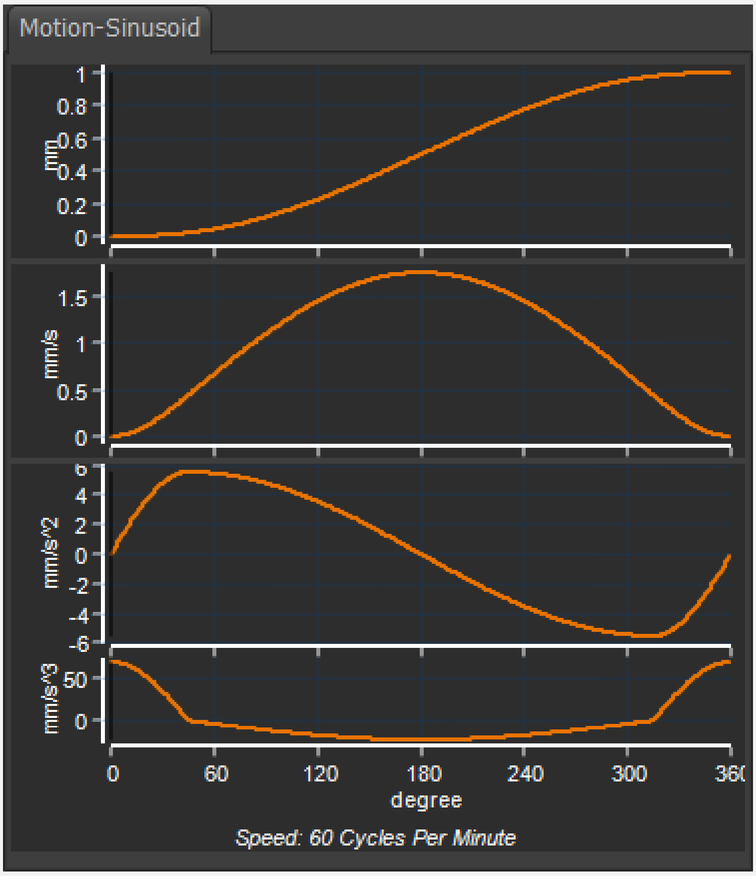
START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Modified-Sinusoid Cam-Law / Motion-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.760$
Acceleration Coefficient :	$C_a = 5.530$
Jerk Coefficient :	$C_j = 69.47$
Jerk at Crossover :	$C_{J(co)} =- 25.13$

APPLICATION NOTES

The **Modified Sinusoid** motion-law has finite jerk throughout the segment.

It has an relatively low peak velocity, but a relatively high value of the nominal acceleration.

Dynamic Performance

This Motion-Law is a good general purpose type particularly in applications where the period ratio is between 5 and 10, particularly if the input drive is flexible or it has backlash. It performs well with respect to residual vibration after the segment is complete.

Pressure Angle Considerations

This one of the **Traditional Motion-Laws** that produce a relatively small pressure angle, and so a small cam for a given lift and pre-prescribed maximum pressure angle.

Drive Torques

The nominal drive torque characteristics and the actual torque values are low even for low values of Period Ratio are good for this motion-law. The low peak values and the smooth variation of drive torque during the motion-law further emphasize the suitability of this motion-law where the input drive is flexible or has backlash.

More information:

The Acceleration function is a series of Sinusoid functions.

- a ¼ Sine wave function, starting from zero acceleration, for 12.5% of the SEGMENT-WIDTH.
- a ½ Cosine function, for 75% the SEGMENT-WIDTH
- a ¼ Sine wave function, returning to zero acceleration, for 12.5% of the SEGMENT-WIDTH.

1.6.11.13 Modified-Trapezoidal Motion-Law

Modified-Trapezoid Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law[755] . Its name is often reduced to **Mod-Trap.**

A motion with continuous Velocity and Acceleration, from start to end. The Jerk is finite at its start and end. Its peak acceleration is moderate.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the **PREVIOUS-SEGMENT.**

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

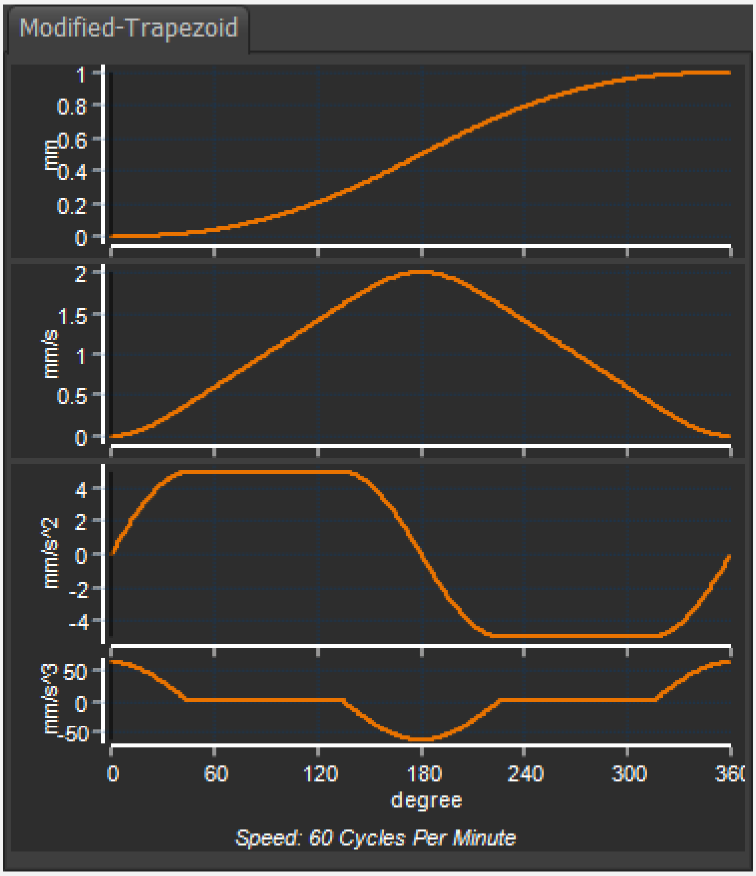
START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Modified Trapezoid Cam-Law / Motion-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 2.00$
Acceleration Coefficient :	$C_a = 4.890$
Jerk Coefficient :	$C_j = \pm 61.43$
Jerk at Crossover :	$C_{J(co)} = - 61.43$

APPLICATION NOTES

The **Modified Trapezoidal** motion-law has finite jerk throughout the segment.

It has an average peak nominal acceleration compared to the other Traditional Motion-Laws.

Dynamic Performance

This Motion-Law is a good general purpose type particularly in applications where the period ratio is above about 5.

It is not good in applications where the input drive has backlash or is relatively flexible. As long as the drive satisfies these conditions, then this segment exhibits low residual vibrations.

Pressure Angle Considerations

This is one of the Traditional Motion-Laws that produce a relatively large pressure angle - and so might need a large cam for a given lift and pre-prescribed maximum pressure angle.

Drive Torques

This Motion-Law exhibits a rapid reversal of inertia torque at the cros-sover (mid) point.

Only the Constant-Acceleration Motion-Law is more rapid, of the Traditional Segments. It is unsuitable to drive heavy masses at high speeds (even though the maximum acceleration is low). The rapid reversal of torque may give rise to severe vibrations and shock loading especially if the period ratio is less than 10.

More information:

The acceleration function of the **Modified-Trapezoidal** is:

- 0.125 of SEGMENT-WIDTH - 1/4 Sine function
- 0.250 of SEGMENT-WIDTH - Constant-Acceleration
- 0.250 of SEGMENT-WIDTH - 1/2 Cosine function
- 0.250 of SEGMENT-WIDTH - Constant-Acceleration
- 0.125 of SEGMENT-WIDTH - 1/4 Sine function

1.6.11.14 Polynomial 2-3 Motion-Law

Polynomial 2-3 Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law [755]. Its name is often reduced to Parabolic Velocity, or Poly 23.**45.**

A motion with continuous **Velocity**, from start to end.

There are large **Acceleration-Discontinuities**, with infinite jerk, at its start and end.

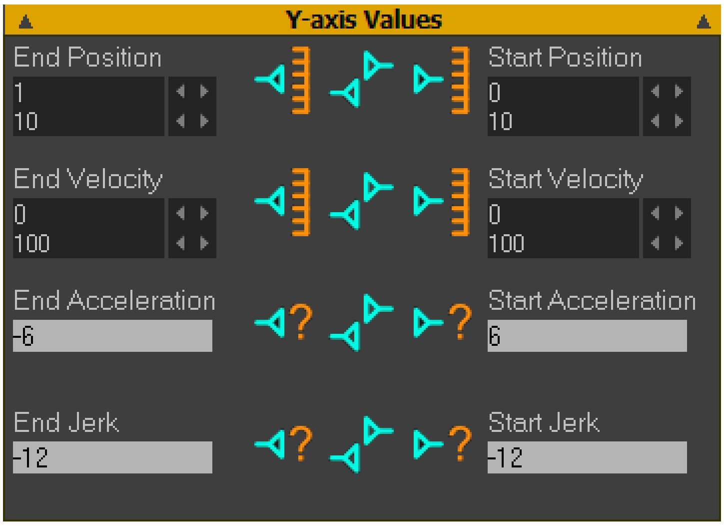
It gives a low peak velocity, but a high peak Acceleration.

It has a low Jerk value at the crossover point (the mid-point).

Its Torque characteristic is very good.

MOTION-VALUES

Use the Control-Buttons and the Flexible Polynomial motion-law



Flexible-Polynomial Control-Buttons for POLYNOMIAL 2-3

Edit the START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

Edit the END POSITION

Use the Control-Buttons to force the START-VELOCITY and END-VELOCITY to Zero (units/s)

Deselect the START-ACCELERATION, END-ACCELERATION, START-JERK, and END-JERK Control-Buttons.

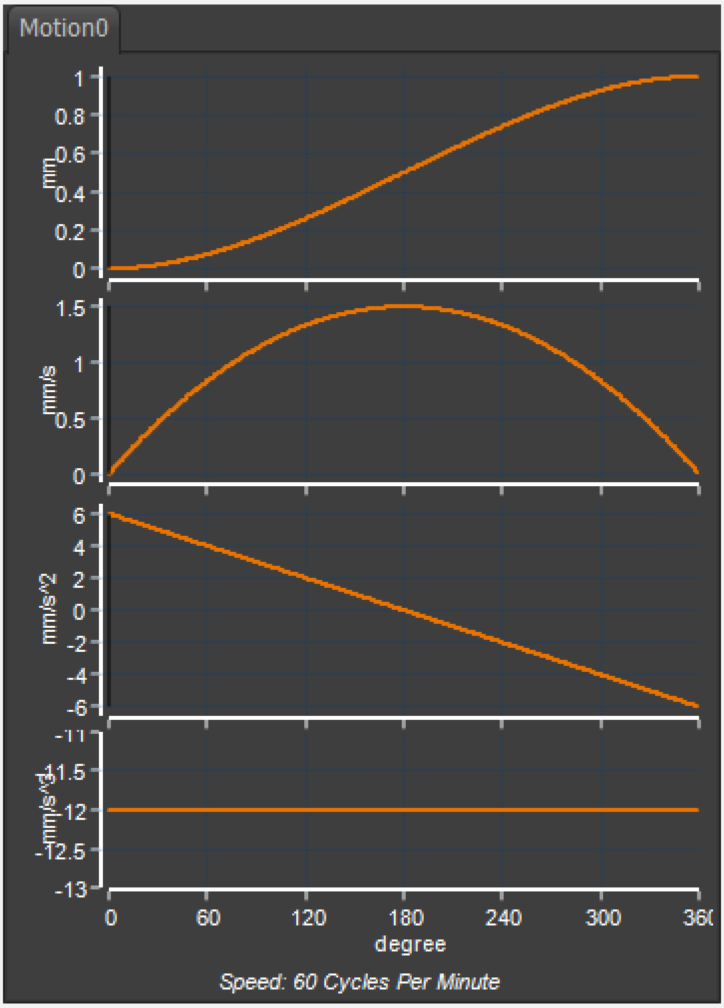
SEGMENT PARAMETERS

None

SEGMENT-RANGE

None

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law
See also : Tutorial 9: Asymmetrical Motions



Polynomial 2-3

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.5$
Acceleration Coefficient :	$C_a = 6$
Jerk Coefficient :	$C_j = \pm 12.000$
Jerk at Crossover :	$C_{Jc} = -12.00$

APPLICATION NOTES

Dynamic Performance:

This Motion-Law is not recommended for applications where the **period-ratio** < 10,

There are large Acceleration-Discontinuities, with infinite Jerk, at its start and end.

Pressure Angle Considerations

This is a Traditional Motion-Law that produces a relatively low pressure angle

Drive Torques

The torque characteristics of this motion law are good compared to other traditional motion-laws, when.

1.6.11.15 Polynomial 3-4-5 Motion-Law

Polynomial 3-4-5 Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law 755. Its name is often reduced to **Poly-345.**

A motion with continuous **Velocity** and **Acceleration**, from start to end. The **Jerk** is finite at its start and end. It has finite **Jerk** throughout.

It gives a relatively low nominal peak velocity, but a relatively high peak nominal Acceleration. It has a relatively low Jerk value at the crossover point (the mid-point). It is commonly used in high-speed mechanisms.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

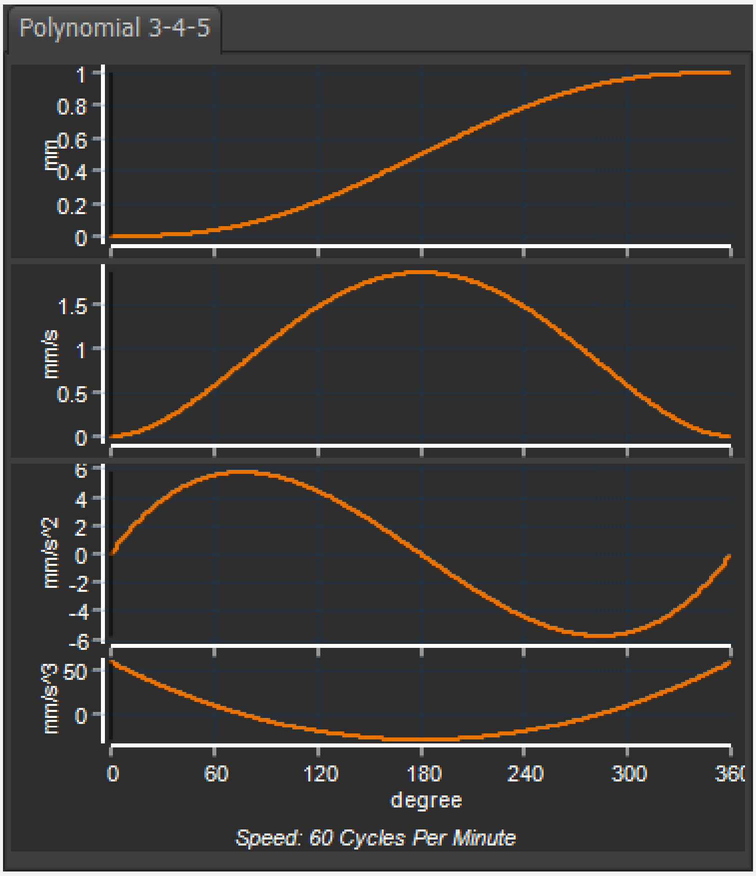
None

SEGMENT-RANGE

None

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law

See also : Tutorial 9: Asymmetrical Motions



Polynomial 3-4-5 Motion-Law / Cam-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.875$
Acceleration Coefficient :	$C_a = 5.773$
Jerk Coefficient :	$C_j = \pm\, 60.000$
Jerk at Crossover :	$C_{Jc} = -\, 30.00$

APPLICATION NOTES

Dynamic Performance:

This Motion-Law is recommended for applications where the period ratio is less than 10, particularly where the input drive is stiff and the shaft speed does not fluctuate significantly under load.

It has good acceleration characteristics and is suitable for applications that need low levels of residual vibration.

Pressure Angle Considerations

This is a Traditional Motion-Law that produces a relatively large pressure angle - and so might need a larger cam for a given lift and pre-prescribed maximum pressure angle.

Drive Torques

The torque characteristics of this motion law are good compared to other traditional motion-laws, when the period ratio is less than 10. IT is recommended when no sudden change in torque is allowed.

1.6.11.16 Polynomial 4-5-6-7 Motion-Law

Polynomial 4-5-6-7 Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law[755]. Its name is often reduced to **Poly-4567.**

A motion with continuous **Velocity** and **Acceleration**, from start to end. The **Jerk** is finite at its start and end. It has finite **Jerk** throughout.

It has a high maximum-velocity, high maximum-acceleration, high crossover jerk. Only the **MODIFIED-TRAPEZOIDAL** (of those with finite Jerk) has a greater crossover jerk.

At its start and end, the **Y-axis** values do not change much with a significant **X–axis** change - e.g. 0.02% Y-axis with 5% X-axis change.

Therefore, a cam needs accurate machine if it is to reproduce this segment. A larger cam often helps, or an encoder with a high resolution.

If possible, increase the **SEGMENT-WIDTH**[707] to reduce its maximum Velocity, Acceleration and Jerk values.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

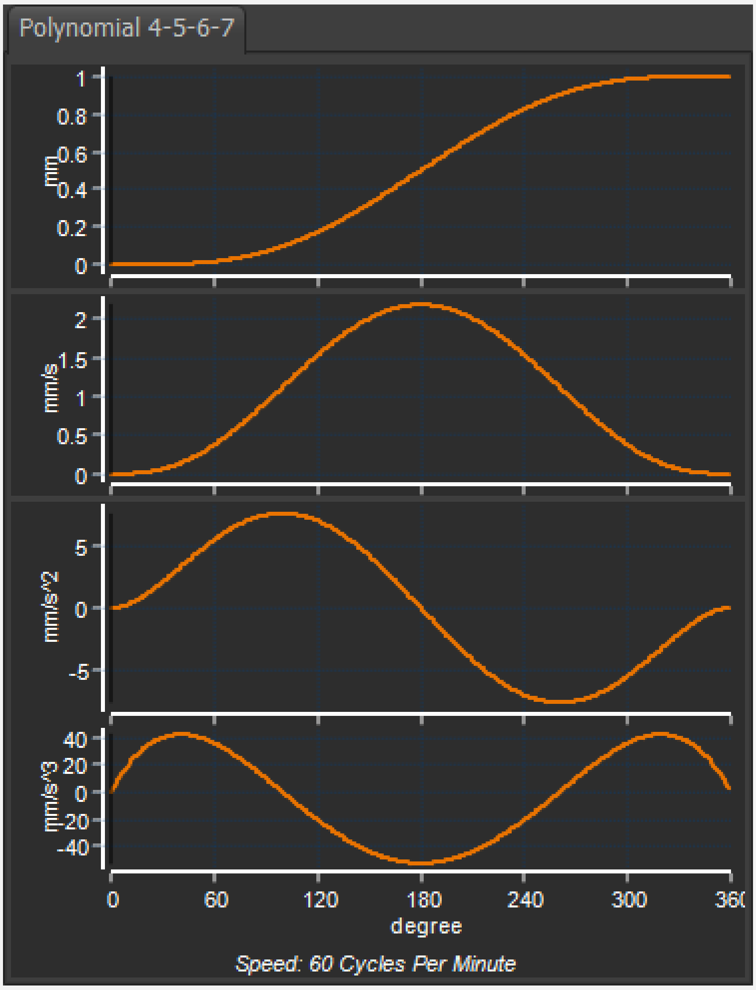
None

SEGMENT-RANGE

None

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Polynomial 4-5-6-7 Motion-Law / Cam-Law

Motion-Law Coefficients

Velocity Coefficient :	$C_v = 2.188$
Acceleration Coefficient :	$C_a = 7.513$
Jerk Coefficient :	$C_j = 52.5$
Jerk at Crossover :	$C_{Jc} = -52.50$

APPLICATION NOTES

Dynamic Performance:

This Motion-Law is recommended in applications where the period ratio is between about 5 and 10. It has a low residual vibration. However, the high peak acceleration means every effort should be made to increase the duration of the segment.

Pressure Angle Considerations

This has a relatively large maximum-acceleration and maximum velocity, which increase the maximum pressure-angle.

Drive Torques

It has a high peak torque.

1.6.11.17 Position List [Import Data]

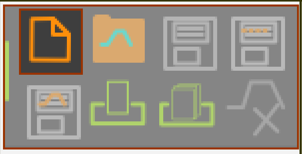
Import Data: Position List

The **POSITION LIST** is a **List Segment-Type.**

The **POSITION-LIST** is a segment that uses the **Data Transfer Table** to import your data as the motion-values.

Other **List Segment-Types** are **Z-Raw-Data**[834] and **Acceleration-List**[758]

STEP 1. Add a new Motion



Add New Motion

See also Add Motion[723]

STEP 2. Delete Segments

Usually, the data you want to import is for one motion cycle.

In that case, you need one segment in the motion.

1. Delete three segments from the default motion-law.

See Delete Segment[719]

STEP 3. Change the Motion-Law of the segment to Position-List

In the Motion-Law Selector[741] **:**

1. Select POSITION LIST

STEP 4. Import your motion-values (data) into the Data Transfer Table

1. Open the Data Transfer Table[744]
2. Click the cell in the first row and left column of the **Data Transfer Table** to make it the active cell.

To transfer data from a data file:

3a : Copy & Paste data from your clipboard into the **Data Transfer Table**

OR

3a : Use the toolbar icon Load Data from a CSV or TXT file-type[747]

OR

3a : Get all displayed P, V- A J Segment-Data[751] or Get all displayed P, V , A, J Motion Data[750] from a **different Motion name-tab.**

Motion-values (data) are now in the **Data Transfer Table.**

STEP 5. Transfer the data from the Data Transfer Table to a Position List segment-type.

To transfer **all** of the data:

1. Select the Position motion-values in the **Data Transfer Table**

To select the data, you can click the header in the **Data Transfer Table** with the Position motion-values.

2. Click Put Data[750] in the **Data Transfer Table** toolbar.

Data Transfer Table toolbar

Note : The **GET DATA** and **PUT DATA** icons show only when the segment is a **List Segment-Type.**

OR

To transfer a section of the data:

1. **CLICK** the **first data-point** you want to paste
2. **SHIFT+CLICK** the **last data-point** you want to paste

When the cells are **active**:

3. Click Put List Data[750] in the **Data Transfer Table** toolbar.

Note : **GET DATA** and **PUT DATA** icons show **only** when the segment is a **List Segment-Type.**

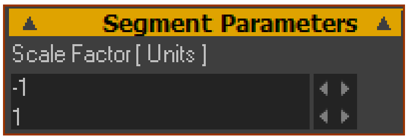
STEP 6. SCALE the data.

After you transfer the data, the minimum and maximum values are equal to the actual values in your data.

However, you can also scale the data.

To scale the data:

If the actual First and Last data points are EQUAL:



Scale-Factor and Position-List
Use when First = Last data point.

1. Open the **SEGMENT EDITOR**
2. Expand **SEGMENT PARAMETERS**
3. Edit the Scale Factor parameter.

Notes:

If required, to see the **SEGMENT PARAMETERS**, expand and collapse the **SEGMENT MOTION-LAW** .

A **SCALE FACTOR = 1** scales the data to the actual minimum and maximum values.

You can edit the **START POSITION** to offset the data on the **Y-axis**

You can edit the **MOTION-START** (**BLEND-POINT EDITOR**, only) value to move the data along the **X-axis**.

The Velocity, Acceleration and Jerk values scale automatically.

If the actual First and Last data points are NOT EQUAL

SEGMENT EDITOR : Start and End Positions of a Position-List segment

1. Start the **SEGMENT EDITOR** or **BLEND-POINT-EDITOR**
2. Edit the **START-POSITION** and **END-POSITION**

1.6.11.18 Quadratic Motion-Law

Quadratic Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law [755]. This is a Polynomial motion-law.

The Velocity increases or decreases linearly.

Acceleration is constant, but it is discontinuous at its start and end.

Jerk is generally zero, but has infinite Jerk at its start and end.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

START VELOCITY

You CANNOT control the:

END VELOCITY

START ACCELERATION and END ACCELERATION

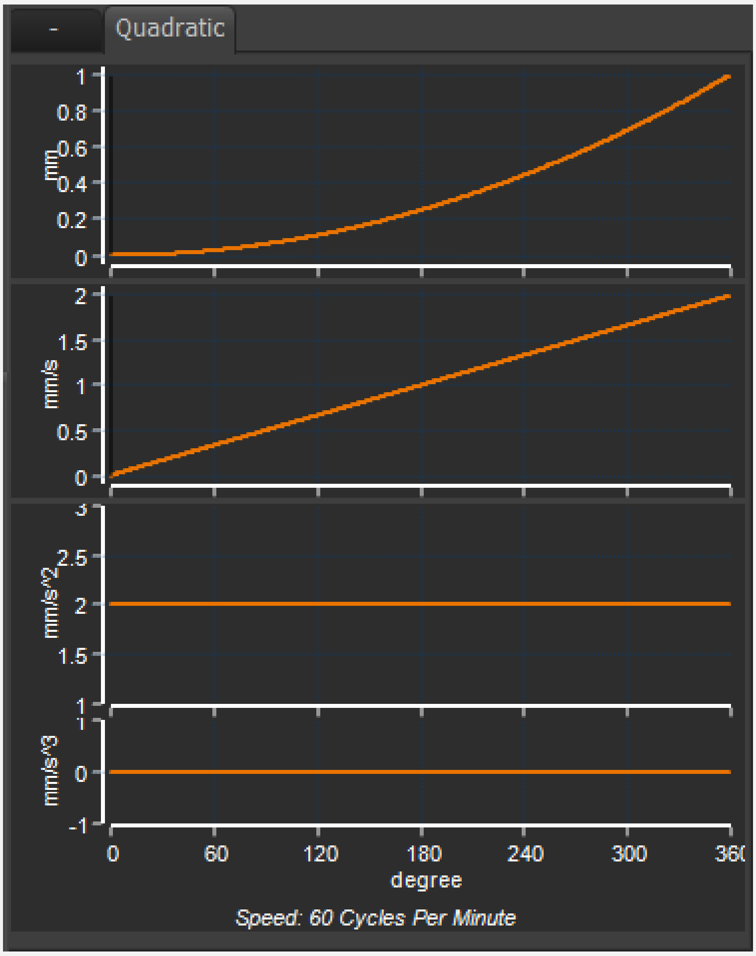
START JERK and END JERK

SEGMENT PARAMETERS

None

SEGMENT-RANGE

None



Quadratic Motion-Law

In the image above of 1 Quadratic segment, the motion-values are:

- START POSITION = 0mm
- END POSITION = 1mm
- START VELOCITY = 0mm/s

APPLICATIONS

Segments with Constant Acceleration, Linearly Increasing-Velocity, or Linearly Decreasing Velocity.

You can use this to model a Part under the influence of a Constant-Acceleration, or a constant force or torque.

1.6.11.19 Ramp Motion-Law

Ramp Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law 755.

The **Ramp motion-law** has three phases:

Phase 1: Acceleration : first ½ wave of a Sine function (see Segment-Parameters)

Phase 2: Zero Acceleration : Constant Velocity

Phase 3: Deceleration : last ½ wave of a Sine function : (see Segment-Parameters)

You can design an **Asymmetric Segment**, in which the **Phase 1** is longer or shorter than **Phase 2**.

Velocity and Acceleration are continuous from start to end.

Jerk is finite but discontinuous at the start and end of Phase 1 and of Phase 3.

MOTION-VALUES

You CAN control the:

START-POSITION

The START-POSITION usually **flows** from the END-POSITION of the **PREVIOUS-SEGMENT**.

END-POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

START-FRACTION × 100 = % of SEGMENT-WIDTH to accelerate from zero-velocity* to maximum-velocity

END-FRACTION × 100 = % of SEGMENT-WIDTH to decelerate from maximum-velocity to zero-velocity**

START-FRACTION + END FRACTION $\leq$ 1

∴ **Constant-Velocity Fraction** = 1 – START-FRACTION – END-FRACTION

* if START-RANGE = zero

** if END-RANGE = zero

SEGMENT-RANGE

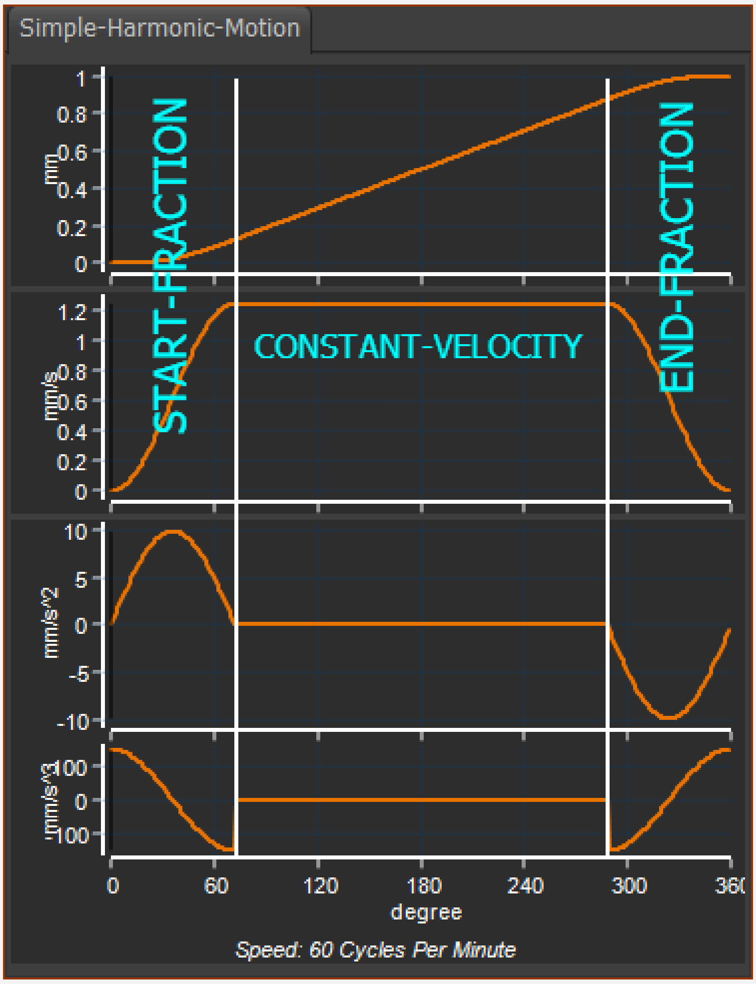
START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law

See also : Tutorial 9: Asymmetrical Motions



1 x Ramp Segment, Symmetrical

Applications

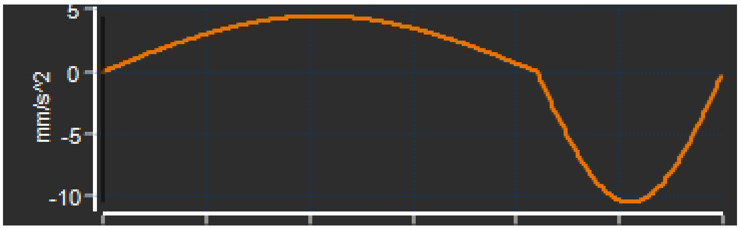
Asymmetric Segments, in which the Acceleration phase is longer or shorter than the Deceleration phase.

Motion with a long displacement, in which the maximum-velocity is less than other motion-laws.

Asymmetrical Example (see image below)

- START-FRACTION ≠ END-FRACTION
- START-FRACTION = 0.7
- END-FRACTION = 0.3
- START-FRACTION + END-FRACTION = 1

∴ CONSTANT-VELOCITY % = 0%



E.g.: RAMP Segment: Start-Fraction = 0.7, End-Fraction = 0.3
(Constant-Velocity Fraction = 0)

1.6.11.20 Simple-Harmonic Motion-Law

Simple Harmonic Motion Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law[755] .

This Motion-Law has the lowest maximum velocity of all the Traditional Motion-Laws. However, it also produces infinite jerk at its start and end.

This makes it a poor choice form a dynamic viewpoint if you use it between Dwell segments in a Dwell-Rise-Dwell type motion.. However, you can usefully apply it between Flexible-Polynomial segments, with which it is possible to remove the acceleration discontinuities at its start and end.

MOTION-VALUES

You CAN control the:

START-POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END-POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

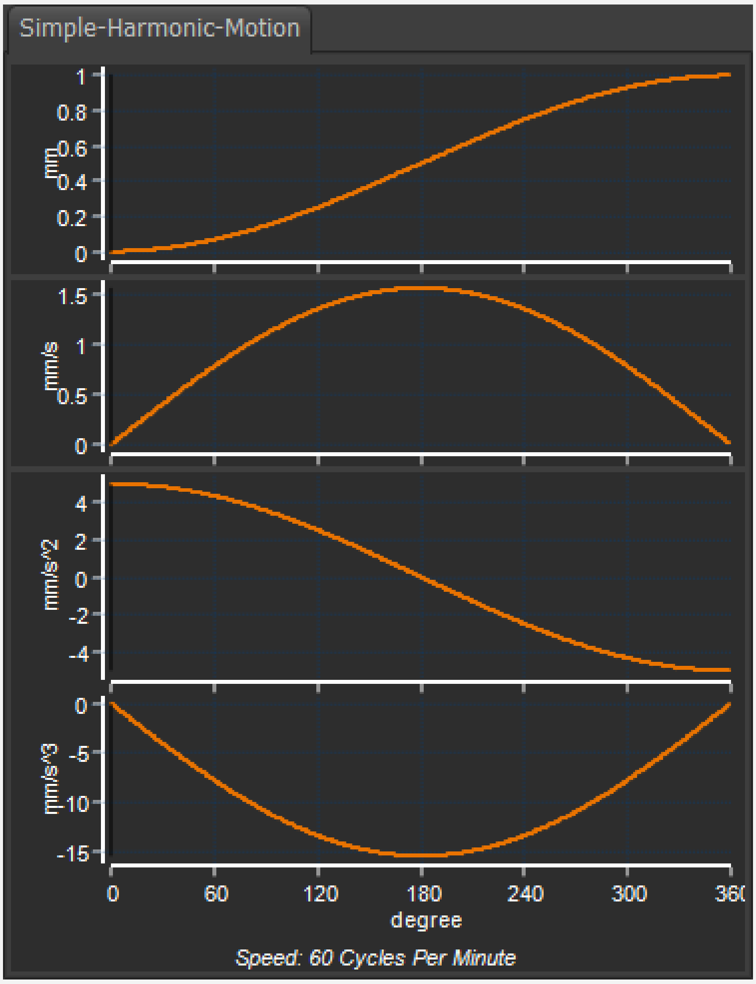
None

SEGMENT-RANGE[712]

None

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Simple-Harmonic-Motion Motion-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 1.517\ or\ (\pi/2)$
Acceleration Coefficient :	$C_a = 4.935\ or\ (\pi^2/2)$
Jerk Coefficient :	$C_j = 15.503\ or\ (\pi^3/2)$
Jerk at Crossover :	$C_{Jc} = -15.503$

APPLICATION NOTES

Dynamic Performance:

This law should be used in applications where inertia loading is not very significant. When Period-Ratio is less than 10, this law will give shock loading, noise, and vibration during operation.

The actual acceleration at the load being driven by this Motion-Law is always more than the nominal value, and for this reason, this segment should only be used in mechanical applications where inertia effects are insignificant.

Pressure Angle Considerations:

This is one of the Traditional Motion-Laws that produce a relatively small pressure angle - and so might allow a smaller cam for a given lift.

OR for a given limit to Pressure-Angle, this motion-law can give a smaller cam, and/or a shorter motion segment.

Drive Torques:

When considering drive torques in isolation, the nominal torque for this Motion-Law is the best of Traditional Motion-Laws - it has both the lowest value and the smoothest variation throughout the segment. However, the motion discontinuities at its beginning and end cannot be ignored, as these will lead to shock loading.

For compliant systems of high speed systems (Period Ratio between 2 and 10) the Modified Sine 790 and the Cycloidal 769 are preferred.

1.6.11.21 Sine-Constant-Cosine (SCCA) Motion-Law

Sine-Constant-Cosine Acceleration (SCCA) Cam-Law, Motion-Law - a Traditional Motion-Law[755]

MOTION DESCRIPTION

The SEGMENT-PARAMETERS make this motion-law very flexible. It is possible to get **many** of the Traditional Motion-Laws that are based on Sine and Cosine harmonics.

See below: Segment-Parameters for Traditional Motion-Laws[816] .

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

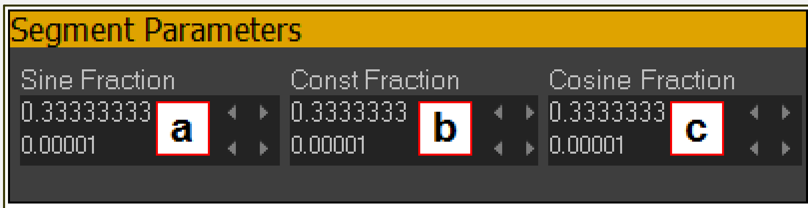
You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS



The **SCCA motion-law** is a defined by a sequence of trigonometric segments in acceleration motion-derivative. The motion-law is symmetrical, thus the sequence is:

From 0.0 ≤ X ≤ 0.5 of the Segment-Width

- **a.** Sine Fraction
- **b.** Constant Fraction
- **c.** Cosine Fraction:
- **d.** Zero Acceleration

From 0.5 ≤ X ≤ 1 of the Segment-Width

- **d.** Zero Acceleration
- **c.** Cosine Fraction
- **b.** Constant Fraction
- **a.** Sine Fraction

Example Motion-Law - see image below

a = 0.25 ; 25% : TOTAL SINE ACCELERATION FRACTION

b = 0.25 ; 25% : TOTAL CONSTANT ACCELERATION FRACTION

c = 0.25 ; 25% : TOTAL COSINE ACCELERATION FRACTION

∴ d = 1 – a – b – c = 0.25 ; 25% TOTAL ZERO ACCELERATION FRACTION

Rules for the segment parameters:

SEGMENT-PARAMETERS may be zero, but not all.

SEGMENT-PARAMETERS cannot be negative.

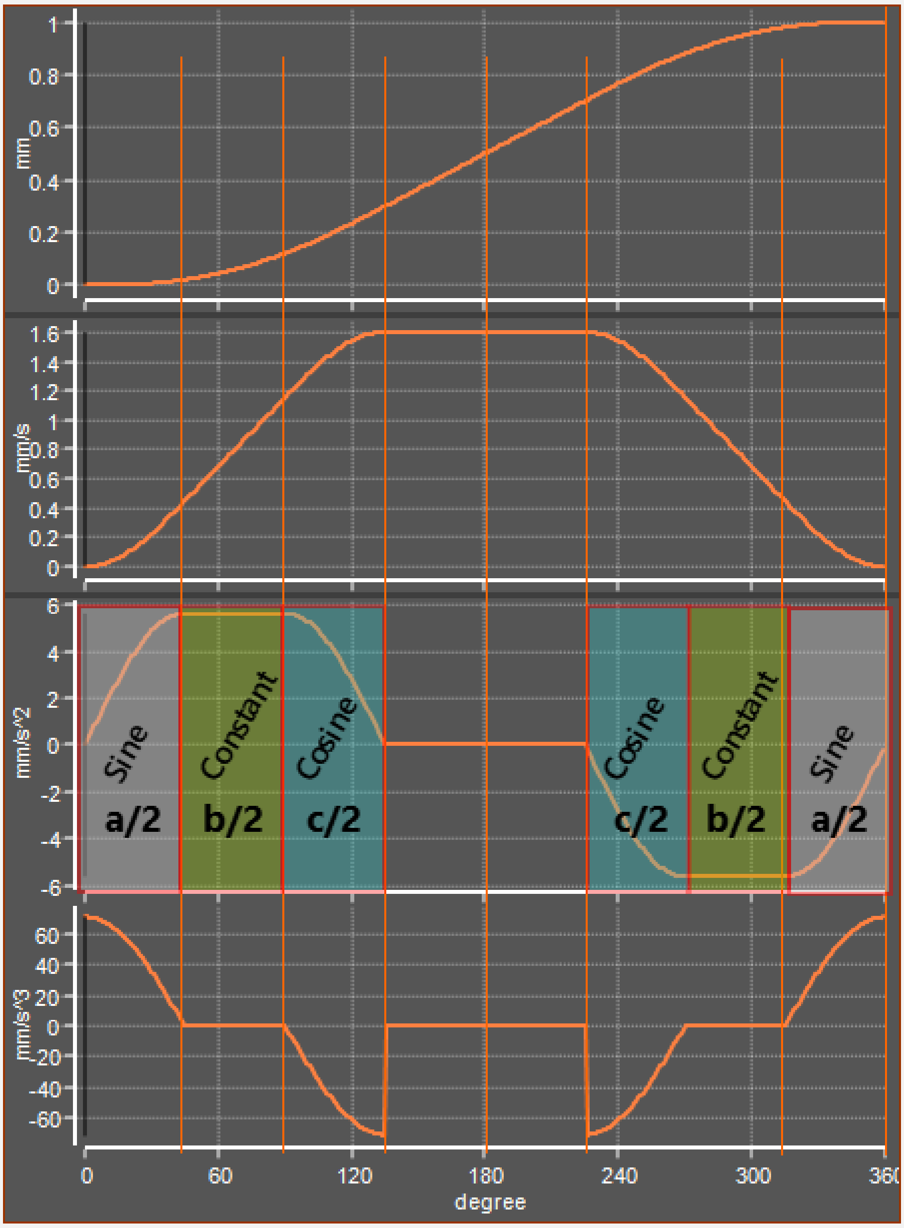
SEGMENT-RANGE

START-RANGE

END-RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

An Example Sine Constant-Cosine Acceleration Law.



Example motion with Sine-Constant-Cosine Motion Law with Segment Parameters: Sine Fraction a=0.25, Constant b=0.25, Cosine Fraction c=0.25

Segment Parameters to give other Traditional Motion-Laws.

MOTION-LAW:	Coefficients		Parameters		
	Cv	Ca	a	b	c
Modified Trapezoidal	2	4.89	0.25	0.5	0.25
'Lazy' Modified Trapezoidal	2	4.88	0.333	0.333	0.333
Modified-Sine	1.760	5.5	0.25	0	0.75
Modified-Sine CV 20%	1.528	5.999	0.2	0	0.6
Modified-Sine CV 33%	1.404	6.616	0.1667	0	0.5
Modified-Sine CV 50%	1.275	8.0127	0.125	0	0.375

Modified-Sine CV 66%	1.168	11.009	0.0833	0	0.25
Cycloidal	2	6.2832	0.5	0	0.5
Cycloidal CV 50%	1.333	8.378	0.25	0	0.25
Constant Acceleration-Deceleration	2	4	0	1	0
Trapezoidal Velocity CV33%	1.5	4.5	0	0.6667	0

1.6.11.22 Sine-Squared Motion-Law

Sine-Squared Cam-Law, Motion-Law

MOTION DESCRIPTION

A Traditional Motion-Law[755].

The maximum velocity and maximum acceleration are large when compared with other motion-laws. However, it has zero crossover jerk.

At the start and end of this Motion-Law, the **Y-axis** does not change very much with a significant **X–axis** change. E.g. 0.02% Y-axis after 5% X-axis change.

Therefore, to accurately reproduce the Motion-Law, it needs precise machining, a large cam, or an encoder with a high resolution. If possible, increase the **SEGMENT-WIDTH**[707] by ~20% to reduce the maximum Velocity, Acceleration, and Jerk values.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

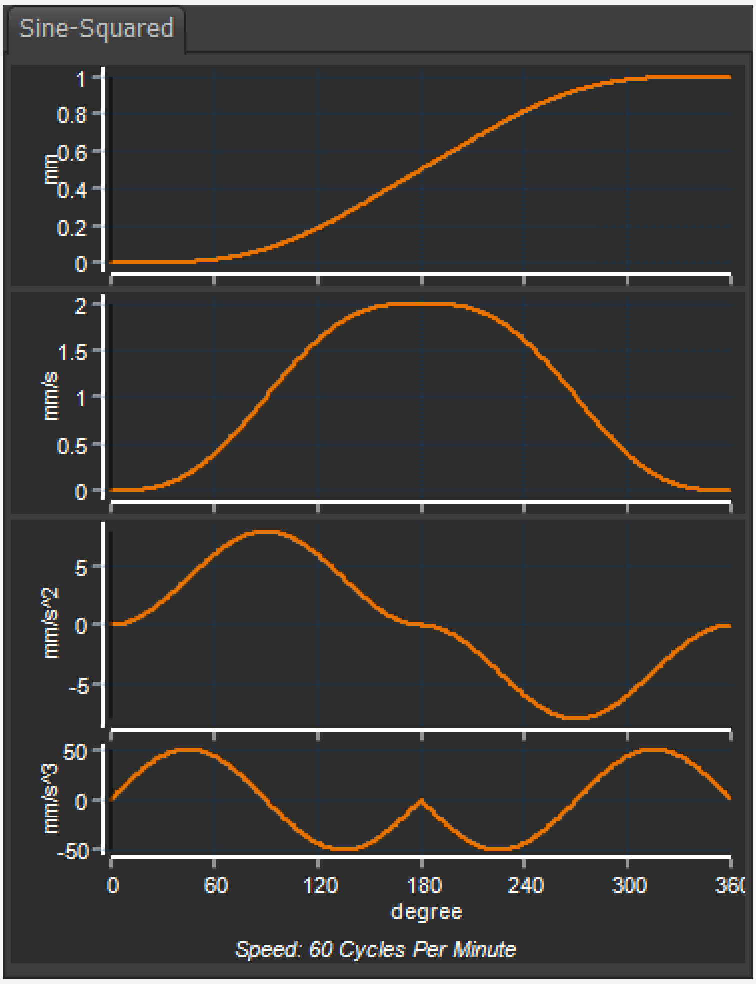
None

SEGMENT-RANGE

None

See also : Tutorial 5: Edit the Start of a Traditional Motion-Law.

See also : Tutorial 9: Asymmetrical Motions.



Sine-Squared Motion-Law / Cam-Law

MOTION-LAW COEFFICIENTS

Velocity Coefficient :	$C_v = 2.000$
Acceleration Coefficient :	$C_a = 8.000$
Jerk Coefficient :	$C_j = 52.265$
Jerk at Crossover :	$C_{Jc} = 0.000$

APPLICATION NOTES

Dynamic Performance:

This Motion-Law is recommended in applications where the period ratio is greater than 10.

Pressure Angle Considerations

This has a relatively large maximum-acceleration and maximum velocity, which increases the maximum pressure-angle.

Drive Torques

It has a high peak torque.

1.6.11.23 Sinusoidal Motion-Law

Sinusoid Cam-Law, Motion-Law

MOTION DESCRIPTION

This is a Traditional Motion-Law [755] .

This motion-law is a Sinusoid or **Sine-Wave**. The SEGMENT-PARAMETERS can define the number of Sinusoids, the phase at which the Sinusoid starts, and the amplitude of the Sinusoid.

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

You CANNOT control the:

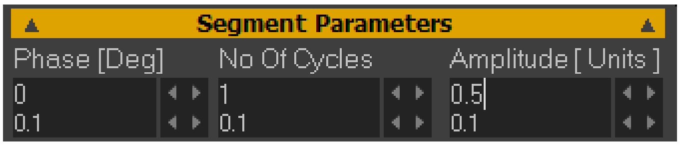
END POSITION

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS



PHASE - **(degrees)**

Enter the circular degrees at the start of the segment

NUMBER-OF-CYCLES - **(360 degrees / Cycle)**

Enter NUMBER-OF-CYCLES

One machine-cycle = 360 of the circular sinusoidal function.

AMPLITUDE

This is the Maximum amplitude of the Sine wave

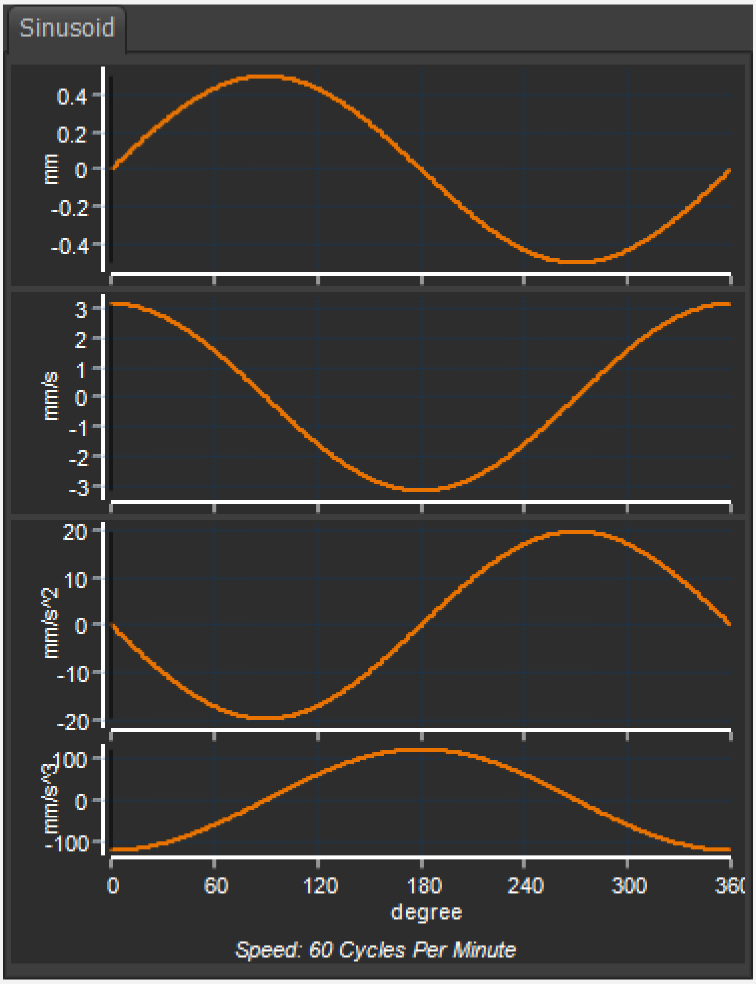
Amplitude = Peak-to-Peak / 2

SEGMENT-RANGE

START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1



SINUSOID segment
Amplitude =0.5 ; Number of Cycles = 1, Phase = 0

1.6.11.24 Triple-Harmonic Motion-Law

Triple-Harmonic Motion-Law

MOTION DESCRIPTION

The **Triple-Harmonic Motion-Law** is a **Traditional Motion-Law**.

It can approximate the Cycloidal[769], Modified-Trapezoidal[793], Modified Sine[790], Polynomial 3-4-5[799] motion-laws by using the SEGMENT-PARAMETERS

MOTION-VALUES

You CAN control the:

START POSITION

The START-POSITION usually **flows** from the END-POSITION of the PREVIOUS-SEGMENT.

END POSITION

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

Three Segment-Parameters:

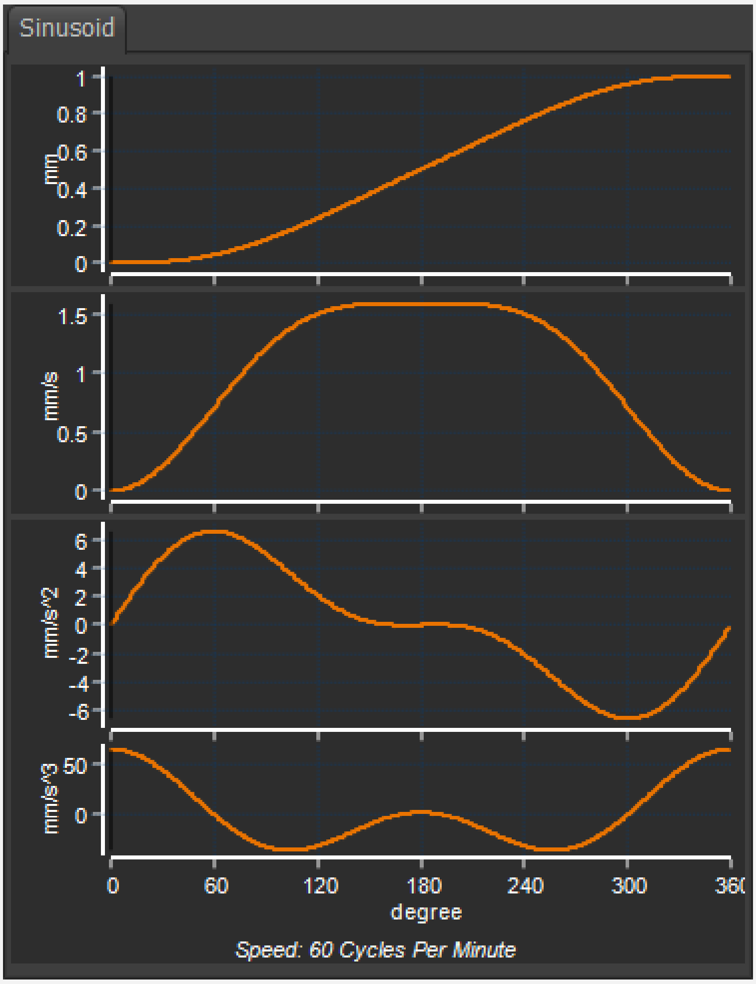
1. FIRST HARMONIC
2. SECOND HARMONIC
3. THIRD HARMONIC (calculated automatically from FIRST HARMONIC and SECOND HARMONIC)

SEGMENT-RANGE

START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1



TRIPLE HARMONIC

1st Harmonic = 4.983 ; 2nd Harmonic = 2.6 ; 3rd Harmonic = 0

Triple Harmonic as Approximate Motion-Laws

Cycloidal

Parameter 1 (First Harmonic): $2.\pi$

Parameter 2 (Second Harmonic): 0.0

Parameter 3 (Third Harmonic): 0.0

Modified Trapezoidal

Parameter 1 (First Harmonic): 6.04

Parameter 2 (Second Harmonic): 0.0

Parameter 3 (Third Harmonic): 0.73

Modified Sine

Parameter 1 (First Harmonic): 5.1968

Parameter 2 (Second Harmonic): 1.769

Parameter 3 (Third Harmonic): 0.6057

Polynomial 3-4-5

Parameter 1 (First Harmonic): 5.9

Parameter 2 (Second Harmonic): 0.704

Parameter 3 (Third Harmonic): 0.9

Triple Harmonic and other Motion-Laws

Zero-Jerk at Start, End and Cross-over

Parameter 1 (First Harmonic): $9.\pi/4$

Parameter 2 (Second Harmonic): 0.0

Parameter 3 (Third Harmonic): $-3.\pi/4$

Zero-Jerk at Cross-over

Parameter 1 (First Harmonic): 4.9832

Parameter 2 (Second Harmonic): 2.6

Parameter 3 (Third Harmonic): 0.0

Zero-Jounce* at Start

Parameter 1 (First Harmonic): 7.79

Parameter 2 (Second Harmonic): -2.29

Parameter 3 (Third Harmonic): -1.08

* Jounce is a term used for rate-of-change of Jerk.

1.6.11.24.1 Triple-Harmonic: Modified Sine Motion-Law

Triple-Harmonic: Approximate Modified Sine

This motion is approximately equal to the Modified-Sinusoid[790] motion-law.

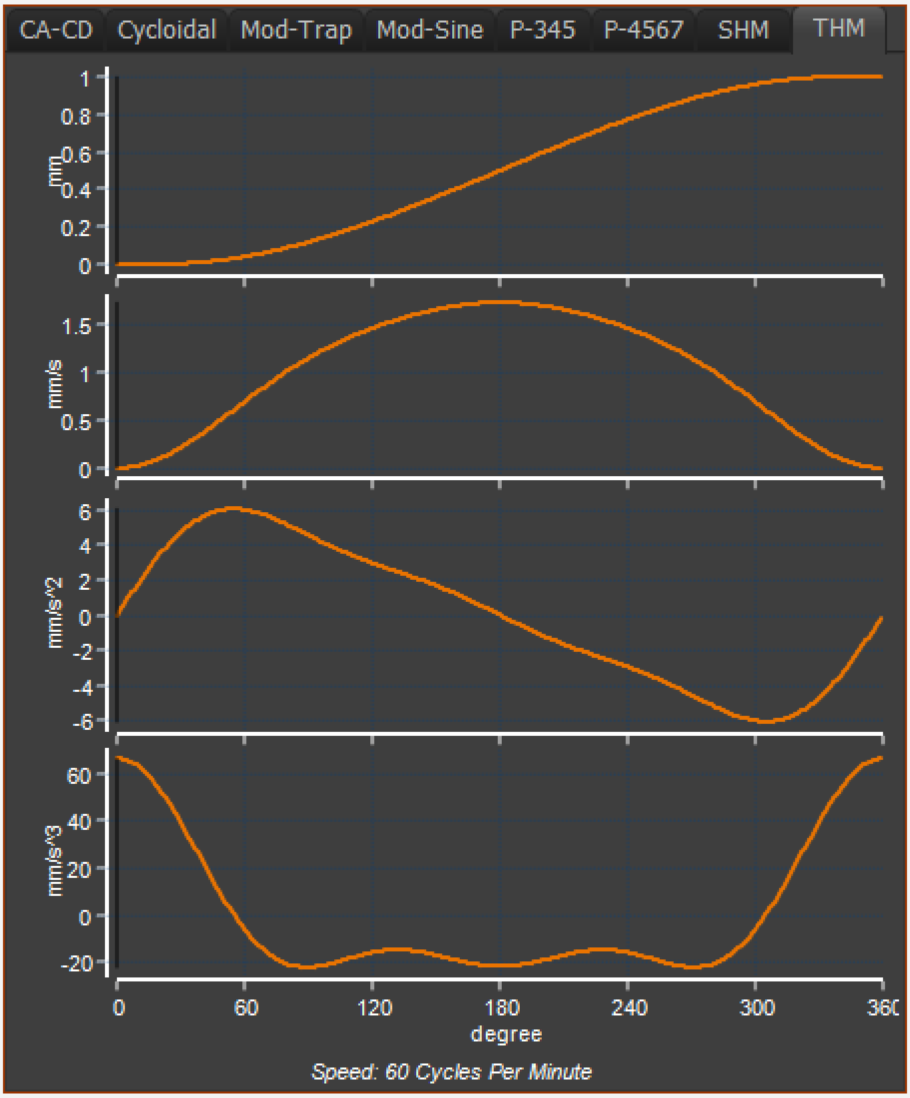
1. Select the **TRIPLE HARMONIC** in the Motion-Law Selector[741]
2. Open the **SEGMENT EDITOR**[704] .
3. Edit the SEGMENT PARAMETERS[715] :

- FIRST HARMONIC = 5.1968
- SECOND HARMONIC = 1.7690
- THIRD HARMONIC = 0.6057

We calculate the THIRD HARMONIC for you/

SEGMENT-PARAMETERS

Segment-Parameters that approximate the Modified Sinusoid motion-law.



Pseudo Modified-Sinusoid motion-law from 3 Harmonics.

Summary

This motion-law is continuous and symmetrical.

It is near to the traditional Modified Sinusoid Cam-Law[790].

However, because it has only three harmonics, it is smoother at the higher derivatives.

The maximum velocity is slightly lower and the nominal acceleration is slightly higher than the Modified-Sinusoid motion law.

1.6.11.24.2 Triple-Harmonic: Modified Trapezoidal Motion-Law

Triple-Harmonic: Approximate Modified Trapezoidal

This motion is approximately equal to the Modified-Trapezoidal[793] motion-law.

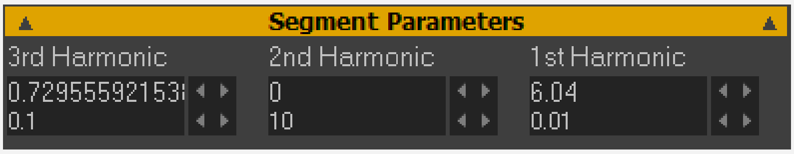
1. Select the **TRIPLE HARMONIC** in the Motion-Law Selector[741]
2. Open the **SEGMENT EDITOR.**
3. Edit the SEGMENT PARAMETERS[715]:

- FIRST HARMONIC = 6.04 (optionally 5.96)

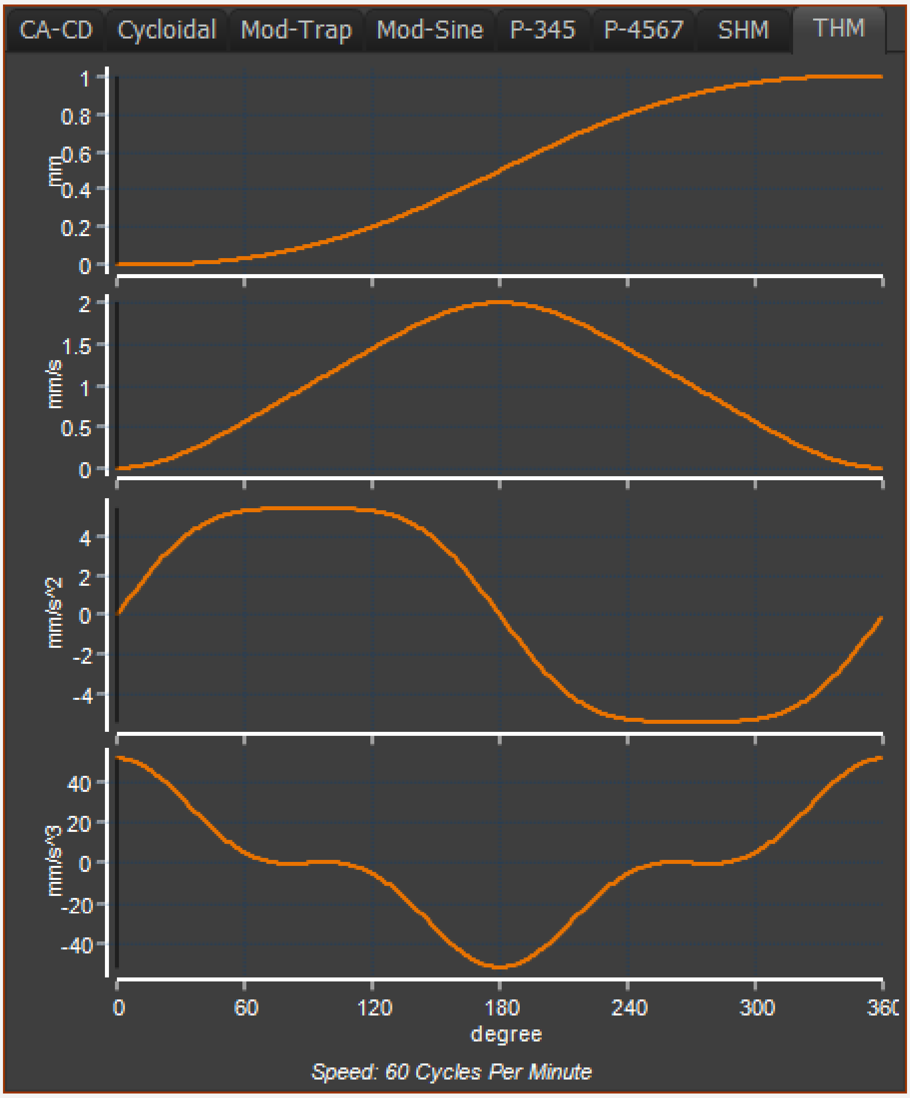
- SECOND HARMONIC = 0.0
- THIRD HARMONIC = 0.7296 (optionally 0.9696)

We calculate the THIRD HARMONIC for you.

SEGMENT-PARAMETERS:



Segment-Parameters that approximate the Modified Trapezoid motion-law



Pseudo Modified-Trapezoid motion-law from 3 Harmonics.

Summary

This law is continuous to Acceleration.

The output motion is near to the traditional Modified Trapezoidal Acceleration Cam-Law[793]. However, it can be described by one mathematical function.

The maximum velocity is the same as the traditional law, but the nominal acceleration is slighter greater.

1.6.11.24.3 Triple-Harmonic: Zero-Jerk-at-Crossover Motion-Law

Triple-Harmonic: 'Approximate Zero-Jerk at Crossover'

Crossover : the point at which the Acceleration changes to Deceleration, or vice-versa

When Jerk is zero as the acceleration changes from a positive value to a negative value, we say the Motion-Law has **Zero Jerk at Crossover**. Acceleration changes slowly.

When acceleration changes slowly, and it is also near to zero, the velocity also changes slowly.

If there is backlash in the mechanical transmission between the follower and the tool, then backlash is traversed as the force changes from a positive action to a negative action. Since the velocity happens to be changing slowly, the impact velocity should also be small, with this motion-law.

Note: the Force changes when the total force on the mechanical element changes sign. The force in the system is not only a function of the Motion-Law. The Force may also include: constant, spring, damping and other forces).

To use this Motion-Law:

1. Select **Triple Harmonic**
2. Open the SEGMENT EDITOR.
3. Edit the SEGMENT PARAMETERS [715] :

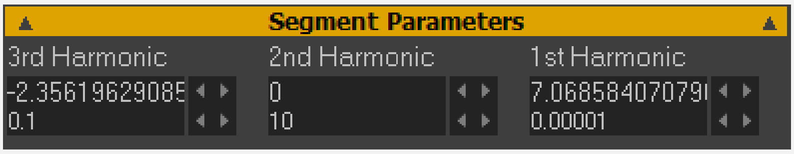
FIRST HARMONIC =$9.\pi/4$

SECOND HARMONIC = 0.0

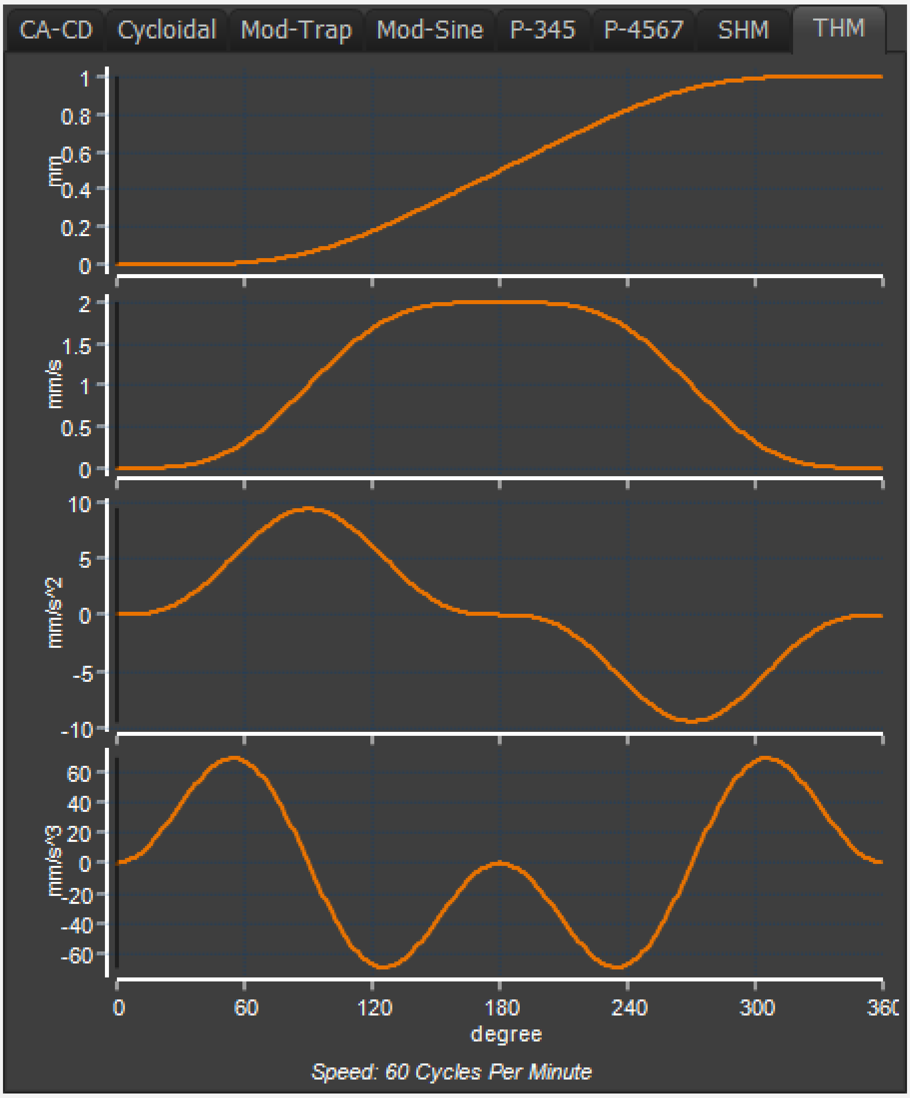
THIRD HARMONIC = $-3.\pi/4$

We calculate the THIRD HARMONIC for you.

SEGMENT PARAMETERS



Harmonic Settings that give an Acceleration with Zero Jerk at Crossover



Pseudo Zero Jerk at Start, End and at Crossover from 3 Harmonics.

1.6.11.25 Y-Inverse-Sinusoid [Special]

Y–Inverse-Sinusoid

Note: The **Y-Inverse-Sinusoid** motion-law is usually applied to a rotating part, e.g. a Crank. There can be only one **Y-Inverse-Sinusoid** segment in each motion.

See also : Constant Crank Velocity 836

MOTION-DESCRIPTION

We can explain this motion-law if we project the motion of a **Point** that is at the end of a rotating **Crank** onto a **Line**.

When a **Crank** rotates with **Constant** angular **velocity,** the motion of a **Point** that we project onto any **Line** is **Simple-Harmonic-Motion.**

When the **Crank** rotates with the **Y-Inverse-Sinusoid** motion-law, the motion of a **Point** that we project onto a particular **Line** is **Constant** Linear **Velocity.**

MOTION-VALUES

You CAN control the:

START-POSITION - control with the SEGMENT-PARAMETERS - see below.

END-POSITION - control with the three SEGMENT-PARAMETERS - see below.

You CANNOT control the:

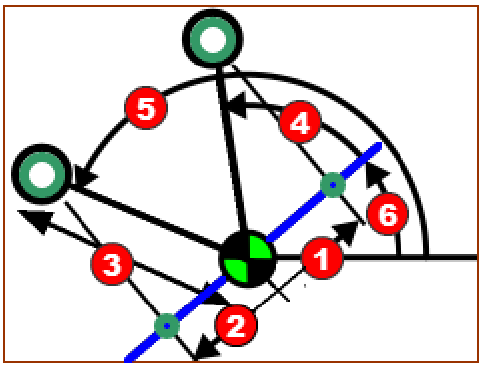
START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

START JERK and END JERK

SEGMENT PARAMETERS

Example Segment Parameters



Schematic of Crank made to give a constant linear velocity ...

Angle 6 is to Blue line relative to any other line, as defined by the BASE-VALUE of the MOTION-DIMENSION FB.

RADIUS OF ROCKER (**Example is** 100mm)

The Radius of the Rocker (rotating-Part) controls the minimum and maximum distance from the rotating-axis of the Green point, at the end of the Rocker, projected onto the Blue line.

START-POSITION❶ (**Example SP=–50mm**)

Directional Distance from the rotating-axis of the **Green** point projected onto the **Blue** line when the **Green** point starts to move with Constant-Velocity along the **Blue** line.

END-POSITION❷ (**Example EP = 50mm**)

Directional Distance from the rotating-axis of the **Green** point projected onto the **Blue** line when the **Green** point ends moving with Constant-Velocity along the **Blue** line.

We calculate for you the angles ❹ and ❺ for the **Rocker** relative to the **Blue** Line, from the START-POSITION and END-POSITION.

Note:

The Crank rotates Counter-Clockwise when START-POSITION is **Negative** and END-POSITION is **Positive.**

The Crank rotates Clockwise when END-POSITION is **Negative** and START-POSITION is **Positive.**

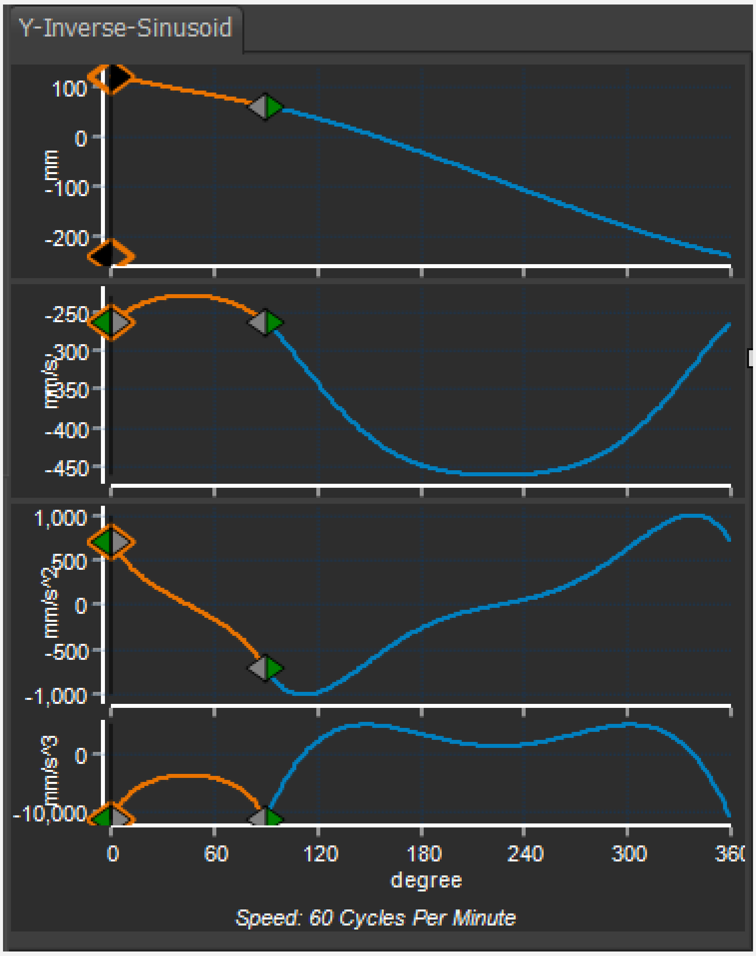
SEGMENT-RANGE

START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1

Play Video of Y-Inverse-Sinusoid Example



Y-Inverse Sinusoid

Example: with two segments.

Crank rotates in a Counter-Clockwise direction

Constant-Velocity Starts at 50mm to Left of Crank-Center (angle 120º)

Constant-Velocity Ends at 50 to Right of Crank-Center (angle 60º)

SEGMENT 1:

- X-axis Start = 0 ; End = 90º

The **Y–INVERSE SINUSOID** **SEGMENT-PARAMETERS** are:

- **RADIUS OF ROCKER** = 100mm, **START POSITION** = -50, **END POSITION** = 50mm.

With these **SEGMENT-PARAMETERS**:

- The Y–axis is 120º†, when the **MASTER MACHINE ANGLE** (**MMA**) is 0º .
- The Y–axis is 60º, when the **MASTER MACHINE ANGLE** is 90º .

SEGMENT 2:

- X-axis Start = 90º, End = 360º (0º)

A **FLEXIBLE-POLYNOMIAL**

- The Y–axis is 60º, when the **MASTER MACHINE ANGLE** is 90º (= end of **SEGMENT 1)**
- The Y–axis –240º when the **MASTER MACHINE ANGLE** is 360º .

Thus the Crank makes a full rotation from +120 to -240 in a counter-clockwise direction.

1.6.11.26 Z-Raw-Data [Import Data]

Import Data: Z-Raw-Data

Z-RAW-DATA is a **List Segment-Type**.

The **Z-RAW-DATA** is a segment that uses the **Data Transfer Table** to import your data as the motion-values.

See also: Acceleration-List [758] **, Position-List** [803] **, Tools: Data Transfer** [744] **,**

STEP 1. Import your data to the Data Transfer Table

1. Use the Motion-Law Selector [741] to select Z-RAW-DATA for a segment.
2. Open the **Data Transfer Table**
3. Click the cell at the left and top row (cell equivalent to A1) of the **Data Transfer Table** to make it the active cell.

   To import your data to into the **Data Transfer Table.**
4. Do:
   a. Copy and Paste your data into the **Data Transfer Table**

or do:

   a. Open a CSV, TXT or DAT (Camlinks based) [747] file

or do:

   a. Get Motion-Values [750] from a different motion or segment

---

Note: In your original data, include as many decimal points as possible.

The data is now in the **Data Transfer Table**

STEP 2. Move your data to the Z-Raw-Data segment from the Data Transfer Table

1. Click the **Pos HEADER** in the **Data Transfer Table** to select the column of data
2. Click Put List Data [750] in the **Data Transfer Table** toolbar.

To move a sub-section of the data:

1. **Click** the **first** data point you want in move to the Z-Raw-Data
2. **SHIFT + Click** the **last** data point you want to move to the Z-Raw-Data
3. Click Put List Data in the **Data Transfer Table** toolbar

---

Note : **Get Data** and **Put Data** icons show only when the segment is a **List Segment-Type**

Data-Transfer Table toolbar

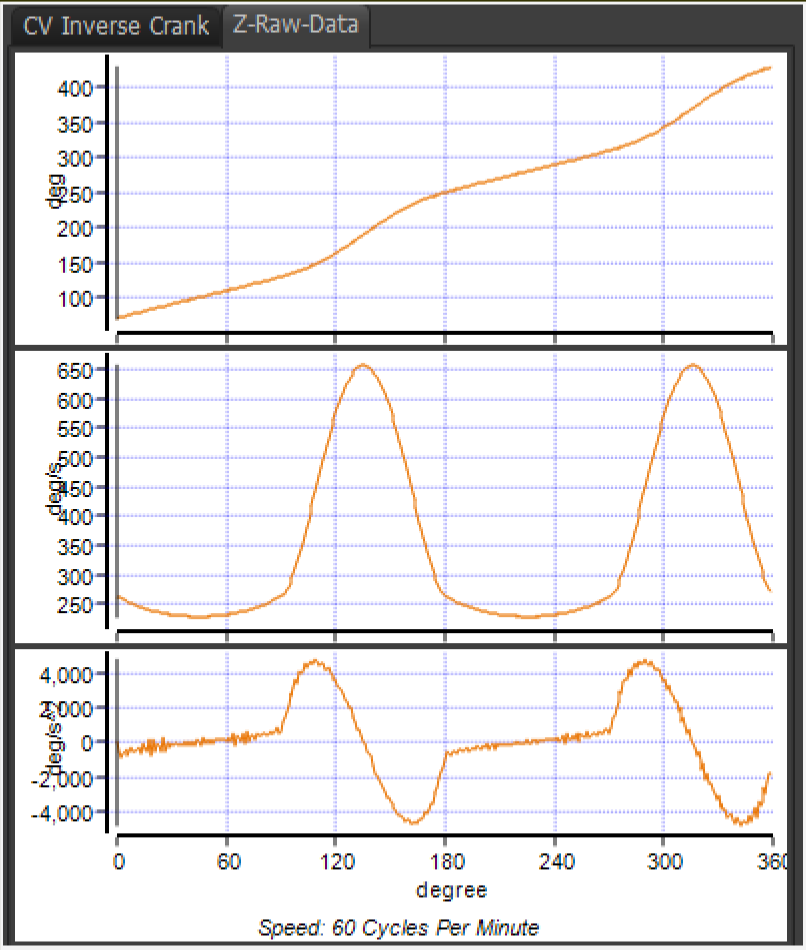
The data is a plot in the **Z-Raw Data segment** in the motion graph.

RESULT: **MotionDesigner** :

- Does nothing if you select less than 5 data-points. **MotionDesigner** tells you to select more data-points!
- Transforms the data to calculate motion-values that coincide with the motion-values in the segment.
- Numerically differentiates the data to create **Position, Velocity, Acceleration, and the Jerk** motion-values.

In the Data Transfer Table:

- You can use the Get Motion Data 750 button or the Get Segment Data 751 button to get the new **Position, Velocity, Acceleration,** and **Jerk** motion-values that **MotionDesigner** has calculated for you from your data.
- When the segment is a **List Segment-Type**, you can use the Get List Data 749 button to move the original data back to the table.



Example of Z-Raw Data Segment

1.6.11.27 CV Inverse Crank [Special]

CV (Constant-Velocity) Inverse Crank

MOTION-DESCRIPTION

We can explain this motion-law if we project the motion of a **Point**, that is at the end of a rotating **Crank**, onto a **Line**.

When a **Crank** rotates with **Constant** angular **velocity,** the motion of a **Point** that we project onto any **Line** is **Simple-Harmonic-Motion.**

When the **Crank** rotates with the **CV-INVERSE-CRANK** motion-law, the motion of a **Point** that we project onto a particular **Line** is **Constant** Linear **Velocity.**

MOTION-VALUES

START POSITION - control with the SEGMENT-PARAMETERS - see below.

END POSITION - control with the SEGMENT-PARAMETERS - see below.

You CANNOT control the:

START VELOCITY and END VELOCITY

START ACCELERATION and END ACCELERATION

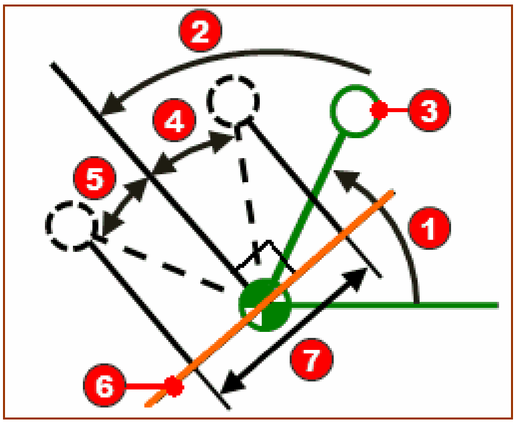
START JERK and END JERK

The actual velocity, acceleration, and jerk values, and the distance the **Point** moves along the LINE are a function of the:

- SEGMENT-WIDTH
- Length of the Rocker/Crank
- SEGMENT-PARAMETERS

SEGMENT PARAMETERS

Typical Segment-Parameters for the CV Inverse-Crank motion-law



Svchematic to help you understand how to use the CV Inverse Crank motion-law.

The SEGMENT-PARAMETERS are **ANGLES**:

MIN VEL❷ (MINIMUM VELOCITY)

The **ANGLE** relative to the BASE-VALUE❶ angle that you control with the MOTION-DIMENSION FB at which the Crank rotates with Minimum-Velocity.

REL START❹ (RELATIVE START)

The **ANGLE,** relative to the angle you control with MIN VEL❷, at which **Point**❸ starts to move along the Orange Line with Constant-Velocity.

REL END❺ (RELATIVE END)

The **ANGLE,** relative to the angle you control by MIN VEL ❷, at which **Point**❸ ends the move along the Orange Line with Constant-Velocity.

Note:

The Crank rotates Counter-Clockwise when REL. START is **Negative** and REL. END is a **Positive.**

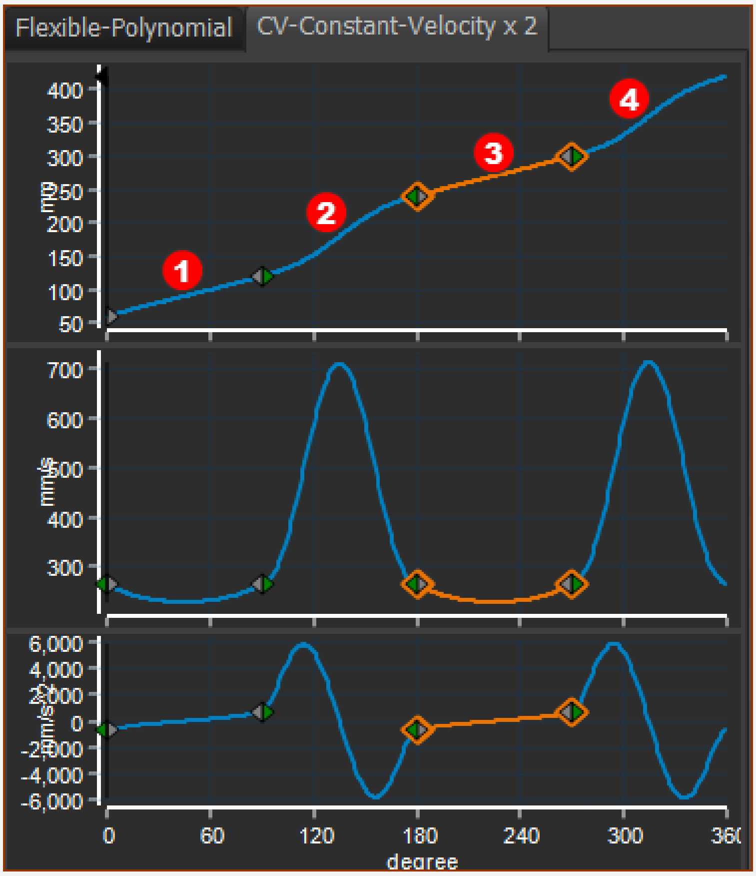
The Crank rotates Clockwise when REL. START is **Positive** and REL. END is **Negative.**

SEGMENT-RANGE

START-RANGE

END- RANGE

0 ≤ START-RANGE < END-RANGE ≤ 1



Example motion with 2 x CV Inverse-Crank motion-laws

EXAMPLE

Two CV Inverse Crank segments in one Motion.

SEGMENT ❶: **Constant-Velocity Inverse-Crank**

- X-AXIS : 0 TO 90º

Segment Parameters are:

- ANGLE OF MINIMUM VELOCITY = 90º
- RELATIVE START ANGLE = –30º
- RELATIVE END = 30º

With these Parameters:

- X-AXIS = 0º ; Y–AXIS = 60º.
- X-AXIS =90 ; Y–AXIS = 120º

SEGMENT ❷: **Flexible-Polynomial**

- X-AXIS : 90 TO 180º
- Y-AXIS AT START P=120. **V, A, J** flow from the end of the **Constant-Crank-Velocity Segment**.
- Y-AXIS AT END 240º

SEGMENT ❸: **Constant-Velocity Inverse-Crank**

- X-axis : 180 to 270º

Segment Parameters are:

- ANGLE OF MINIMUM VELOCITY = 270º
- RELATIVE START ANGLE = –30º
- RELATIVE END = 30º

With these Parameters:

- X-AXIS = 180º ; Y–AXIS = 240º
- X-AXIS = 270 ; Y–AXIS = 300º

SEGMENT ❹: **Flexible-Polynomial**

- X-AXIS : 90 TO 180º
- Y-AXIS P AT START = 300º. **V, A, J** flow from the end of the **Constant-Crank-Velocity Segment**.
- Y=AXIS AT END = 420º.

1.6.12 Motion-Law Coefficients

MOTION-LAWS COEFFICIENTS

Use **Motion-Law Coefficients** DE: Kennwert to compare motions that you design with the **Traditional Motion-Laws.**

Motion-Law Coefficients

C_v	**Velocity Coefficient**
C_a	**Acceleration Coefficient**
C_j	**Jerk Coefficient**

The **Motion-Law Coefficients** are the maximum motion-values for the motion-derivatives when the motion has a:

- Motion Time Period of $T = 1\ second$

and an

- Output Displacement of $Y = 1\ linear\ or\ angular\ unit$

Actual Maximum Velocity, Acceleration, and Jerk

You can calculate the **actual** maximum motion-values of each motion-derivative if you know the **Actual Displacement** (y), the **Actual Period** (t), and the **Motion-Law Coefficient** for a rise or return motion segment.

Actual Maximum Velocity =	$C_v \times y/t$
Actual Maximum Acceleration =	$C_a \times y/t^2$
Actual Maximum Jerk =	$C_j \times y/t^3$

Torque Coefficients

C_t	**Output Torque Coefficient** - E.g. the torque that rotates the swinging arm of a follower.
The **Output Torque Coefficient** considers the dynamic-response of a load when the mass or mass moment of inertia is dominant. The coefficient is the approximate ratio between the maximum acceleration of the dynamic-response and the maximum acceleration of the command.	
C_c	**Input Torque Coefficient** - E.g. the torque at the output of a gearbox connected to the Cam-Shaft.
$C_c = max(v_i \times a_i)/C_a$	
Note on Input Torque Coefficient The maximum torque of a motion-law is important. The rate-of-change of torque at crossover from acceleration to deceleration is more important.	

> A positive input torque on the cam-shaft winds-up (twists) the cam-shaft. A negative torque winds-down (untwists) the cam-shaft.
>
> When the Torque changes from a positive to a negative value - at the crossover - backlash is traversed. The speed of the drive-motor may increase rapidly as the torque is released from it and then, after the Backlash has been traversed, becomes driven by the load. If the speed of the motor does increase, then the motion-law is also distorted. The maximum deceleration increases when the driving-shaft momentarily increases its speed.

Power

Constant Power

$P = \mathrm{T} \times \omega$	**Power - constant Torque and constant Angular Velocity**
$P = F \times v$	**Power - constant Force and constant Linear-Velocity**

Variable Power

Of course, Torque and Angular Velocity at the Follower continuously change throughout the motion. Thus, the Power at the output shaft also changes continuously.

Use the suffix i to indicate an instant in the motion, then the Instantaneous Power, when calculated at the output is:

$P_i = \mathrm{T}_i \times \omega_i$	**Instantaneous Power - varying Torque and Angular Velocity**
$P_i = F_i \times v_i$	**Instantaneous Power - varying Force and Linear-Velocity**

Total Load Torque or Load Force are found from values of inertia, mass, and acceleration.

However, the:

- Acceleration continually changes throughout the motion - of course.
- Load Inertia and Mass, referred to the driven-shaft, can be constant (e.g. Dial-Plate) or can continually change (e.g. Toggle mechanism).

In the general case, the Load Inertia and Mass that reflect to the Follower varies throughout the motion.

Use the suffix 'i' to indicate any instant in the motion, the instantaneous **Load Torque** and **Load Force** are:

$T_i = I_i \times \alpha_i$	Load Torque with changing Load Inertia and Angular Acceleration.
$F_i = m_i \times a_i$	Load Force with changing Load Mass and Linear Acceleration

Also, the instantaneous Load Power is:

$P_i = I_i \times \alpha_i \times \omega_i$	Load Power with changing Load Inertia, Angular Acceleration, and Angular Velocity.
$P_i = m_i \times a_i \times v_i$	Load Power with changing Load Mass, Linear Acceleration, and Linear Velocity.

When reflected Load Inertia is not a function of the motion, the **Power-Coefficient** is less complex.

The instantaneous Load Power, with constant reflected Load Inertia or Load Mass is:

$P_i = I \times \alpha_i \times \omega_i$	Load Power with constant Load Inertia, Angular Acceleration, and Angular Velocity.
$P_i = M \times a_i \times v_i$	Load Power with constant Load Mass, Linear Acceleration, and Linear Velocity.

Power Coefficient

Power Coefficient	$C_P = max(v_i \times a_i)$
$C_{P(rms)} = \sqrt{\dfrac{\sum_{i=1}^{n} (v_i \times a_i)^2}{n}}$	

MOTION COEFFICIENTS OF THE TRADITIONAL MOTION-LAWS

Motion-Law Name	Velocity Coefficient C_v	Acceleration Coefficient C_a	Torque Coefficient C_C	Power Coefficient C_P
Constant Acceleration Parabolic	2	4	2	8
Simple Harmonic	1.570796 ($\pi/2$)	4.934803 ($\pi^2/2$)	0.785	3.8758
Cycloidal	2	6.283185	1.298	8.1621
Modified Trapezoid	2	4.888124	1.655	8.0894
Polynomial 3-4-5	1.875	5.773503	1.159	6.6925

Motion-Law Name	Velocity Coefficient C_v	Acceleration Coefficient C_a	Torque Coefficient C_C	Power Coefficient C_P
Polynomial 4-5-6-7	2.1875	7.5132	1.431	10.750
Modified Sine	1.759603	5.527957	0.987	5.4575

SINE-CONSTANT-COSINE ACCELERATION (SCCA) with CONSTANT VELOCITY

Edit the SEGMENT PARAMETERS 715 (in the SEGMENT EDITOR 704) of the SINE-CONSTANT-COSINE ACCELERATION 814 *(SCCA)* ***Motion-Law*** to give many of the popular motion cam-laws for industrial cams.

Motion-Law Name	Coefficients		SCCA Parameters (Factors)		
	Velocity Coefficient C_v	Acceleration Coefficient C_a	a	b	c
Modified-Sine CV 0%	1.760	5.528	0.25	0	0.75
Modified-Sine CV 20%	1.528	5.999	0.2	0	0.6
Modified-Sine CV 33%	1.404	6.616	0.1667	0	0.5
Modified-Sine CV 50%	1.275	8.0127	0.125	0	0.375
Modified-Sine CV 66%	1.168	11.009	0.0833	0	0.25
Cycloidal CV 50%	1.333	8.378	0.25	0	0.25
Trapezoidal Velocity CV 33%	1.5	4.5	0	0.6667	0

3-HARMONIC MOTION-LAWS

Edit the SEGMENT PARAMETERS[715] (in the SEGMENT EDITOR[704]) of the ***Triple Harmonic Motion-Law*** to give alternatives to some of the popular motion-laws.

Motion-Law Name	Coefficients		Harmonic		
	Velocity Coefficient C_v	Acceleration Coefficient C_a	1st	2nd	3rd
3-Harmonic Modified Trapezoidal	2.0	5.16	5.96	0	0.9696
3-Harmonic Modified Sine	1.72	6.07	5.1968	1.7690	0.6057
3-Harmonic Zero-Jerk at Crossover	2.0	9.42	$9.\pi/4$	0	$-3.\pi/4$

1.6.13 How to? and other FAQs...

How to and other FAQs

How to .... ?

1. How to Rename a Motion [846] .
2. How to Float or Dock MotionDesigner [847] .
3. How to design a Motion - First Steps [848]
4. How to edit a value in a data-box [850]
5. How do I edit the start of the motion so it does not start at 0. [853]
6. How to quickly find the motion-values [854] .

FAQs

1. What is 'Motion-Design'? [858]
2. Where is the Spin-Box in the Segment / Blend-Point Editor? [859]

1.6.13.1 How to?

How to .... ?

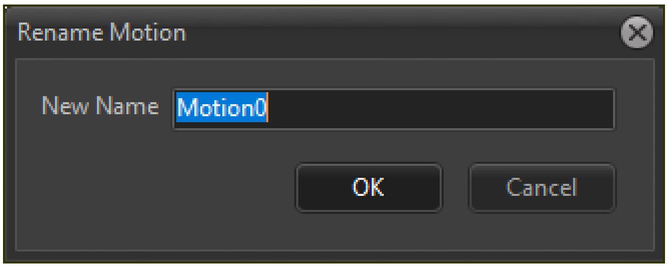
1.6.13.1.1 How to Rename a Motion

To Rename a Motion

The default motion names are not very helpful, and do not remind you in which mechanism it is used.

To rename a motion.

1. Right-click a motion graph-area or its **Motion name-tab**
2. Click **Rename** in the shortcut menu



Motion: Rename dialog

3. Enter a new name in the **Rename dialog**
4. Click the ⊗ at the top to close the **Rename dialog**

OR

1. **Do Edit toolbar > Active Motion-Settings > Motion tab >** [731] MOTION NAME > Motion name [731]

1.6.13.1.2 How to Float or Dock MotionDesigner

How to Float MotionDesigner.

You can float and dock **MotionDesigner** with a tool that is in **MechDesigner**.

1. Click the **Visibility menu** or **Visibility toolbar**
2. Click **Float / Dock MotionDesigner** button.

To re-dock MotionDesigner:

1. Click the **Visibility menu** or **Visibility toolbar**
2. Click **Float / Dock MotionDesigner** button.

1.6.13.1.3 How to Design a Motion - First Steps.

Motion Design

It is always important to try to improve the design of your motion when you need to improve the performance of a machine.

First Steps

To design a motion:

1. Plan and sketch the Motion for the tooling, on paper, over one machine-cycle

   Note on the sketch:

   - The Motion's name - usually relate the motion's name to the function of the tooling or the interaction with the packaging. Try to make the name short.
   - Each segment, with its approximate timing on the X-axis.
   - The key positions of the tooling on the Y-axis. Example names for the positions may be: Out, In, Contact, ...
   - If a segment has a velocity requirement - e.g. to track a pack during heat-sealing
   - If a segment has a minimum time-periods - e.g. for heat-sealing jaws
   - If the motion-cycle is progressive (indexing) or non-progressive (rise and return)
2. Use the Blend-Point Editor, to set the Y-axis position value of each Blend-Point to zero, then close the Blend-Point Editor.
3. If you need more than four segments, use **Insert-Blend-Point** command to split the motion into the number of segments you believe you need- or delete a segment if you need fewer segments.
4. Use the **BLEND-POINT EDITOR** to make sure the **MATCH CONTROL-BUTTONS** are active for Position, Velocity, Acceleration for each **BLEND-POINT** - to make sure there is motion-continuity.
5. If the motion is a progressive motion, set the **BLEND-POINT #1** to Do NOT Match.
6. If a segment has a particular motion-law , e.g. Constant-Velocity, use the **MOTION-LAW SELECTOR** to change the motion-law.
7. Use the **BLEND-POINT EDITOR** to define the approximate X-axis value of each **BLEND-POINT** and the **SEGMENT-WIDTH** for each segment. Begin to define the duration of each segment making some shorter and others longer. The total duration remains as 360°.
8. Edit the Y-axis motion-values of each segment with the Blend-Point Editor and/or Segment Editor - to fully satisfy the motion requirements.
9. Make sure that none of the segments give a large spike in Acceleration compared to the other segments
10. If possible, avoid Jerk-discontinuities.

11. If possible, remove short Dwell segments. Try to replace with Zero Velocity, Acceleration, and Jerk at the Blend-Point.

See also: **What is a motion?** 858

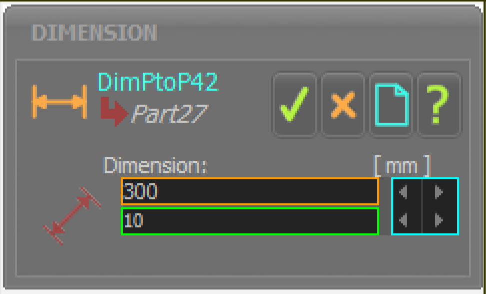
1.6.13.1.4 How to edit a parameter value in dialog

Parameters values in a dialog.

You edit motion-values or parameter-values in exactly the same way as in all dialog-boxes.

This image is the **DIMENSION DIALOG** that you use in **MechDesigner.**

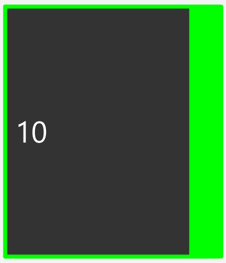
It has one parameter (**DIMENSION**) and data-box (currently set to 300).



In this image of the **DIMENSION DIALOG**, I have added a 'window' to highlight the **PARAMETER BOX**.

The three areas of the **PARAMETER BOX** are:

PARAMETER VALUE - the data-value that you edit and apply to the element.



SPIN-INCREMENT VALUE - edit with the arrows at the bottom of the Spin-Box control [851]

SPIN-BOX CONTROL: arrowheads - see below [851]

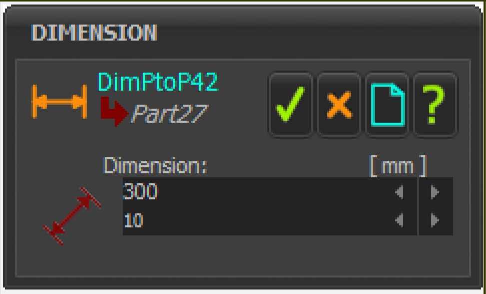
If you cannot see the **Spin-Box**:

- Double-click in the **PARAMETER VALUE** box.
- Again, double-click, if required.

How to edit parameters in a dialog.

There are three different procedures you can use to edit a parameter in a dialog.

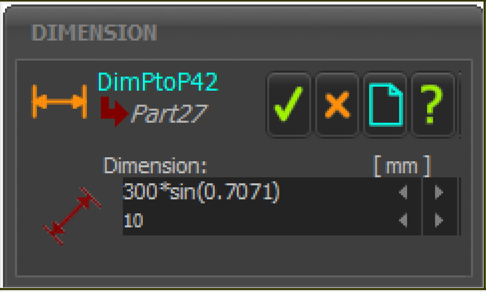
Method 1: Enter the Parameter Value with your Keyboard



Enter a value directly:

1. Use your keyboard to enter the data-value
2. Press the Enter key on your key-board to update to the new value

You must press the Enter key.



Enter a value as a symbolic equation:

1. Use your keyboard to enter an equation
2. Press the Enter on your keyboard to update to the new value

You must press the Enter key

Symbolic parameters for an Equation:

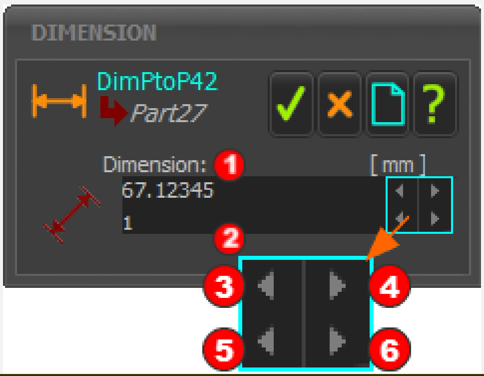
- **Simple Arithmetic**: +, –, *, /
- ^, Sqrt()
- **Trigonometric** (Angles are Radians), Sin(), Cos(), Tan(), Sinh, Cosh, Tansh, ArcSin(), ArcCos(), ArcTan2(;)

Method 2: Use the 'Spin-Box' tool

If you cannot see the Spin-Box tool

< >

Double-click **inside** the data-box to toggle from show to hide and from hide to show the **Spin-Box tool.**



Spin-Box arrowhead buttons (in the CYAN-BOX)

❸ **TOP** : **LEFT** arrowhead to subtract (–) the PARAMETER-VALUE❶ by the **SPIN-INCREMENT**❷

❹ **TOP** : **RIGHT** arrowhead to add (+) the PARAMETER-VALUE❹ by the **SPIN-INCREMENT**❷

❺ **BOTTOM** : **LEFT** arrowhead to divide (÷) the **SPIN-INCREMENT**❷ by 10

❻ **BOTTOM** : **RIGHT** arrowhead to multiply(×) the **SPIN-INCREMENT**❷ by 10

EXAMPLE:

Edit the PARAMETER-VALUE

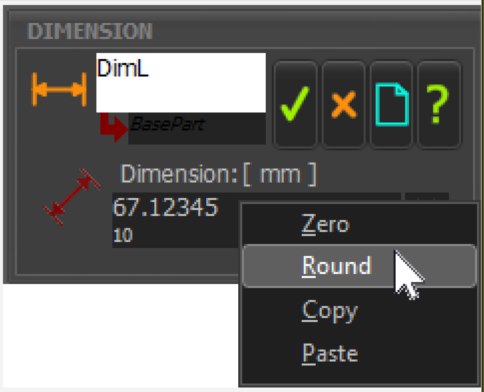
- **Click the Top & Left❸ arrowhead**: Subtract the Spin-Increment(1)❷ from the PARAMETER-VALUE❶
  PARAMETER-VALUE after one click: **67.12345 – Spin-Increment** = **66.12345**
- **Click the Top & Right❹ arrowhead** two **times:** Add the Spin-Increment(1)❷ to the PARAMETER-VALUE❶ 2 x
  PARAMETER-VALUE after one click: **66.12345** + **2** × **Spin-Increment** = **68.12345**

Edit the Spin-Increment

- **Click the Bottom & Left❺ arrowhead**: Divide the Spin-Increment by 10❷
  Spin-Increment value after one click: **1** ÷ **10** = **0.1**
- **Click the Bottom & Right❻ arrowhead** two **times:** Multiply the Spin-Increment by 10❷ 2 x
  Spin-Increment value after one click: **0.1** × **10** x **10** = **10**

WARNING: The model re-builds each time you click the top arrowhead buttons in the **Spin-Box tool**. If the model is complex, it may be a long time to update the model.

Method 3: Use the Zero/Round shortcut menu



To see the Zero / Round / Paste / Copy :

1. Right-click inside the data-box

The **Zero / Round / Copy / Paste** shortcut-menu shows.

- **Zero -** the parameter-value becomes zero(0), or the smallest possible value for the parameter-value
- **Round -** the parameter-value becomes the nearest value that is exactly divisible by the **Spin-Increment**. The **Spin-Increment** is below the data-box - ten(10) in the image
- **Copy -** to copy the parameter-value to your clipboard.
- **Paste** - to paste the parameter-value from your clipboard.

1.6.13.1.5 How to start a motion at Xº that is not 0º

How to start a motion at an X-axis value that is not zero?

Frequently, the timing of a motion means the X-axis value of Blend-Point #1, the start of Segment #1, cannot be at 0.

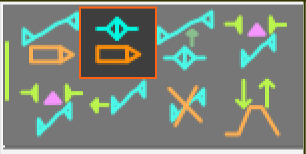
In this case you want to move **BLEND-POINT #1** from 0.

To move **BLEND-POINT #1** to a value that is not 0, edit the **MOTION-START** parameter in the **BLEND-POINT EDITOR**.

The motion moves along the **X-axis** of the graph by the **MOTION-START** parameter.

The plot of the motion will start at 0, somewhere between two **BLEND-POINTS**.

STEP 1. Open the Blend-Point Editor



Blend-Point Editor icon

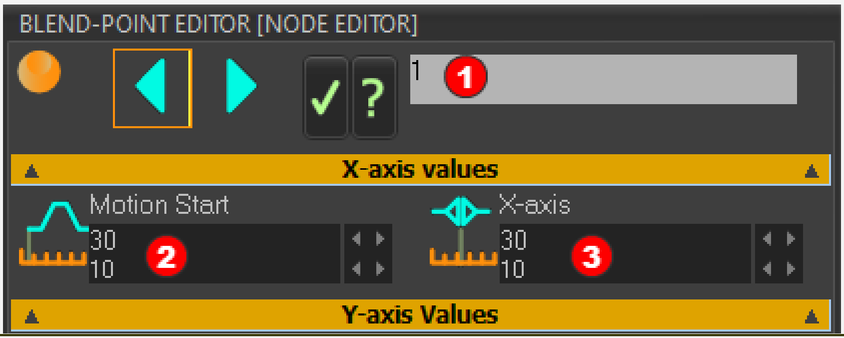
Use the toolbar.

1. Click **Blend-Point & Segment toolbar > Start Blend-Point Editor**

The **BLEND-POINT EDITOR** is now open.

STEP 2. Expand the X-AXIS VALUES separator

STEP 3. Edit the Motion-Start-parameter



MOTION START

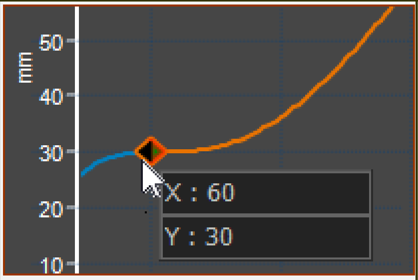
Edit **MOTION- START** to move **BLEND-POINT #1** and all of the motion moves relative to the **MASTER MACHINE ANGLE**.

1.6.13.1.6 How to find the motion-values anywhere in the motion/segment?

To find Motion-Values.

There are 4 methods to find the Y-axis motion-values at an X-axis value.

Method 1: Motion-Values at Pointer

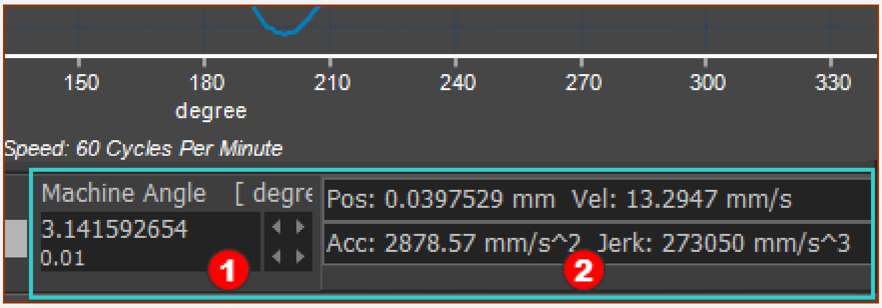


Motion-values at your pointer

1. Move your mouse-pointer above a motion plot-line, or to a **BLEND-POINT**.

The X-axis and Y-axis motion-values show near to your pointer.

Method 2: Motion-Values Evaluator



Machine-Angle(1) : Evaluate Motion-Values(2)

For any real number you enter as a **MACHINE-ANGLE**❶, we evaluate for you the exact **motion-values**❷ (**P**, **V**, **A**, **J**).

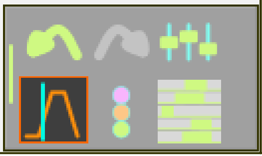
You may need to increase the width of the MotionDesigner panel.

Or, you can Float **MotionDesigner** - See **MechDesigner** > **Visibility menu** > **Float/Dock MotionDesigner**.

Method 3: Use the Sweep-Display

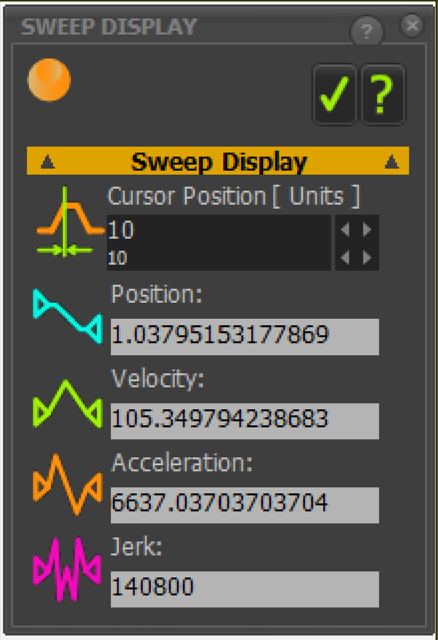
Note:

The **SWEEP-DISPLAY** works best for a motion that start at 0, and has a Motion-Width of 360.



To open the **SWEEP-DISPLAY**:

1. Click **Edit toolbar** > **Sweep-Display icon**



Sweep-Display dialog

SWEEP-DISPLAY

CURSOR POSITION

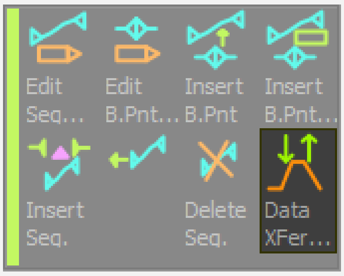
The **X-axis value** at which to evaluate exact motion-values.

POSITION, VELOCITY, ACCELERATION, JERK (read-only)

The exact POSITION, VELOCITY, ACCELERATION, and JERK motion-values at the **X-axis value** as defined by the CURSOR-POSITION.

A vertical cursor shows in the graphs at the **X-axis value** as defined by the CURSOR POSITION.

Method 4: Open Data Transfer Table

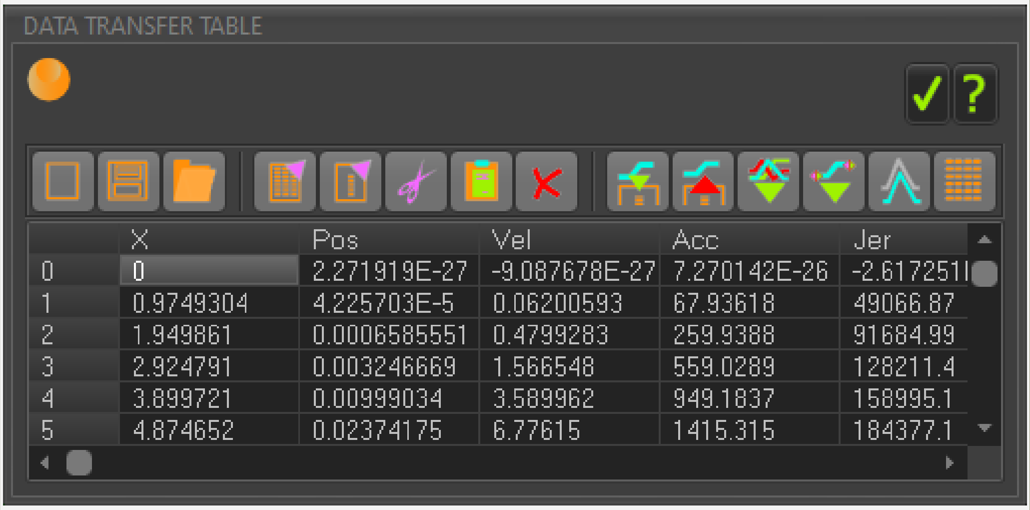


Blend-Point and Segment toolbar

To open the **Data Transfer Table**:

1. Click Blend-Point & Segment toolbar > Data Transfer Table icon.

The **Data Transfer Table** is now open.



Data Transfer Table

Look up in the list the X-axis value for which you want to know the Y-axis motion-values.

If you want more accuracy,, then increase the **NUMBER OF POINTS** in Active Motion Settings dialog > Motion tab > Motion Cycle 731

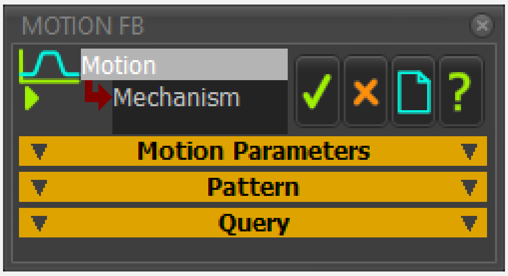
To find the X-axis values from a Y-axis positional value

There is one method. You must use a **MOTION FB** in **MechDesigner**.

You can enter the Y-axis of the Position motion-derivative.

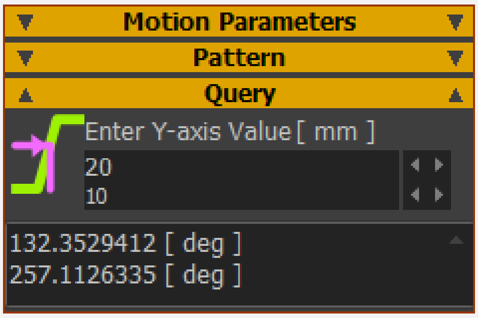
In **MechDesigner**:

1. Add a Motion FB to the graphics-area
2. Open the **MOTION FB DIALOG**



3. In the **MOTION PARAMETER** separator, click the drop down arrow in the **SELECT A MOTION** box, and select a Motion whose X-axis value you need to know at a particular Y-axis value.
4. In the **QUERY** separator, enter a **Y-AXIS VALUE** (Position motion-derivative, only)

If one or more **X-axis values** exist at the Y-axis value, then we show the values in the box below.



X-axis values from a Y-axis value

1.6.13.2 FAQs

FAQs

1. What is 'Motion-Design'? 858
2. Where is the Spin-Box in the Segment / Blend-Point Editor? 859

1.6.13.2.1 What is 'Motion Design'?

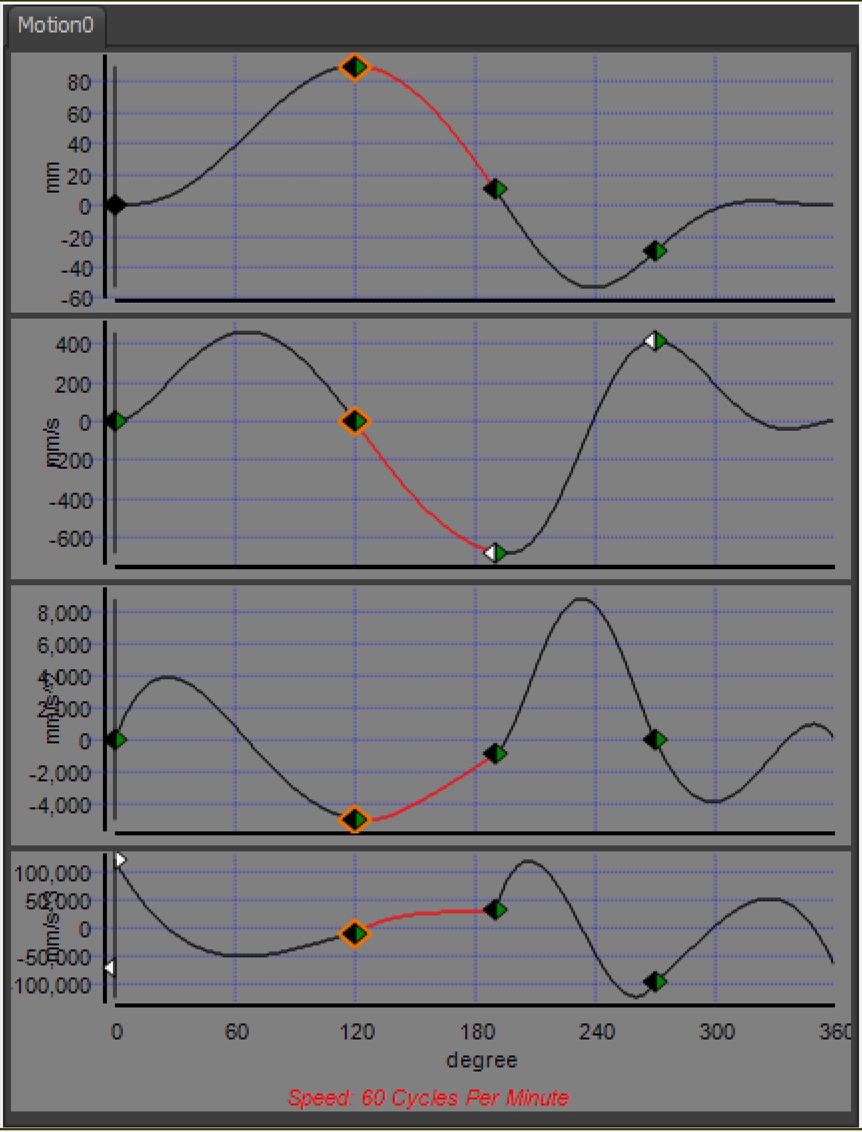
What is Motion Design

There are many disciplines that use the term **Motion Design**: E.g. Graphic Design, Dance Choreography.

However, in **MotionDesigner**, you usually design motions for machine elements. In machinery, all the machine parts have mass and inertia. As such, the forces that develop between machine elements as a result of their motions are also important. Parts with inertia must be moved carefully, especially as speeds are increased. If motions are not designed carefully, machine elements vibrate needlessly.

MotionDesigner

MotionDesigner provides all of the tools to design motions for high-speed, multi-axis machines, such as those found in the packaging, assembly, and textile industries.



What is Motion Design?

1. A motion is a sequence of positions for a machine element - or a Rocker or Slider in **MechDesigner.**

2. A motion-design satisfies a number of position, velocity, acceleration, and/or jerk specifications for the angle or distance between two parts throughout a machine cycle.
3. When the number of motion specification become extensive or complex, it is difficult to find one mathematical function that can satisfy the motion specification throughout a machine cycle.
4. Therefore, it is convenient to split a motion into **segments**. Segments are joined end-to-end (concatenated, to give the technical term). The number of segments in the machine-cycle is dependent on the number of different motion requirements in the machine-cycle.
5. The process of splitting into segments is called **segmentation**. The image above shows a motion split into 4 segments.
6. Each segment may have a different mathematical function, which is its **motion-law**. Select the **motion-law** that can satisfy the motion specification during its segment period.
7. A **Motion-Law** may have different parameters that you can edit to satisfy different motion specification.
8. A **Blend-Point** is at the instant when one segment ends and another starts.
9. There are two editors in **MotionDesigner**

- Segment Editor 704
- Blend-Point-Editor 692

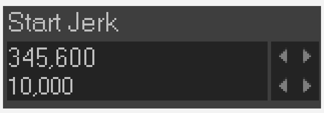
1.6.13.2.2 Where is the Spin-Box in the Segment-Editor/Blend-Point Editor?

Where is the Spin-Box tool in the Segment and Blend-Point Editor?

In the SEGMENT EDITOR and the BLEND-POINT EDITOR, it is convenient to edit motion-parameters with the **Spin-Box tool**.

However, the **Spin-Box tool** may not show at the right-side of the motion-parameter.

To show or hide the Spin-Box tool

	If the **Spin-Box tool** is not to the right-side of a motion-parameter: 1. Double-Click with your mouse-pointer in the data-box. The first time you double-click, the **Spin-Box** does NOT show.
Again ... 	2. Double-Click again with your mouse-pointer in the data-box.
	Now the Spin-Box should show.

1.6.14 Motion Design Considerations

Motion Design Considerations

1.6.14.1 Refresher: Blend-Point and Segments

A Refresher on Segments and Blend-Points in MotionDesigner

It is almost impossible to design a motion for a machine-cycle with one mathematical function.

Therefore, you usually split, or divide, the machine-cycle into a series of motion-periods that you join end-to-end to give a complete machine cycle.

> We use the term **SEGMENT** for a motion-period. We use the the term **BLEND-POINT** for the instances at the start and end of each **SEGMENT**.

You can then use a different mathematical-function for each motion-period.

> We use the term **MOTION-LAW** or **CAM-LAW** for the mathematical-function.

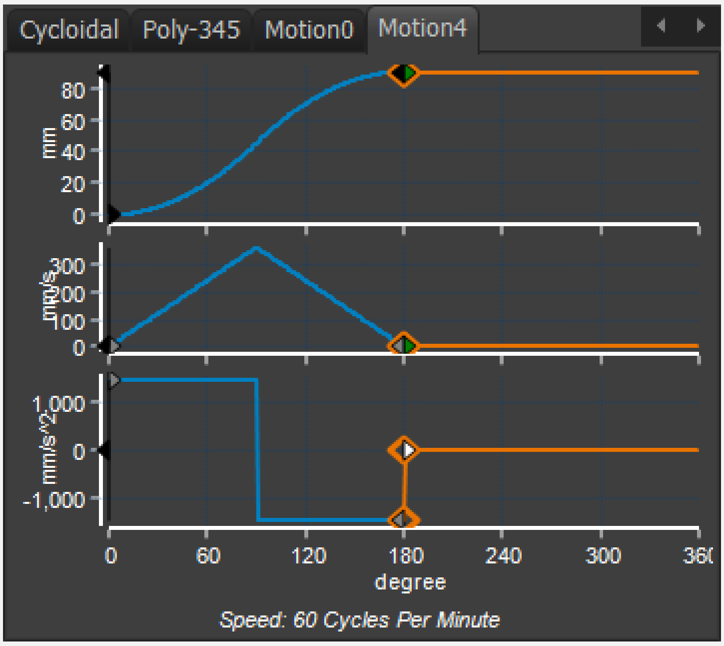
Not only do motion-designers need to control when and where to split the motion into different Segments, they must also select the mathematical function that can best satisfy the motion requirements at all points in the machine-cycle, nut just at the Blend-Points.

The mathematical-functions, from which you can select, have been chosen by PSMotion to meet the different requirements of most machine designs, each with different applications or advantages.

1.6.14.2 Segment Blending and Motion-Continuity

Segment Blending and Motion Continuity

see also: Impact, Acceleration Shock, How to Blend Two Segments 861



Motion-Law Discontinuity

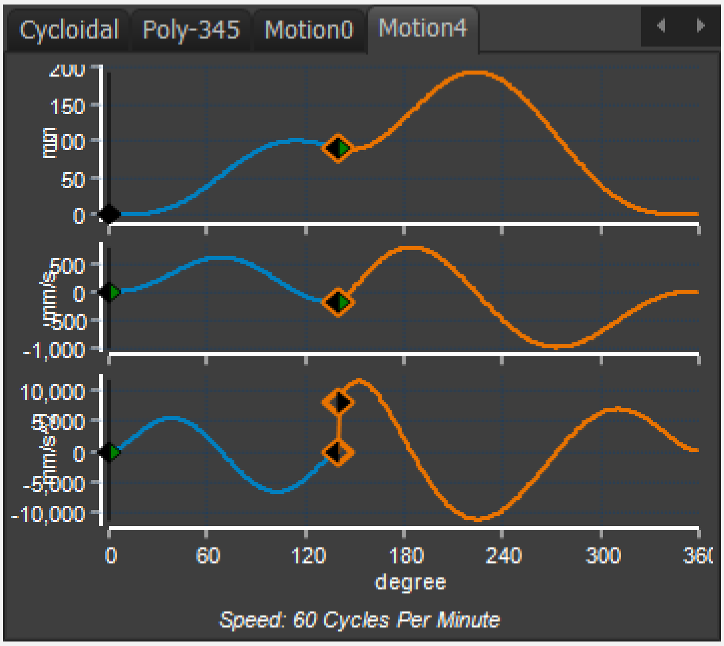
Motion Discontinuity Definition.

A **motion discontinuity** is one in which the **Y-axis** of a motion-derivative has two values at one instant on its **X–axis**. The name of the motion-discontinuity refers to the lowest motion-derivative at which the motion-discontinuity occurs.

In the image above, the motion-law uses the **Constant Acceleration & Deceleration Motion-Law.** It has **three(3) acceleration discontinuities**. The motion discontinuity of the acceleration at the mid-point is the most aggressive, as it changes from the maximum acceleration to the maximum deceleration.

In the image below, the motion also has an **Acceleration-Discontinuity**.

All motion-discontinuities can be can be eliminated (up to Jerk) if you use the **Flexible-Polynomial** motion-law.



Segment Discontinuity

Segment Blending

Segment Blending considers the motion-values at the **Blend-Points**.

It is recommended that you design your motions with at least **Position**, **Velocity**, and **Acceleration** continuity.

Jerk continuity may also be appropriate, but not in all circumstances.

IMPORTANT - In **MotionDesigner**, It is possible to design a motion with motion-discontinuities at any motion-derivative, even Position.

A Position motion-discontinuity is only needed with a progressive (indexing) motion, in which the position at the end of the index motion is different to the position at the start of the index motion. Clearly, the mechanical system does not move from one position to the next in zero time. It does not have a positional motion-discontinuity.

Position Continuity

A Step-change in Position?

Mechanical systems cannot respond to a **Position-Discontinuity** - to move from one position to a different position in zero time! It would be a magic trick! Cartoon characters can do this motion, but not mechanical systems. A Cam would need a step in it.

You must use at least the **Match Control** button in the **Segment and Blend-Point Editors** to give **Position-Continuity**.

Velocity Continuity

A Step-change in Velocity?

Mechanical system cannot respond to a **Velocity-Discontinuity**. You are trying to make the system respond as if it has been hit.

A Servo motor would need to change its speed instantly, with infinite acceleration. This is unattainable.

A Cam would have a corner, or kink.

Acceleration Continuity

A Step-change in Acceleration?

Mechanical systems do not like **Acceleration-Discontinuities**. Any mechanical system will vibrate.

Do this experiment to see an **Acceleration-Discontinuity**:

1. Clamp (or hold down) a 300mm ruler at one end, so it hangs over the edge of a table.
2. Release a coin from **zero height** onto the ruler, near to its end.

   The velocity-impact is zero because you release the coin from zero-height.

   The ruler experiences a step change in force (gravitational force) as you release the coin on to it.

   The ruler vibrates with a displacement amplitude of about two times the final resting position of the ruler with the coin on it

Jerk Continuity

A Step-change in Jerk?

Finally, it is sometimes required that adjacent segments have **Jerk-Continuity**.

Jerk-Continuity gives the least mechanical vibration in the mechanical system, at the expense of higher peak nominal accelerations.

When Jerk is Zero at the start of a segment, there is only a tiny change of the Position graph for the first 10º of input. It is almost a dwell for the first 10º.

If it frequently possible to increase the duration of a segments with Jerk-Continuity, and thereby reduce the accelerations.

1.6.14.3 Motion-Laws Compared

Motion-Laws.

A motion usually has a number of segments that are joined end-to-end at Blend-Points. You select the motion-law for each segment with the Motion-Law Selector 741.

A common question is **'Which motion-law is best?'**

When the motion is complex, with many segments that must satisfy different position, velocity, and acceleration requirements, it is almost impossible to answer the question: **'Which motion-law is best?'.**

However, when the motion is simple, when the segments are designed for a **Dwell-Rise-Return-Dwell** motion, then it is easier to select a motion-law that is best for the mechanical system.

Which Motion-Law?

With many of the motion-laws, especially the "Traditional Motion-Laws" 755, you can only control the position at the start and end of the segment. If you compare the each **Traditional Motion-Law** , you will notice their displacement plots are almost the same!

You may ask: **Why are there so many motion-laws when each provides nearly the same result?'.**

Actually, it is the acceleration plot, and not the displacement plot, that is more important.

While their displacement plots are nearly the same, their Velocity plots are noticeably different, and their Acceleration plots are significantly different.

The **SHAPE** of the **ACCELERATION** plot has a significant influence on the dynamic response of the mechanical system.

For this reason, name of a **TRADITIONAL MOTION-LAW**, relates to the shape of the Acceleration plot.

When the motion is simple, it is easier to explore the advantages and disadvantages of each motion-law.

See also: General Design Information Manual(coming 2019): Design of Cam Mechanical Systems.

Initial Selection

The relative ratings of five commonly used **Traditional Motion-Laws**. You can use the ratings to help you select a law at the initial stage of a machine design. The ratings range from1 (bad) to 5 (excellent). The ratings apply to Dwell-Rise Dwell type motions.

Of the motion-laws in the table, the Modified Sine(MS) is the best for general purposes. Its particular merit is that it is very tolerant of a bad input drive and transmission (elasticity, backlash, stiffness, inertia). It is frequently the first choice for designers and is almost always used by commercial manufacturers of cam-operated indexing mechanisms.

Additionally, you can look at the Motion-Law Coefficients 839 of the common motion-laws. These indicate the relative peak values of the **Velocity** and **Acceleration**.

Cam-Law Designation	Peak Acceleration	Output Vibration	Peak Velocity	Impact	Input Torque	Input Vibration	Residual Vibration
Constant Acc & Dec 759	5	1	2	1	1	1	1
Simple Harmonic 811	3	1	4	4	5	2	1
Modified Trapezoid 793	3	3	2	2	2	3	3
Modified Sinusoid 790	2	4	3	4	4	4	4
Cycloidal 769	1	5	2	3	3	4	5

Explanatory Notes

Peak Acceleration

This merit rating applies to the nominal maximum output acceleration during the motion period, calculated by the motion-law equation.

Output Vibration

Output vibration is superimposed on the nominal output acceleration, thereby increasing the nominal peak value. The vibration severity depends on the elasticity and operating speed of the mechanism. The merit rating applies to mechanisms of average rigidity running at fairly high speed.

Peak Velocity

Peak Velocity is the nominal maximum output velocity during the motion period, calculated by the motion-law equation. Its value is also increased by superimposed vibration.

Impact / Backlash

Impact forces occur at the locations of backlash in the mechanism when the changeover from acceleration to deceleration occurs. The severity of the impact depends on how gradually the changeover takes place. That is, how low the jerk is at point of impact. Strictly speaking, it is the changeover from positive to negative force or torque that matters, but in

most high speed systems, that almost coincides with the acceleration changeover.
Input Torque The nominal input torque of a mechanism varies throughout the motion period and is a function of the output load profile, and the velocity pattern. The peak acceleration and the peak velocity do not coincide and neither coincides with the peak input torque. Motion-Laws with good, that is low, acceleration do not necessarily have good input torque.
Input Vibration The elasticity and backlash of the input transmission can cause serious 'over-run'. This is when the sudden reversal of the input torque at the changeover from acceleration to deceleration - or load - causes the cam to jump forwards before it can transmit a decelerating force to the output. The more gradual that the nominal input torque changes over, the less severe is the overrun and its consequences.
Residual Vibration Residual Vibration takes place in the dwell period immediately following the motion period in high speed or elastic systems. Its amplitude depends on the vibration generated during the motion period, and the degree of damping present in the output transmission. It is very difficult to add sufficient damping to high speed mechanisms to eliminate residual vibration, so the choice of a motion-law is vital in some cases.

1.6.14.4 Motion: Dynamic Considerations

Dynamic Response and Considerations

We can use vibration terminology to describe the dynamic response of a mechanical system to a motion command.

Nominal Motion: The motion command you want a mechanical part to follow. This is your motion-design from **MotionDesigner**.

Transient Motion: The dynamic response of the mechanical system within the period of the motion command.

Residual Vibration: The dynamic response of the mechanical system after the motion-command. This term usually applies to the dwell period after an indexing motion period.

Dynamic Performance

When we look at the Dynamic-Performance, it is easier to discuss the acceleration of the motion-command and the motion-response.

All mechanical systems have a degree of elasticity, mass, and mass moment of inertia. The means that the acceleration response of the system is greater than that of the acceleration command. This is a reality of all mechanical systems.

The **Dynamic Performance** is a function of many factors, that include:

- the speed of the drive shaft (cycle speed),

- the natural frequency of the mechanical system (derived from its stiffness and mass, or its rigidity and mass moment of inertia).
- the segment period (time) in the motion-command
- the continuity of the motion-law
- the magnitude of the movement (lift) = the LEAST significant.

The maximum allowable operating speed is also influenced by the manufacturing accuracy of a cam-profile. The adverse effect of profile inaccuracies is aggravated as the machine-speed increases. Very stiff mechanisms (to give a high natural frequency) are to be preferred in all cases, provided the cam-profile is smooth.

Residual Vibration

Vibrations do not stop when the motion segment is finished! Residual vibration levels should be considered. If high vibration levels are experienced by the system in a dwell immediately after a segment, then frequently the machine tooling may be out of position while another mechanism attempts to interact with it. Some designers then redesign the motion with an even longer dwell (= shorter motion segment) to give a longer time for the vibrations to cease. However, this is not usually good solution to the problem as accelerations increase, and the Period-Ratio decreases.

Period Ratio

In order to provide an accurate definition of the dynamic-performance of a mechanism, we use a non-dimensional parameter called **Period-Ratio.**

The **Period-Ratio** is the:

The Period (time duration) of the motion segment divided by the Period (time duration) of the fundamental vibration of the following system.

A high Period-Ratio is always better than a low one.

Period-Ratio > **10** : indicates a combination of a stiff, low mass system, operating at a medium or low cam-shaft speed.

5 < **Period-Ratio 5** < **10** : a combination less stiffness, greater driven mass/inertia, and greater cam-shaft speed.

Period Ratio < **5** : a combination of low stiffness, high mass/inertia, and/or high speed cam-shaft

Motion Continuity

When the motion-law of the motion command is continuous in position, velocity, and acceleration, and if the **Period-Ratio** is more than 20, the acceleration of the mechanical system approaches the acceleration as predicted by the Motion-Law. The dynamic response of the follower system may be neglected when determining actual accelerations.

However, in the case of the Simple-Harmonic-Motion811 and the Constant-Acceleration motion-laws759, which are not continuous in acceleration, the acceleration of the dynamic-response is always significantly more than the acceleration of the motion-command, even if the **Period-Ratio** is greater than 20.

Motion-Laws that are discontinuous in acceleration (infinite jerk), at any point in their cam profile, produce vibrations of the mechanical-system. The actual acceleration/deceleration of the driven system is up to 2 times the nominal acceleration when driven by a cam motion with infinite jerk.

Pressure Angle Considerations.

The pressure angle and the way in which it varies throughout a motion depends upon the basic dimension of the cam, the type of the follower (roller, or flat faced) and, to a lesser extent on the particular motion-law.

Drive Torque

The operating torques for a cam system depends on the Motion-Law.

In general, you want the cam-shaft to rotate as near as possible to constant-velocity. You should design the input drive system to reduce the effect of the varying Drive Torque on the speed of the cam-shaft.

Typically, the drive shaft should be short, and have a large a diameter as possible. Add a flywheel to the input near to the Cam.

Maximize the rotating speed of the drive motor with a gear-box. The armature of the motor acts as a flywheel. The Load Torque (and its variation), referred to the motor are minimized.

There are three Torque factors to consider:

Constant Load Torque Factor

This is the component of torque required to overcome the constant component of the external load on the Follower. The constant load is usually due to the weight of the following system (or the referred weight), the load at the start of the motion due to any spring constraint, and also friction. This is usually the least significant of the three, for a 'normal' cam driven system - but it depends on the other two!

Inertia Torque Factor

This is the component of torque required to accelerate the mass of the follower assembly. It is usually the most significant in normal systems - but that depends on the others!

Spring Stiffness Torque Factor

This component is due to the linear change of spring constraint with the follower movement. This factor is based on the minimum spring force required at the point of maximum deceleration to maintain contact between the follower and the cam. The spring, might be an 'air-cylinder' which might be either a 'constant force' or as a 'fixed air mass'.

The magnitude of the total drive torque gives some indication of the amount of torsional deflection in the drive shaft and therefore the amount of segment motion distortion that may occur. The distortion tends to attenuate (reduce) the accelerations and amplify (increase) the decelerations of the follower. An abrupt reversal of torque (e.g. due to backlash in the drive train) results in torsional vibration in the driving shaft which is transmitted through the cam to the driven system. Such distortions can be reduced by increasing the torsional stiffness of the shaft and by increasing the mass moment of inertia, especially near the cam.

Motion distortion can result from shaft bending/flexing (due to cam contact forces)The shaft size and the position of its support bearings should be chosen to minimize any distortion of the cam-shaft.

Motion distortion can also result from the deflection of the Follower support shaft due to the pressure angle and cam contact-force.

Jerk

The rate-of-change of the strain-energy is related to the maximum value of jerk in the motion.

Jerk should be considered in addition to the system's rigidity/stiffness, and its operating speed.

Jerk values can be compared for different motions. Such as the:

- **Start and End Jerk**: At the start and end of a motion or segment
- **Maximum Jerk**: Motions with zero jerk at the start, may have a large maximum acceleration. The mechanical system strains more when the acceleration is increased.
- **Crossover Jerk**: The value of jerk as the acceleration changes sign from positive to negative, or vice versa. Low values of **crossover jerk** are beneficial for systems with backlash. Backlash typically traverses as and after the velocity reaches its maximum and begins to reduce. Motion-Laws with low **crossover jerk** values usually also have lower maximum velocity values. A low peak velocity means a reduced impact as the backlash completes its traverses.
- **Steps in Jerk**: For many of the Traditional Motion-Laws755, jerk changes instantaneously from zero to some finite value immediately after the motion segment starts. Steps in jerk induce vibrations in the mechanical system being driven. Other motions start and end with infinite jerk, which is an even worse.
- **Infinite Jerk**: Motion-Laws that have a step in acceleration also have infinite jerk-values at the acceleration step. We have already stated that acceleration continuity is important.

1.6.14.5 To Improve a Motion

Improve the Motion

This is a very subjective problem. A good motion for one application may not always be a good motion for another.

An attempt to answer the question of "How to improve a motion?"

Assumptions:

- The motion is for a machine, and not for the animation of a cartoon character.
- The motion is intended for a machine where the machine elements reciprocate, oscillate, index, or the speed modulates in some way. Each machine element has mass, mass moment of inertia, stiffness, and backlash.
- The inertia forces are dominant - or at least 80% of the total load.

General Advice:

- Remove all Velocity motion-discontinuities.
- Remove all Acceleration motion-discontinuities.
- Use a minimum number of segments.
    - Always ask yourself: "Can I reduce the number of segments?"
    - Always ask yourself: "Can I delete a Dwell Segment?" - especially short dwells.
- Reduce the number of motion constraints. E.g. Do you need to control the position of a Blend-Point - possibly you only need to control its velocity.
- Try to make the maximum acceleration values of each segment similar to each other. This is not always possible or desirable. But consider balancing the motion to give similar motion durations or peak accelerations, or both.
- When different tools must interact in some way, consider moving a tool further than you need to, if you can also give it more time. This is often a very powerful way to reduce accelerations of tools.

  For example, if you increase the displacement by 20% and increase the duration by 20%, the maximum velocity will not change, but the maximum acceleration will reduce by 20%.

Why select different Motion-Laws?

A motion-law might:

- give more flexibility for you to control the motion-derivatives at the Blend-Points.
- suit the mechanical system. For example, the motion-law might have a "low peak maximum velocity".
- give a good dynamic response to the mechanical system. For example, the motion-law might have a good response to system backlash, low drive stiffness.

- agree with a company preference(!) - for example Modified Sinusoid is often a company preference.

Note:

I nearly always design my motions with Flexible-Polynomial segments as they give me almost all of the flexibility I need.

1.6.15 TOP-TIPS

TOP-TIP #1

When you start using **MotionDesigner**, it is easy accidentally to design a motion with a very short-segment that you cannot see in the graph, and that you do not know or want in your motion.

To see if there is a very short **SEGMENT**:

1. Open the **BLEND-POINT EDITOR** or the **SEGMENT EDITOR**
2. Click the **NEXT** button, to move the **SELECTED-SEGMENT** across the complete motion

If you click the **NEXT** button, but you cannot see the **SELECTED-SEGMENT** in the motion graphs, then you have found a very short segment.

3. Click the Delete Segment 719 button to remove the very short segment

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TOP-TIP #2

On paper, plan you motion over one machine-cycle before you begin with MotionDesigner.

From your plan, you should:

1. Know if the motion is a progressive or non-progressive motion (indexing type, or Rise and Return type)
2. Know how many segments you need in your motion - over a full machine cycle.
3. Approximate the X and Y-axis positions of each Blend-Point.

1.6.16 Motion-Law Equations

Motion-law Equations

When there is an equation for each derivative of a motion-law, the output of each motion-derivative can be evaluated exactly and quickly from one input.

For example:

If the normalized input, x, is 0.5467321892, then it is possible to evaluate exactly the normalized values of Position,Velocity, Acceleration, and Jerk for any of the motion-laws.

Motion-Laws

The important motion-laws are:

- Dwell 872

Motion Functions

$$x = normalized\ input\ variable\ (0 \rightarrow 1)$$
$$f(x) = Position$$
$$f'(x) = Velocity$$
$$f''(x) = Acceleration$$
$$f'''(x) = Jerk$$

Actual Velocity, Acceleration, and Jerk

You can calculate the **actual** motion-values of each motion-derivative if you know the **Actual Displacement** (y), the **Actual Period** (t), and the motion function

Actual Position =	$f'(x) \times y$
Actual Velocity =	$f'(x) \times y/t$
Actual Acceleration =	$f''(x) \times y/t^2$
Actual Jerk =	$f'''(x) \times y/t^3$

Dwell

$0 \leq x \leq 1$	$f(x) = 1$; $f'(x) = 0$; $f''(x) = 0$; $f'''(x) = 0$

Constant Velocity

$0 \leq x \leq 1$	$f(x) = x$; $f'(x) = 1$; $f''(x) = 0$; $f'''(x) = 0$

Constant-Acceleration, Constant-Deceleration (CACD)

$0 \le x \le 0.5$	$f(x) = 2.x^2$
	$f'(x) = 4.x$
	$f''(x) = 4$
	$f'''(x) = 0$
$0.5 < x \le 1$	$f(x) = 1 - 2.(x-1)^2$
	$f'(x) =- 4.(x-1)$
	$f''(x) =- 4$
	$f'''(x) = 0$

Simple Harmonic Motion (SHM)

$0 \le x \le 1$	$f(x) = \frac{1}{2}[1 - \cos(\pi.x)]$
	$f'(x) = \frac{\pi}{2}.\sin(\pi.x)$
	$f''(x) = \frac{\pi^2}{2}.\cos(\pi.x)$
	$f'''(x) =- \frac{\pi^3}{2}.\sin(\pi.x)$

Cycloidal

$0 \le x \le 1$	$f(x) = x - \frac{1}{2.\pi}.\sin(2.\pi.x)$
	$f'(x) = 1 - \cos(2.\pi.x)$
	$f''(x) = 2.\pi.\sin(2.\pi.x)$
	$f'''(x) = 4.\pi^2.\cos(2.\pi.x)$

Polynomial 2-3

$0 \le x \le 1$	$f(x) = 3.x^2 - 2.x^3$
	$f'(x) = 6.x - 6.x^2$
	$f''(x) = 6 - 12.x$
	$f'''(x) = 12$

Polynomial 3-4-5

$0 \leq x \leq 1$	$f(x) = 6.x^5 - 15.x^4 + 10.x^3$ $f'(x) = 30.x^4 - 60.x^3 + 30.x^2$ $f''(x) = 120.x^3 - 180.x^2 + 60.x$ $f'''(x) = 360.x^2 - 360.x + 60$

Polynomial 4-5-6-7

$0 \leq x \leq 1$	$f(x) =- 20.x^7 + 70.x^6 - 84.x^5 + 35$ $f'(x) =- 140.x^6 + 420.x^5 - 420.x^4$ $f''(x) =- 840.x^5 + 2100.x^4 - 1680$ $f'''(x) =- 4200.x^4 + 8400.x^3 - 504$

Modified Sinusoid

$0 \leq x \leq 0.125$	$f(x) = \frac{1}{\pi + 4}.\left[\pi.x - \frac{1}{4}.\sin(4.\pi.x)\right]$ $f'(x) = \frac{\pi}{\pi + 4}.[1 - cos(4.\pi.x)]$ $f''(x) = \frac{4.\pi^2}{\pi + 4}.sin(4.\pi.x)$ $f'''(x) = \frac{16.\pi^3}{\pi + 4}.cos(4.\pi.x)$
$0.125 < x \leq 0.875$	$f(x) = \frac{1}{\pi + 4}\left[2 + \pi.x - \frac{9}{4}.\cos\{4.\pi.(\right.$ $f'(x) = \frac{1}{\pi + 4}[\pi + 3.\pi.\sin\{4.\pi.(x -$ $f''(x) = \frac{4.\pi^2}{\pi + 4}.cos\{4.\pi(x - 0.125)/3$ $f'''(x) = \frac{- 16.\pi^3}{3.(\pi + 4)}.\sin\{4.\pi(x - 0.12$
$0.875 < x \leq 1$	$f(x) = \frac{1}{4 + \pi}.\left[4 + \pi.x - \frac{1}{4}.\sin(4.\pi.x\right.$ $f'(x) = \frac{\pi}{\pi + 4}[1 - \cos(4.\pi.x)]$

	$f''(x) = \frac{4.\pi^2}{\pi + 4}.sin(4.\pi.x)$ $f'''(x) = \frac{16.\pi^3}{\pi + 4}.cos(4.\pi.x)$

Modified Trapezoid

$0 \leq x \leq 0.125$	$f(x) = \frac{1}{\pi + 2}.\left[2.x - \frac{1}{2.\pi}.\sin(4.\pi.x)\right]$ $f'(x) = \frac{2}{\pi + 2}.[1 - cos(4.\pi.x)]$ $f''(x) = \frac{8.\pi}{\pi + 2}.sin(4.\pi.x)$ $f'''(x) = \frac{32.\pi^2}{\pi + 2}.cos(4.\pi.x)$
$0.125 < x \leq 0.375$	$f(x) = \frac{1}{\pi + 2}.\left[4.\pi.x^2 - \left(\pi - 2\right)x + \pi\right.$ $f'(x) = \frac{1}{\pi + 2}.[8.\pi.x - \pi + 2]$ $f''(x) = \frac{8.\pi}{\pi + 2}$ $f'''(x) = 0$
$0.375 < x \leq 0.625$	$f(x) = \frac{1}{\pi + 2}\left[2(\pi + 1)x - 0.625 - \right.$ $f'(x) = \frac{1}{\pi + 2}[2(\pi + 1) + 2.\sin[4.\pi($ $f''(x) = \frac{8.\pi.\cos[4.\pi(x - 0.375)]}{\pi + 2}$ $f'''(x) = \frac{-32.\pi^2.\sin[4.\pi(x - 0.375)}{\pi + 2}$
$0.625 < x \leq 0.875$	$f(x) = \frac{-1}{\pi + 2}.\left[4.\pi.(1 - x)^2 - \left(\pi - 2\right.\right.$ $f'(x) = \frac{1}{\pi + 2}.[8.\pi.(1 - x) - \pi +$

	$f''(x) = \frac{-8.\pi}{\pi + 2}$ $f'''(x) = 0$
$0.875 < x \leq 1$	$f(x) = \frac{-1}{\pi + 2}.\Big[2.(1 - x) - \frac{1}{2.\pi}.\sin\{4$ $f'(x) = \frac{2}{\pi + 2}.[1 - cos(4.\pi.x)]$ $f''(x) = \frac{-8.\pi}{\pi + 2}.sin(4.\pi.x)$ $f'''(x) = \frac{32.\pi^2}{\pi + 2}.cos(4.\pi.x)$

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