

Working Model Tutorial for Slider Crank

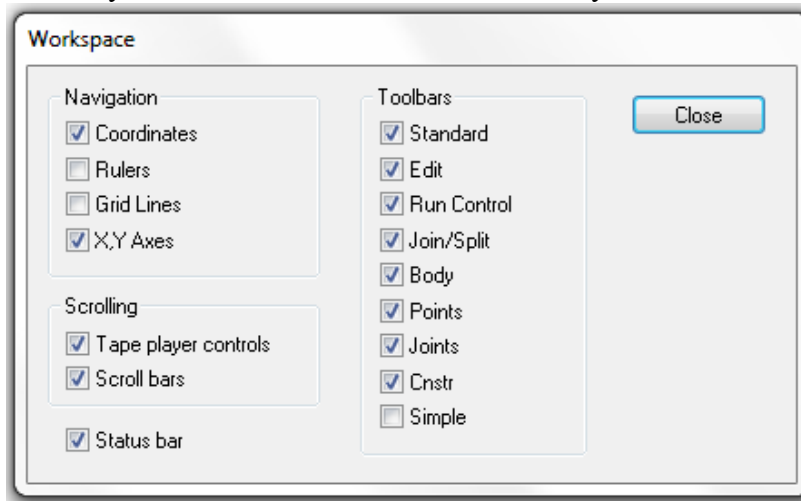
1) Start Working Model 2D

2) Set display and units

Select View then Workspace

Check the X,Y Axes and Coordinates boxes and then select Close

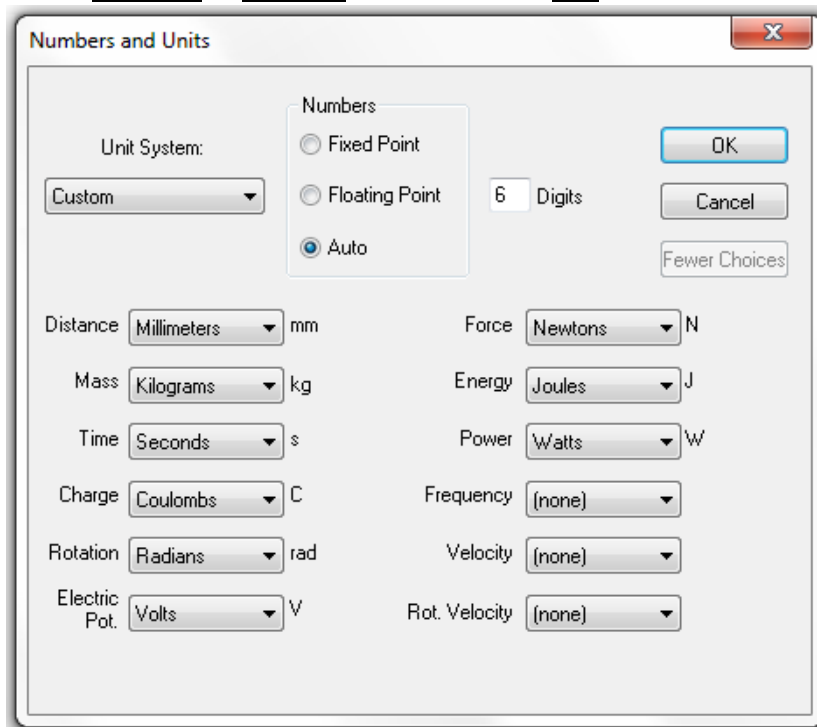
You may also select Grid Lines and Rulers if you wish



Select View then Numbers and Units then More Choices

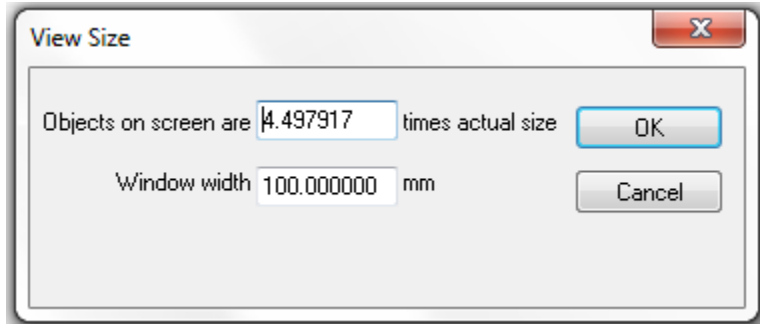
Select Distance in Millimeters

Select Rotation in Radians and then select OK



Select View then View Size

Set Window width to 100 then select OK



3) Save this example

Select File then Save As and choose a suitable folder and filename and then select Save

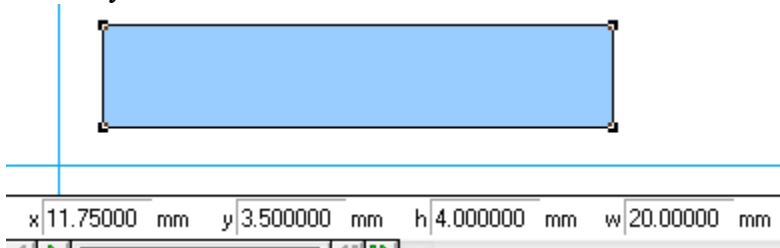
REMEMBER TO SAVE YOUR WORK OFTEN!

4) Draw a link and add points to it

Select the Rectangle drawing tool from the tool bar on the left and draw a rectangle



You may use the H and W indicator boxes at the bottom tool bar to resize



Select the round Point Element drawing tool from the tool bar on the left

Position the cursor over an edge of the link and **WAIT** for a small X to snap onto that edge

Left-click to attach the point to the link

Place a second round point on the link



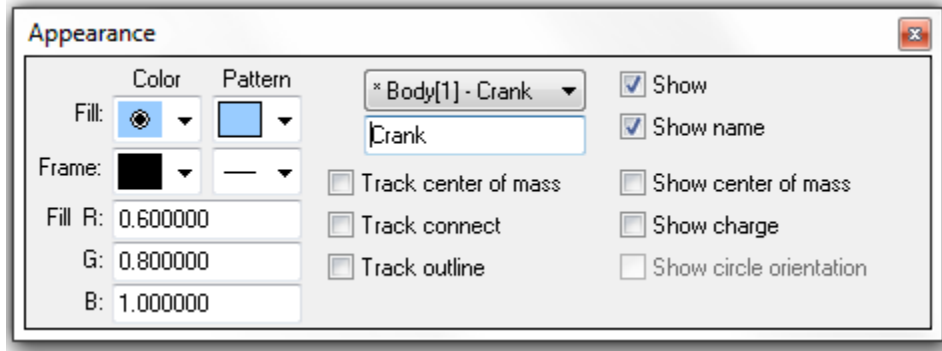
5) Label the link and points

Left-click on the link to highlight it and select Window then Appearance

Remove checks on Track center of mass and Track outline box

Check Show, Show name and Show center of mass boxes

Left-click on the box containing “Rectangle” and enter the name “Crank”

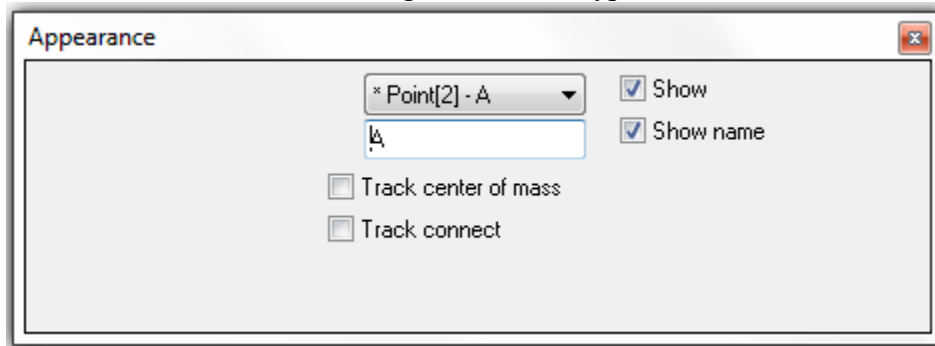


Left-click on one point on the link and select Window then Appearance

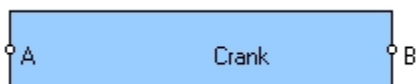
Remove the check on the Track center of mass box

Check the Show name box

Left-click on the box containing “Point” and type the name “A”



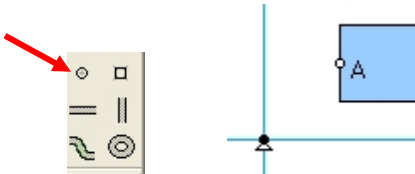
Repeat to name the other point B



6) Create a revolute joint connected to ground

Select the round Point element drawing tool from the tool bar on the left

Position the cursor and left-click to attach a ground pin



Left-click on the ground pin to highlight it if necessary

Hold down the Shift Key and left-click on point A on the Crank to highlight it also

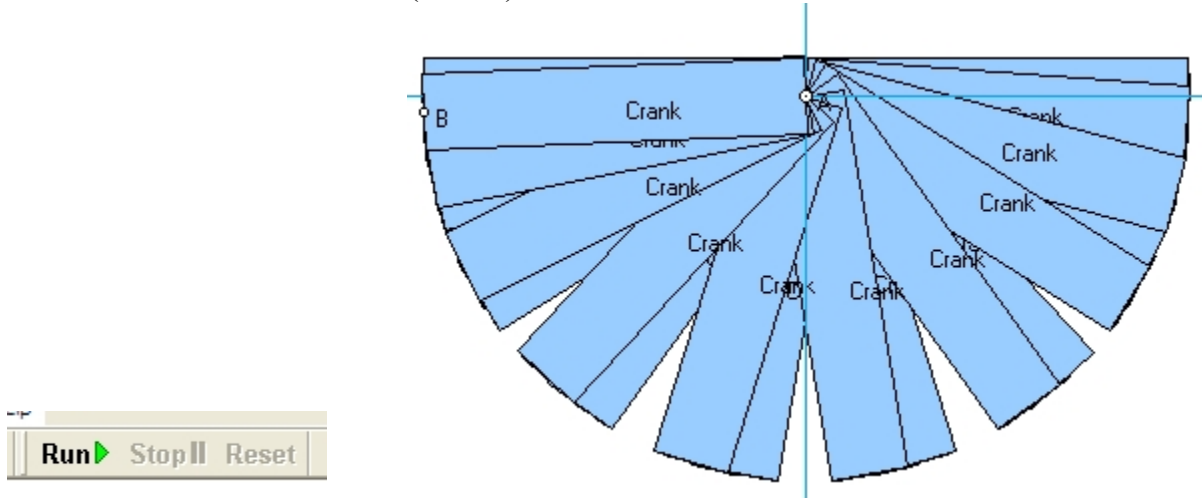
Select the Join button from the tool bar on the left to create a revolute joint



You should be able to left-click and drag the link to move it around

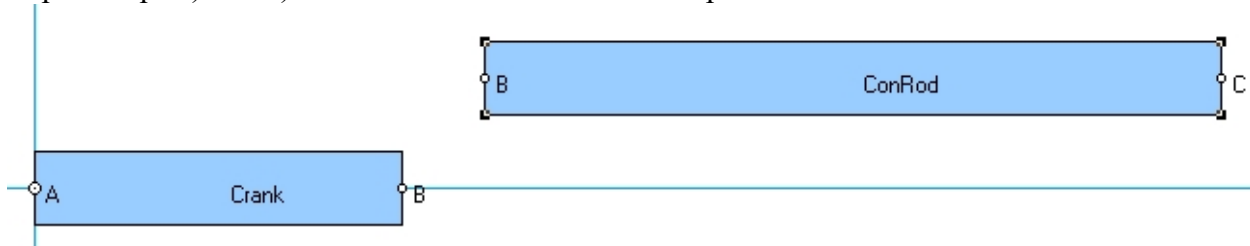
Animate your pendulum by selecting Run and then later Stop from the toolbar at the top

Select World then Erase Track (Ctrl+E) to clean the screen if needed



7) Create a revolute joint connected to another link

Repeat steps 4) and 5) to create “ConRod” with round points B and C attached to it



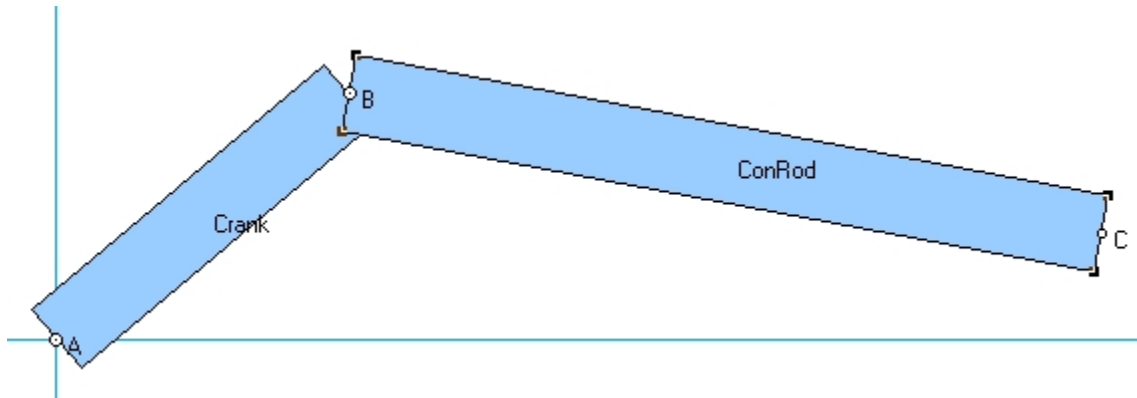
Left-click on point B on Crank to highlight it

Hold down the Shift Key and left-click on point B on the ConRod to highlight it also

Select the Join button from the tool bar on the left to create a revolute joint

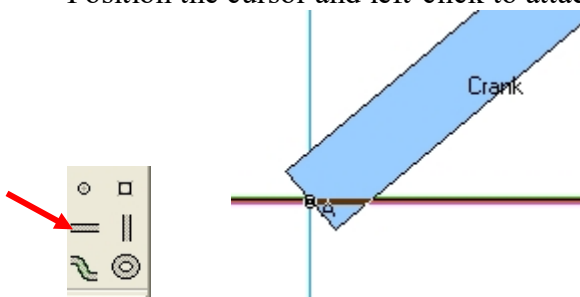


You should be able to left-click and drag the links to move them around



8) Create a pin-in-slot joint connected to ground

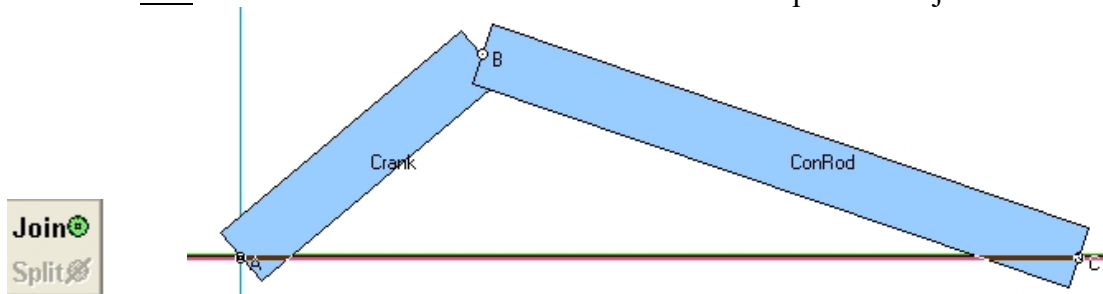
Select the horizontal Slot element drawing tool from the tool bar on the left
Position the cursor and left-click to attach a slot to ground



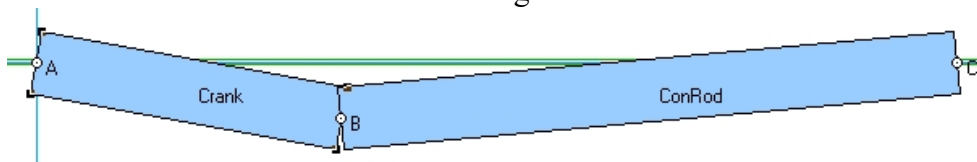
Left-click on the slot to highlight it if necessary

Hold down the Shift Key and left-click on point C on the ConRod to highlight it also

Select the Join button from the tool bar on the left to create a pin-in-slot joint



You should be able to left-click and drag the links to move them around



9) Create a prismatic joint

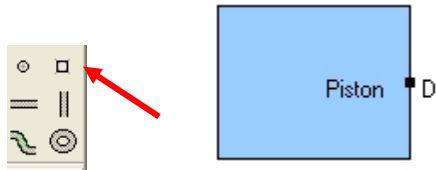
Repeat step 4) to create a small block “Piston”



Select the Square Point element drawing tool from the tool bar on the left

Position the cursor over an edge of the Piston and **WAIT** for a small X to snap onto that edge

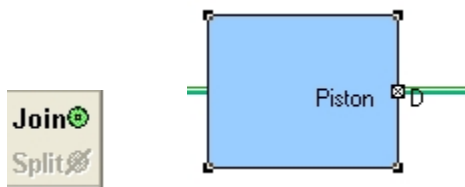
Left-click to attach the point to the Piston and name it D



Left-click on the slot to highlight it

Hold down the Shift Key and left-click on square point D on the Piston to highlight it also

Select the Join button from the tool bar on the left to create a prismatic joint

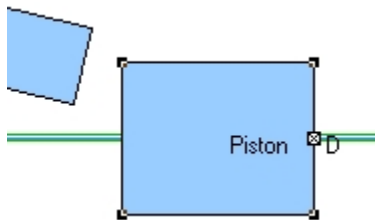


You should be able to left-click and drag the link to slide it

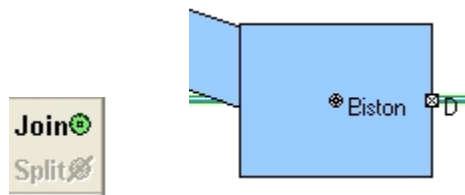
10) Create a slider crank

Left-click on point C on the ConRod to highlight it and press the Delete Key to remove point C

Left-click and drag the ConRod away from the slot



Add a new round point C to the end of the ConRod
 Add a new round point C to the middle of the Piston
 Highlight the points and use the Join button to create a revolute joint



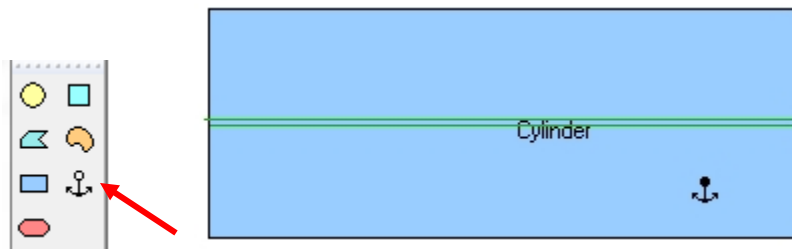
You should be able to left-click and drag the links to move them around

11) Create a slot connected to a link

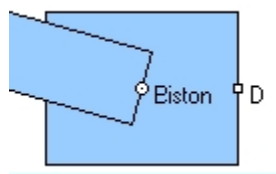
Repeat steps 4) and 5) to create a large block “Cylinder”
 Select the horizontal Slot element drawing tool from the tool bar on the left
 Position the cursor over the Cylinder and left-click to attach a slot to the Cylinder



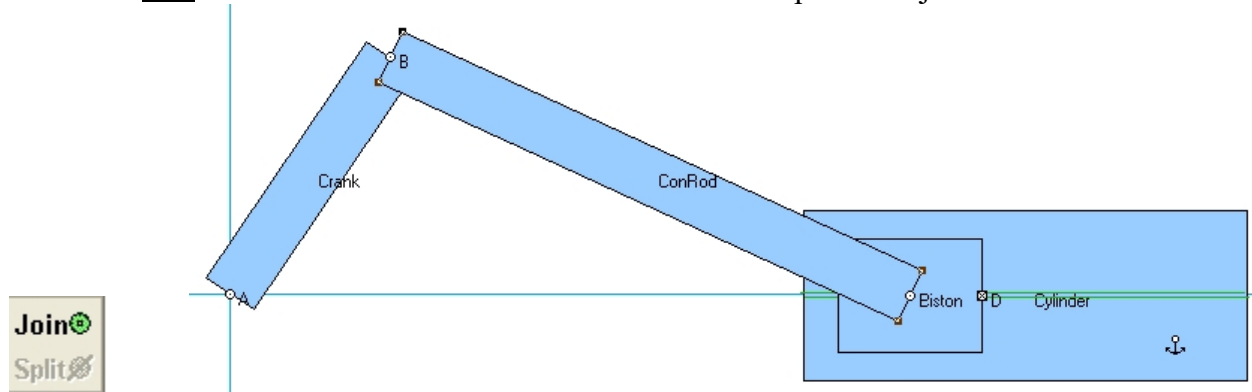
Select the Anchor tool from the tool bar on the left
 Position the cursor over the Cylinder and left-click to connect the Cylinder to ground



Left-click on square point D to highlight it and press the Delete Key to remove point D
 Left-click and drag the Piston away from the ground slot
 Left-click on the ground slot and press the Delete Key to remove it
 Add a new square point D to the Piston
 Left-click on the Piston and select Object then Move to Front
 Left-click on the ConRod and select Object then Move to Front



Move the slot in the cylinder where the ground slot had been
 Left-click on the slot attached to the Cylinder to highlight it if necessary
 Hold down the Shift Key and left-click on point D on the Piston to highlight it also
 Select the Join button from the tool bar on the left to create a prismatic joint



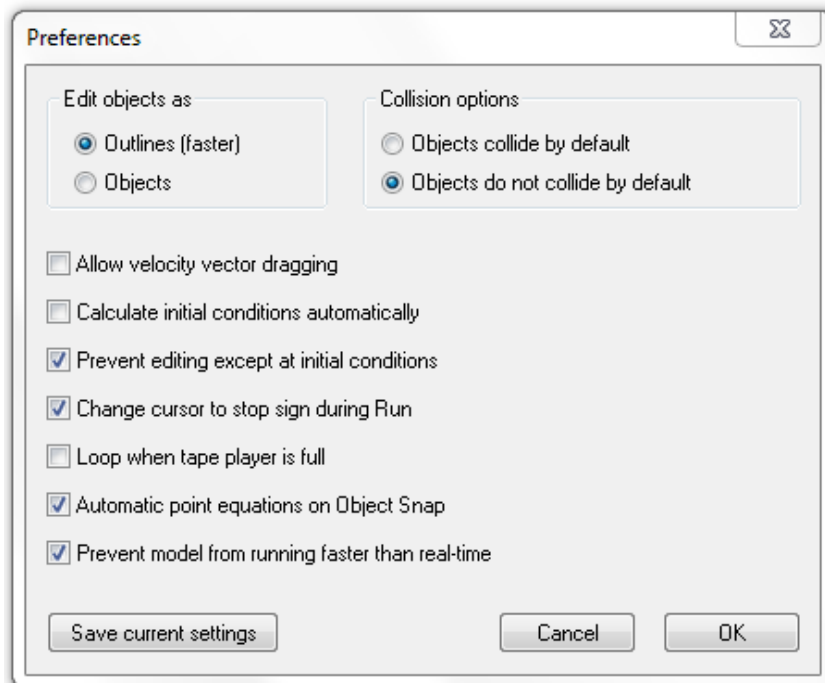
You should be able to left-click and drag the links to move them around
 The Cylinder should not move

12) Collision

Depending on how you designed your Piston, the ConRod may collide with your Cylinder
 You can ignore or enforce collision between objects in two ways

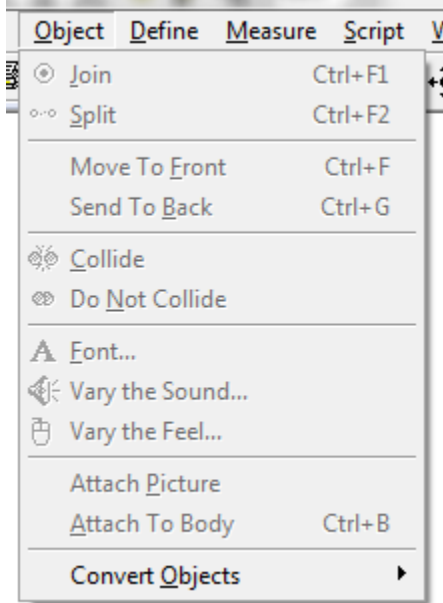
Global setting

Select World then Preferences and choose if you want all objects to collide or not collide



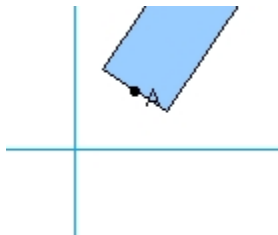
Pairs of objects

Left-click on one object and then hold down the Shift Key and left-click on another object
Then select Object and Collide or select Object and Do Not Collide



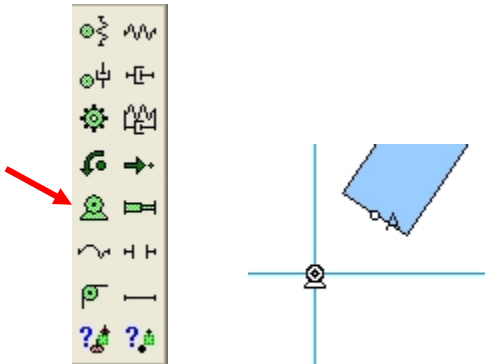
13) Add a motor

Left-click on point A on the Crank to highlight it and press the Delete Key to remove point A
Move the end of the crank away from the origin and add a new round point A to the Crank



Select the Motor drawing tool

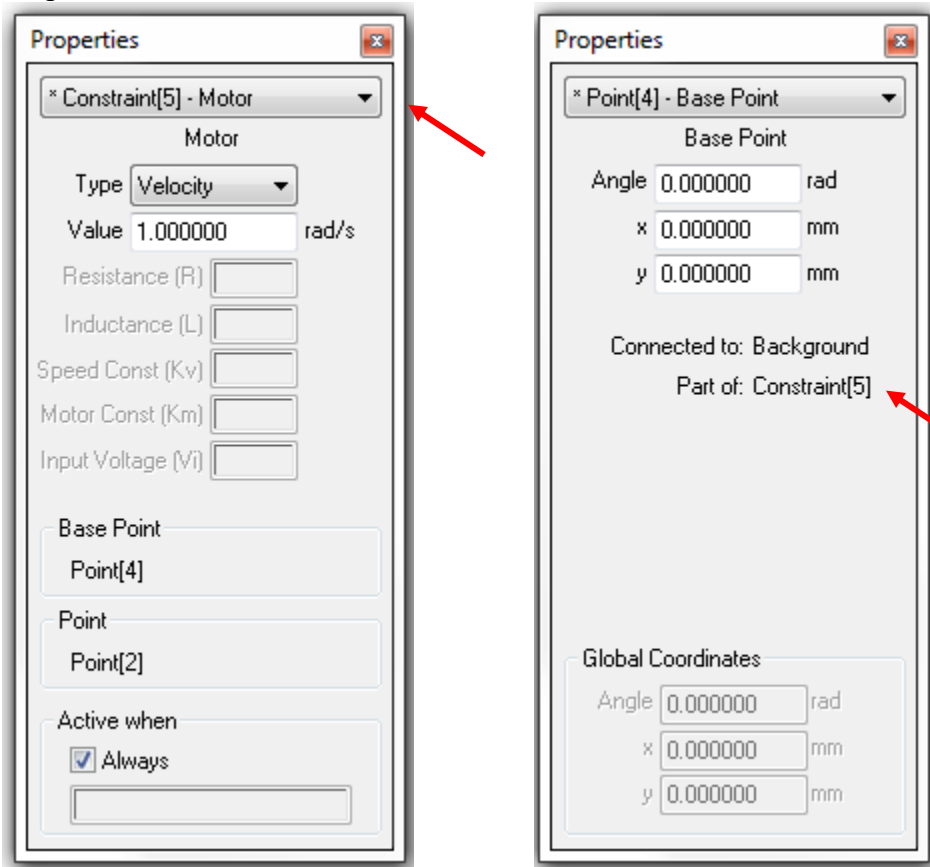
Position the icon and left-click to attach the motor to ground



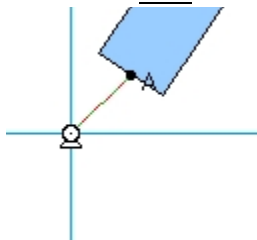
Left-click on the motor to highlight it

Select Split from the tool bar on the left

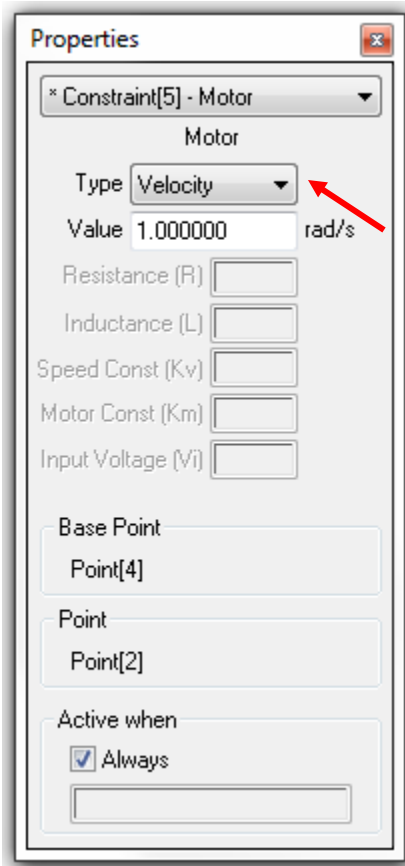
Select Window then Properties to see the names for the Base Point and the Motor in the Properties window



Left-click on the CENTER of the motor and drag the point icon onto point A on the Crank
Select the Join button from the tool bar on the left



Double left-click on the motor to show the Properties pop-up
Use Type Velocity to create a speed control motor
A constant positive value causes a constant CCW rotation speed



Animate your slider crank by selecting Run and then later Stop from the toolbar at the top
Select World then Erase Track (Ctrl+E) to clean the screen if needed

Use Type Rotation to create a position control motor

You may enter a formula in the value window to vary position as a function of time

The formula “ $1.57 \cdot \sin(3.14 \cdot t)$ ” will produce ± 90 degrees of rotation at 0.5 Hz (2 second period).

Use Type Torque to create a torque control motor

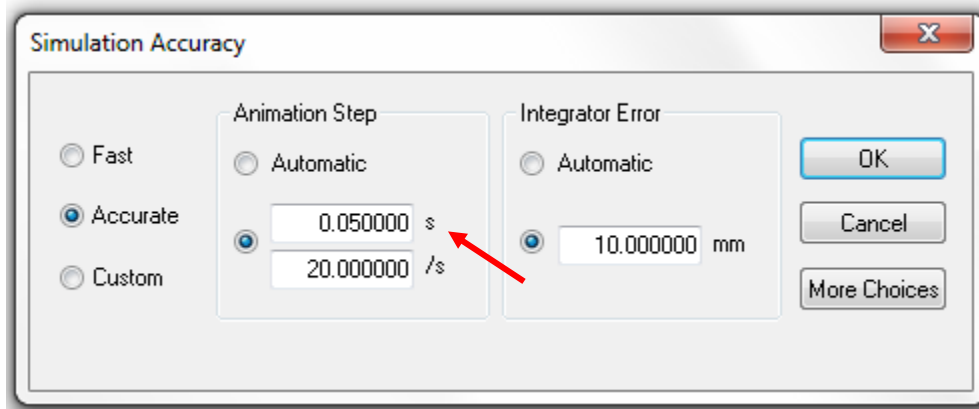
A constant positive value causes a constant CCW torque

Alternately you may enter a formula in the value window to vary torque as a function of time

14) Changing animation speed and integrator error

Select World then Accuracy

Smaller values for the upper box under Animation Step provide fewer animation steps



For very fast motion, default settings may cause joints to drift apart
The following settings are a good place to start when making adjustments

Select World then Accuracy

Manually set Animation Step to 0.001 sec

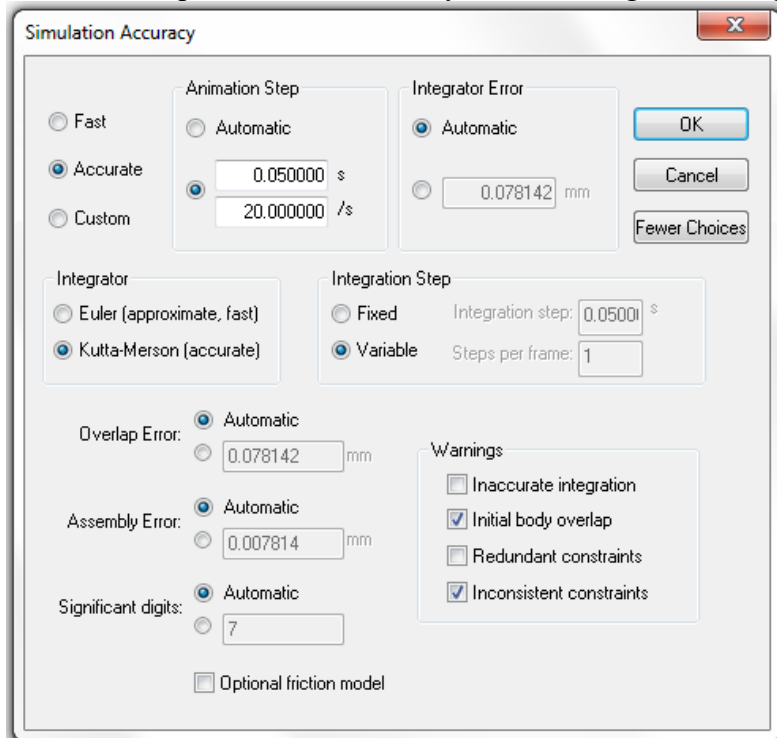
Select the Integrator Error radio button for Automatic

Then select More Choices

Select the Integrator radio button for Kutta-Merson (accurate)

Select the Integration Step radio button for Variable

Select Overlap Error and Assembly Error and Significant digits radio buttons for Automatic



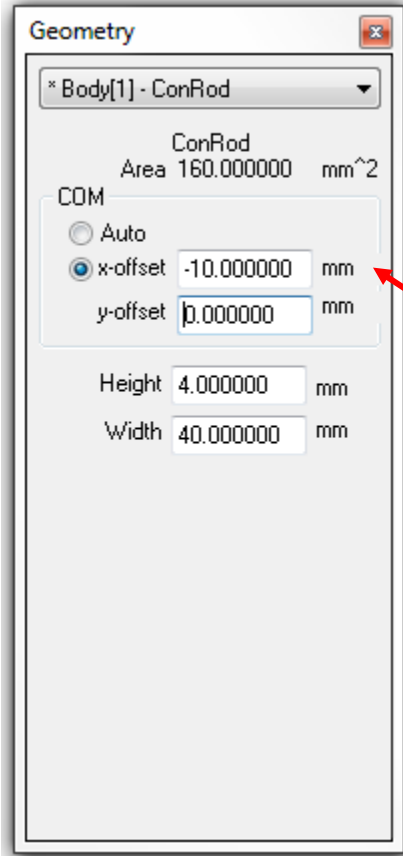
15) Modify link inertial properties

Left-click on the ConRod to highlight it and select Window then Appearance

Check the Show center of mass box

Select Window then Geometry

Select the radio button for COM x-offset to change the centroid location



Select Window then Properties

You may change the mass and mass moment of inertia

Note: WM assumes all objects are 1 unit thick

16) Create a polygonal link

Select the Polygon drawing tool from the tool bar on the left

Left-click for the first vertex

Move the cursor and left-click to place more vertices

Double left-click to complete the Polygon

Left-click on the polygonal object to highlight it

Select Window then Geometry

Edit the table at the bottom of the Geometry pop-up to resize your object

You may edit in World coordinates or Shape coordinates

You may Insert new vertices or Delete current vertices

17) Displaying and exporting numerical data

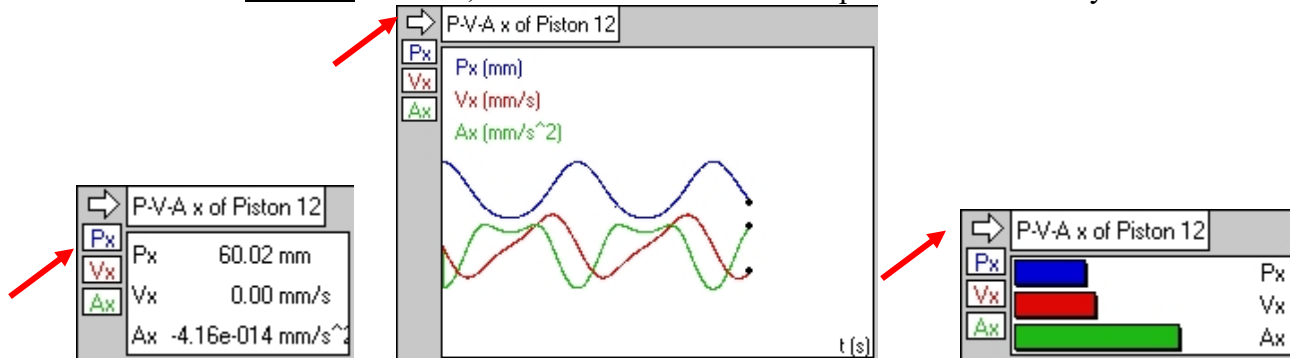
Left-click on the Piston to highlight it and select Measure then P-V-A then X

Select Run and then later Stop from the toolbar at the top

Different output formats for the Measure window may be selected with the hollow arrow

You may have several Measure windows for different variables open at the same time

To remove a Measure window, left-click on it to select and press the Delete Key

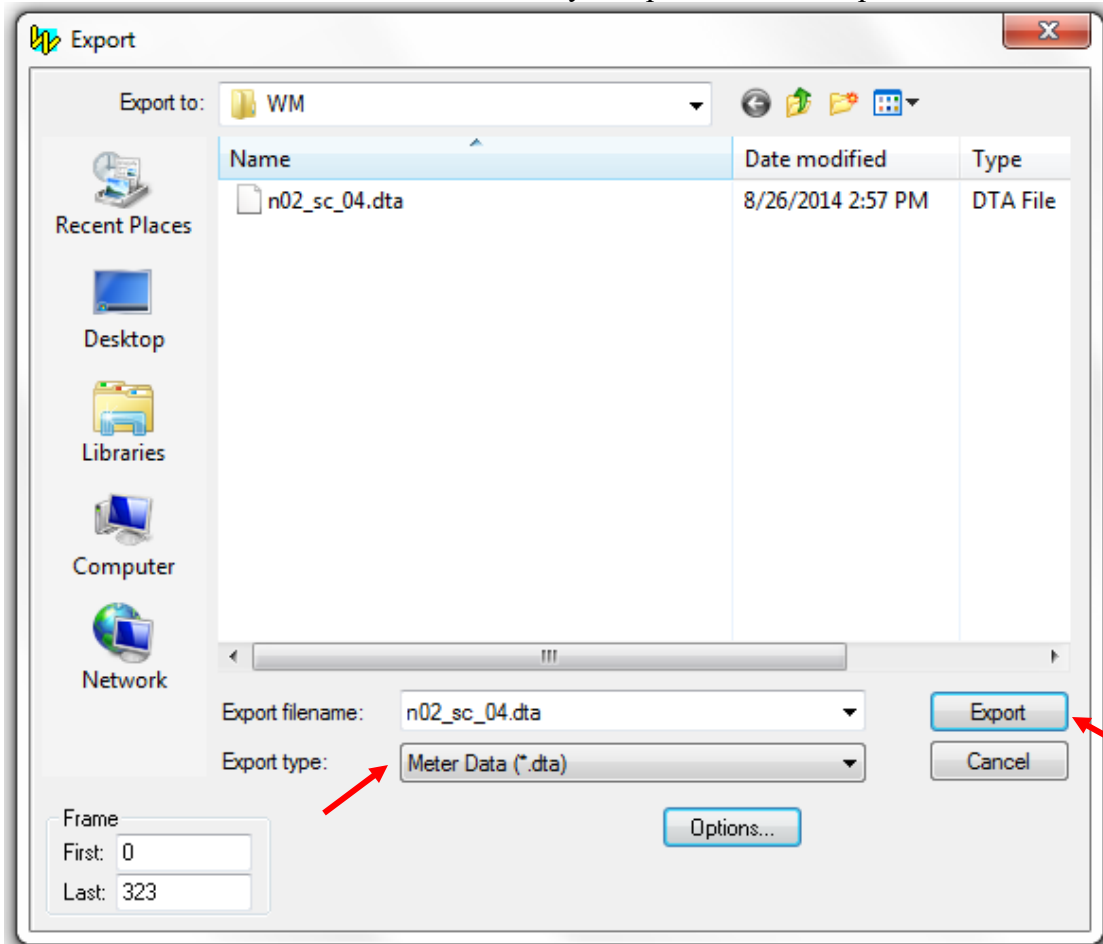


Select File then Export and choose a suitable folder and filename

Select Export type Meter Data (*.dta)

Select Export to save meter data from your most recent run

*.dta files contain tab-delimited text and may be opened with Notepad, Word or Excel



18) Exporting animation

Select File then Export and choose a suitable folder and filename

Select Export type Video for Windows (*.avi)

Select Export to save an AVI animation of your most recent run

You may also control the number of frames that are exported

Note: Exporting *.avi files may cause problems with exporting *.dta files in future runs

