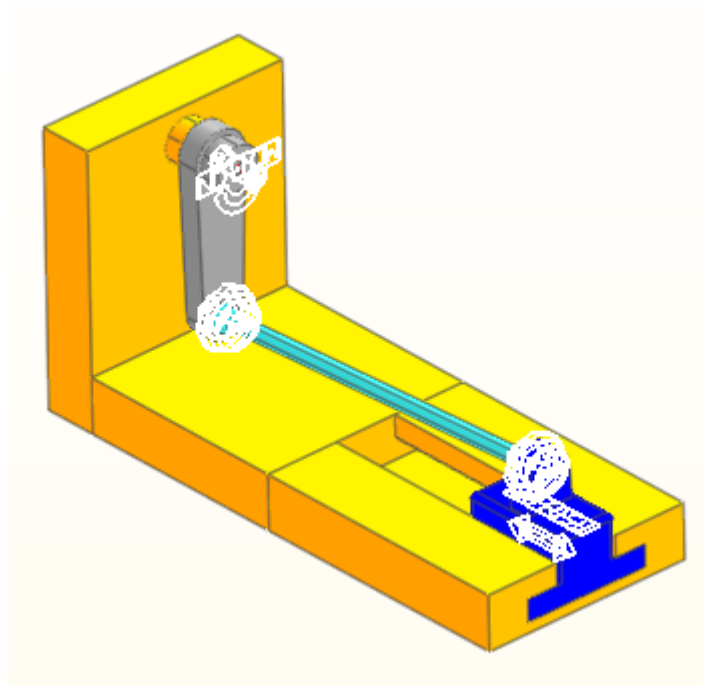




3D Slider Crank Tutorial (Professional)



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Edition Note

This document describes the release information of **RecurDyn V9R4**.

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Chapter

1

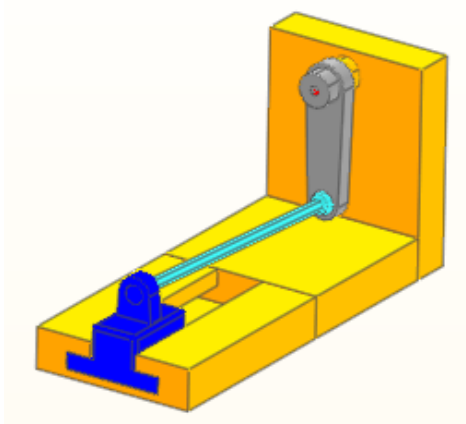
Getting Started

Objective

In this introductory tutorial, you will learn how to:

- Set up a model with the correct units and environment
- Create bodies with geometric detail
- Add joints and associated input motions
- Analyze the model to investigate the effects of motion and forces on it.
- Communicate the results of your simulation as:
 - X-Y plots
 - Animations that can be played interactively within RecurDyn
 - AVI files that can be inserted into PowerPoint presentations

The target model is a 3D slider-crank mechanism. This mechanism is used to convert an input rotary motion to an output translational motion. You will see how the combination of moving bodies and four kinematic joints can produce a complex relationship between the input and output motions.



Audience

This tutorial is an excellent starting point for the engineer who is using RecurDyn for the first time. The basic tasks that are needed for all simulations are explained carefully.

Prerequisites

Because this is an introductory tutorial, we assume that you have no prior experience with RecurDyn. We assume that you have a basic knowledge of physics.

Procedures

The tutorial is comprised of the following procedures. The estimated time to complete each procedure is shown in the table.

Procedures	Time (minutes)
Simulation environment setup	5
Geometry creation	35
Joint creation	10
Analysis	5
Animation/AVI	10
Plotting	10
Total	75



Estimated Time to Complete

75 minutes

Chapter

2

Setting Up Your Simulation Environment

Task Objective

Learn how to set up the simulation environment, including units, materials, gravity, and the working plane.



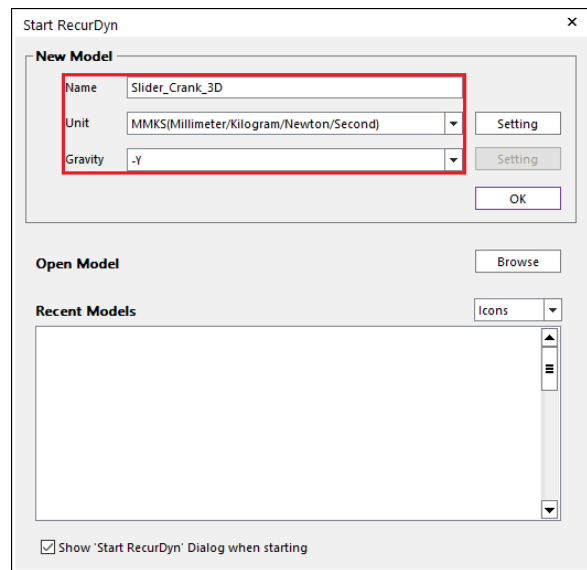
Estimated Time to Complete

5 minutes

Starting RecurDyn

To start RecurDyn and create a new model:

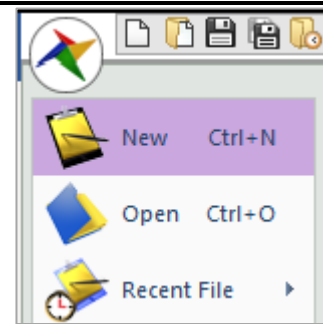
1. On your Desktop, double-click the **RecurDyn** icon.
- RecurDyn** starts up and the **Start RecurDyn** dialog box appears.
2. Enter the name of the new model as **Slider_Crank_3D**.
 3. Change **Unit** to **MMKS**.
(Millimeter/Kilogram/Newton/Second)
 4. **Gravity** is the Default (-Y) setting.
 5. Click **OK**.



Tip: Other ways to create a new model

If you want to use a user to create a new model in RecurDyn, you can do one of the following:

- In the **Quick Access Toolbar**, click the **New**.
- From the **File** menu, click **New**.
- Use the shortcut key (**Ctrl + N**).



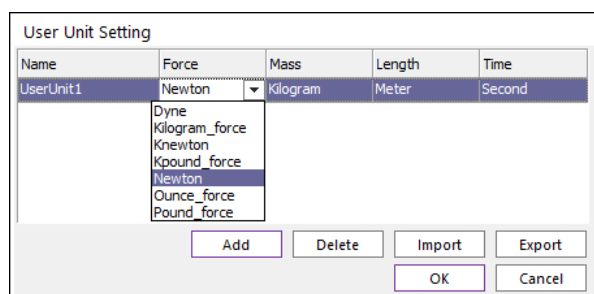
Tip: Allowed Characters for Model Name

You cannot use spaces or **special characters** in the model name. You can use the **underscore character '_'** to add **space** to improve the readability of the name.

Tip: Create User Unit Setting

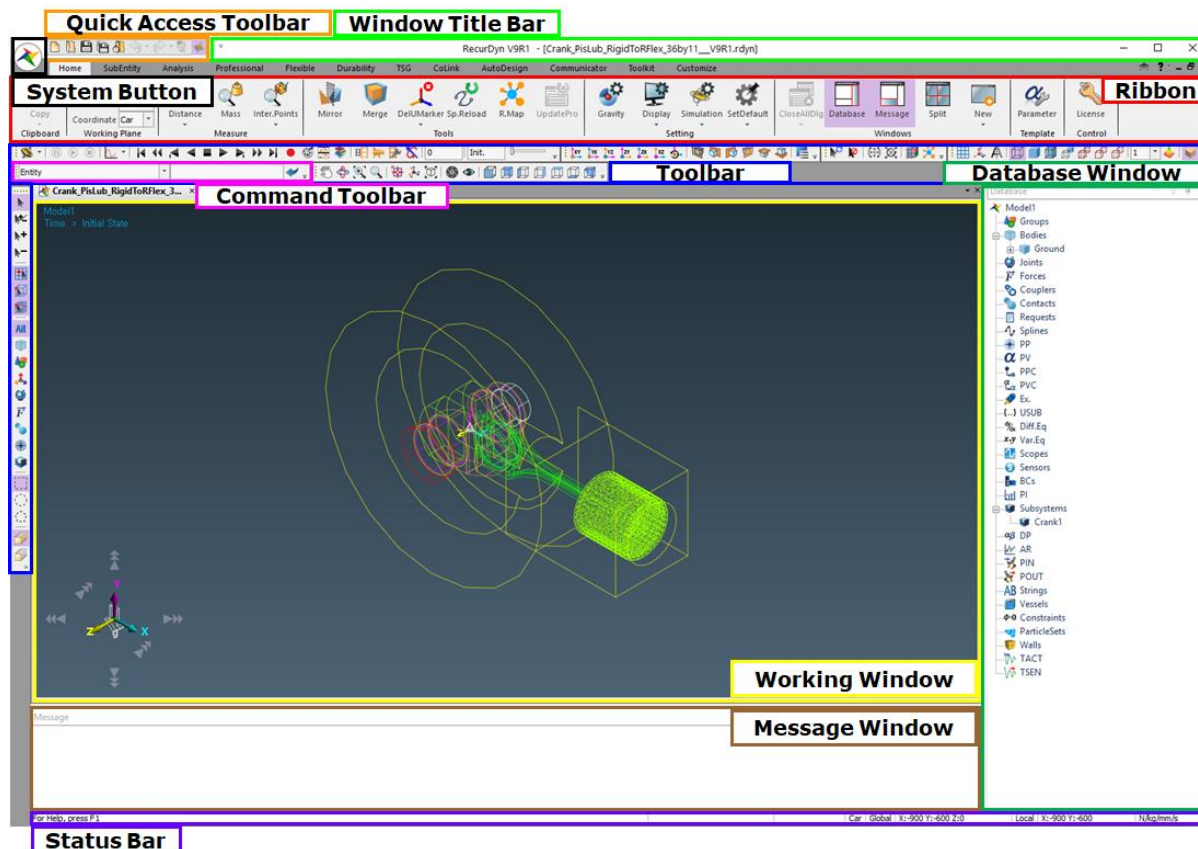
You can create user defined units when you need custom unit settings.

- Click **Setting** button next to **Unit**.
- **User Unit Setting** dialog will appear. You can define units regarding **Force, Mass, Length** and **Time**.



Understanding the Interface

The RecurDyn interface consists of several basic areas as shown in the figure below. You can turn on and off the display of any areas and rearrange the areas any way you want. Each area is explained below.



Using the Ribbon menu

The Ribbon menu provides you with all the tools you need to create a model, including the geometries, constraints, and motions. It divides the tools into subcategories to make it easier for you to find the tools.

To select a tool:

1. Click the tab, such as **SubEntity** or **Professional**.
The set of tools in that category appears.
2. Click the desired tool.

Using the Database Window

You can view all the data and entities in your model using the Database window. In addition, you can:

- View and change the properties of each entity.
- Make constraints and forces inactive and reactivate.

- Change the display modes of individual bodies.
- Change to the edit mode of subsystems, bodies, and profiles.
- Check information of lower-level entities by clicking + button in front of entities.

To view the entities in your model:

Click the + in front of an entity in the database window.

Using the Working Window

The Working window is where you build your model. You can use the tools to zoom and rotate your model and set the working plane on which you build your model.

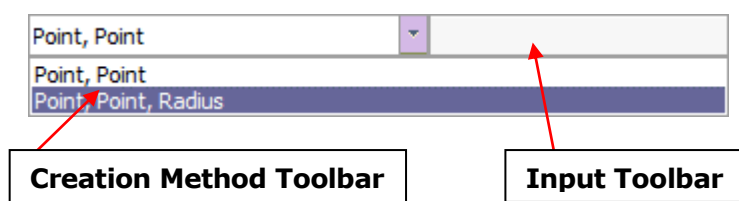
Using the Working Plane

Working plane is where you modify entities. You can modify the working plane setting using the working plane toolbar. Grid changes according to axis of working plane. Status of working plane can affect forms and directions of entities you work on



Using Command Toolbar

Command Toolbar is located at the top of the window. It is composed of those two modeling toolbars below and helps you create your model:

- The **Creation Method Toolbar** sets the options for the current operation.
- The **Input Toolbar** lets you enter coordinates or a parametric point name and value, depending on the required input.



To use the toolbars together to create your model:

1. Select an entity to create, such as a cylinder.
2. From the Creation Method Toolbar, select a creation method, such as **Point, Point, Radius**.
3. Enter the first point in the Input Window toolbar.
4. Press **Enter** or click.  (right side of the command toolbar).
5. Enter the second point in the Input Window toolbar.
6. Press **Enter** or click. 

Status Bar

The Status bar provides information about the state of your model.

System Modes in RecurDyn

There are four modes in which you can work in RecurDyn:

- **Model Edit Mode**
 - Work on the entire model. Let you create objects in your model at the top level in the model hierarchy.
 - You can work on every entity.
- **Subsystem Edit Mode**
 - Work on the all of the entities in a subsystem.
 - Let you create objects in your model that belong to a logical subsystem in your model. A subsystem can contain a group of entities that are created by using the process automation of a RecurDyn toolkit, such as a belt, chain, or track assembly.
- **Body Edit Mode**
 - Edit geometry of bodies.
 - Edit a particular entity in your model, such as ground, a link, or force.

By default, **RecurDyn** is in model-editing mode. You switch between the modes depending on the operations that you want to perform. In this tutorial, you'll switch to body-editing mode to edit the ground and then you will switch to the profile-editing mode as needed to create geometry.

Changing System Modes:

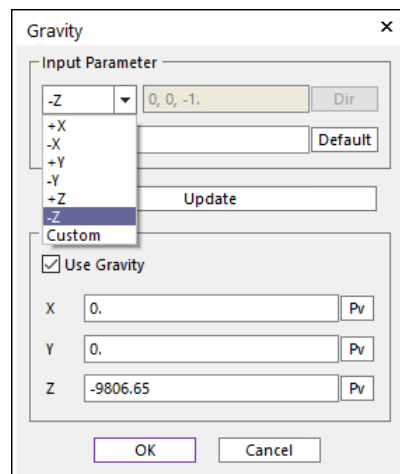
- In the **Database** window, right-click an entity, and from the menu that appears, click **Edit**.
- In the **Working window**, double-click a subsystem, body, or profile geometry.
- Click on one of the mode tools on the toolbar.

Changing the Gravitational Force Direction

In this tutorial, you will change the gravitational force of the $-Z$ directions.

To change the gravitational force direction:

1. From the **Setting** group in the **Home** tab, select **Gravity**.
2. Choice direction of the $-Z$ and click **Update** button.
3. Click **OK**.



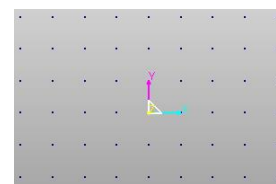
Changing the Working Plane

You will now use the Working Plane tool on the toolbar to change the current working plane into the XZ plane about the inertia reference frame.

To toggle Grid on working plane

If you turn on Grid, you can check the status of working plane

- Toggle **Grid On/Off** in **Render Toolbar**.
Grid will appear in Working Window.



To change the working plane:

1. In the **View Control Toolbar**, click the combo box next to the **Working Plane Change (Axis)**.
2. Select **Change to XZ**.

Working Plane and Inertia Reference Frame will be rotated **to XZ Plane** as shown below.



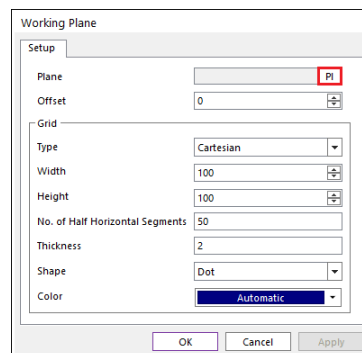
The **Working Plane Change (Axis)** function can only change the working plane about the **Inertia Reference Frame**. If you want to change the working plane about another plane, see the Tip below.



Tip: How to select the working plane

- From the **View Control Toolbar**, click the **Working Plane Setup**.

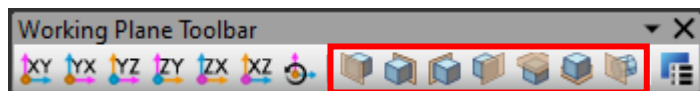
The **Working Plane Setup** dialog box appears. In this dialog, you can set the options about **Plane** and **Grid**.



- By clicking **PI** button, you can set the user-defined **Working Plane**. You can define it by using two method below.
 - Using user-defined **Marker Plane**: You can set the Working Plane to **XY, YZ, XZ** Plane of user-defined **General Marker**.
 - Using **Face** of user **Geometry**: You can set the Working Plane to **Face** of **CAD Geometry** in model.
- In the dialog, you can modify the status of grid (Type, Size, Color etc) shown in Working Window.

Tip: Rotating user-defined Working Plane.

- You can change the direction of user-defined working plane using **Working Plane Change** Function.

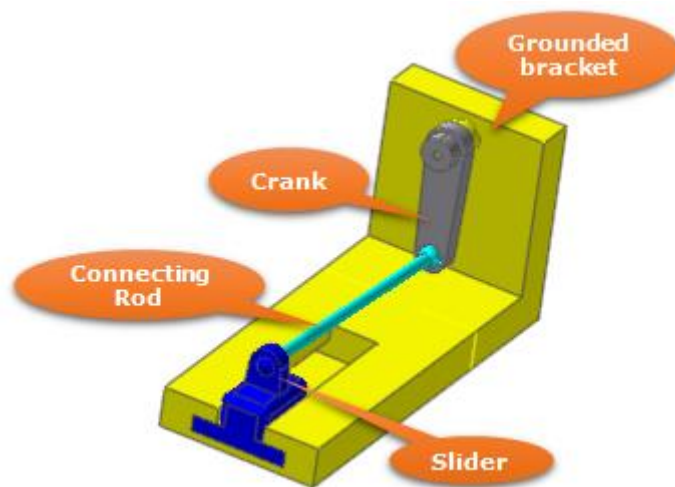


Creating Geometry

Task Objective

In this chapter, you will create geometry to define the 3D slider crank, which consists of:

- Grounded bracket
- Crank
- Connecting rod
- Slider bodies

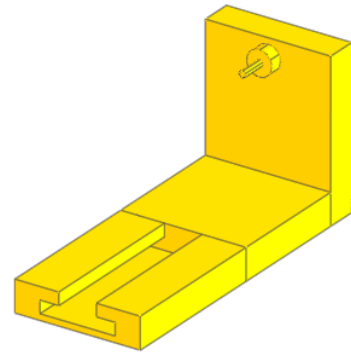


Estimated Time to Complete

35 minutes

Modeling the Grounded Bracket

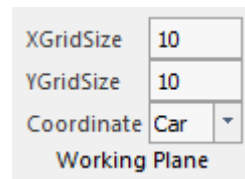
In this section, you create geometry to define the grounded bracket. You will create the bracket using two boxes, two cylinders, and two extrusions. This will also introduce you to the basics of using the toolkits to create geometry.



To change the Grid Size

- From the **Home** tab in the **Working Plane**, input **10** and press **Enter** key as shown at right

(Also, you can modify it in **Working Plane** dialog mentioned in chapter 2.)

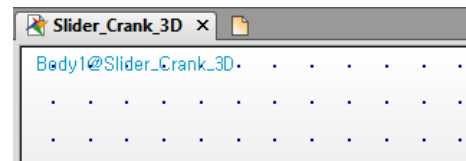


To change Body Edit Mode to create a bracket

- From **Professional** tab in the **Marker and Body** group, click **General** for entering body edit mode.

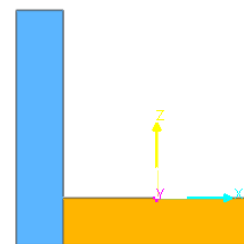
Body1@Slider_Crank_3D is marked on the top left of working window as shown at right.

It means that you entered the edit mode of **Body1** Entity in **Slider_Crank_3D** Model. All created geometries in this edit mode are considered as one rigid body **Body1**.



To create Box Geometry

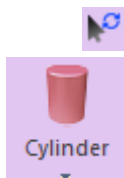
- From **Geometry** tab in the **Marker and Geometry** group, click **Box**.
- Set **Creation Method** to **Point, Point, Depth**.
- Create Boxes using following information. You can click on the Working Window or use Input Toolbar. (For detailed information, refer to Chapter 2.)
 - Point1:** 100, 0, -50
 - Point2:** -100, 0, 0
 - Depth:** 200
- Repeat **Steps 1-3** using following information.
 - Point1:** -150, 0, 200
 - Point2:** -100, 0, -50
 - Depth:** 200



Box geometries are created as shown at right.

To create the cylinder geometry:

Since you will create two cylinders at one time you will use the Auto Operation mode to automatically remain in the cylinder creation mode. The Auto Operation mode can be used with any input command and it can save a substantial amount of time when you are creating many entities of the same type.



1. Click on the **Auto Operation** tool to activate the **Auto Operation** input mode.
2. From the **Solid and Marker** group in the **Ground** tab, click **Cylinder**.
3. Set the **Creation Method** toolbar to **Point, Point, Radius**.
4. In the **Working window**, click these points and input a depth for both cylinders in the **Input Window toolbar**:

Cylinder 1:

- **Point1:** -100, 0, 170
- **Point2:** -80, 0, 170
- **Radius:** 20

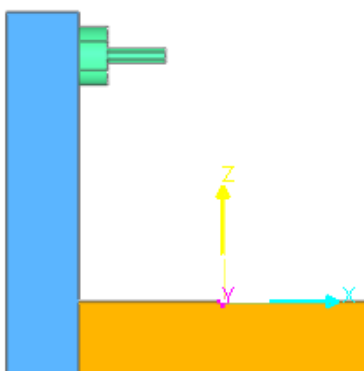
Cylinder 2:

- **Point1:** -80, 0, 170
- **Point2:** -40, 0, 170
- **Radius:** 5



5. Click on the **Auto Operation** tool again to exit the **Auto Operation** input mode. (Click on the **Escape** (Esc) key to exit the Cylinder input tool.)

The cylinders you created should look like the following:

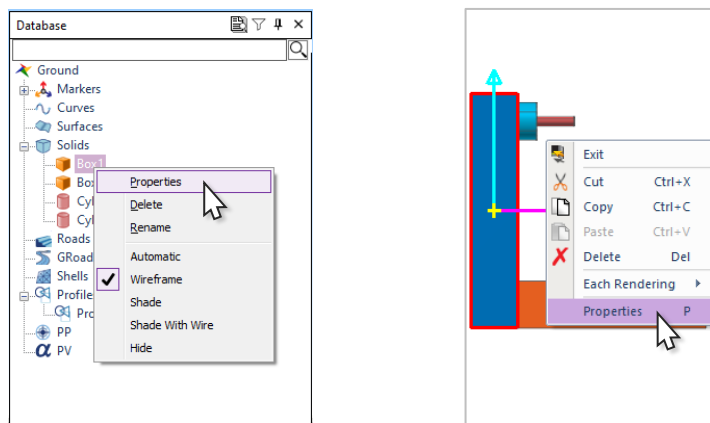


Tip: How to modify the geometry properties

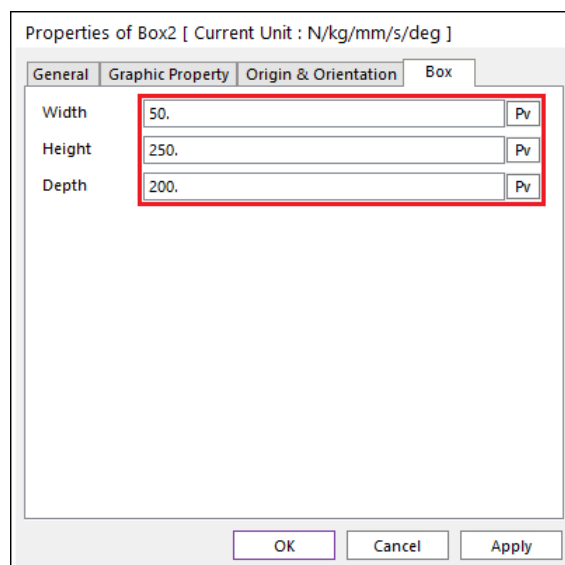
If you want to modify the parameters of geometry, you can modify them by using the Property dialog box.

- You can open Properties dialog by using one of three method below.
 - In **Database**, right-click the entity and click Properties.
 - Select the entity in **Working Window**, click Property in right-click menu.
 - In **Database** or **Working Window**, select entity and click 'P' key on the keyboard which is the shortcut for Property

The following shows the properties for a box and a cylinder.



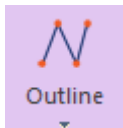
- Properties Dialog is shown which can modify parameters.
 - For example, you can edit Width, Height, Depth in Box tab in Properties of Box2.
 - Clicking **OK/Apply** will apply the modified value.



To create outline for extrusion



1. In **View Control Toolbar**, click **Combo Box** next to **Working Plane Change (Axis)** tool and select **Change to YZ**.



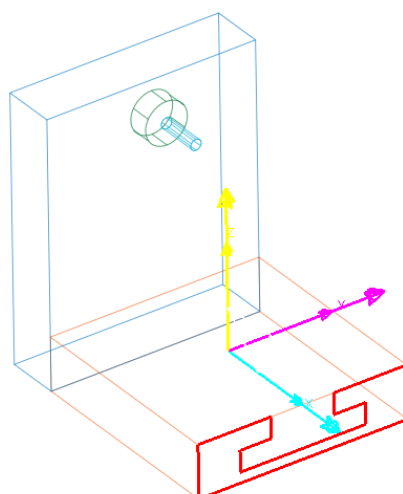
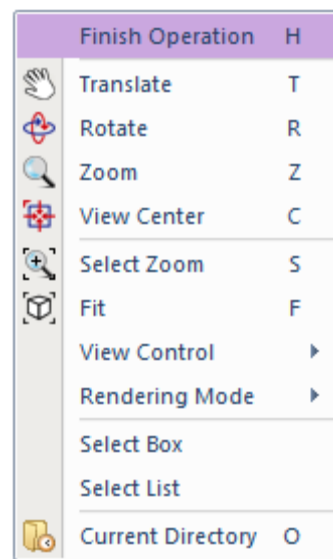
2. Click **Outline** from **Curve** group in the **Geometry** tab.
3. Input Point values using information below.

Point	X	Y,	Z
1	100	-100,	0
2	100	-100,	-50
3	100	100,	-50
4	100	100,	0
5	100	30,	0
6	100	30,	-20
7	100	60,	-20
8	100	60,	-40
9	100	-60,	-40
10	100	-60,	-20
11	100	-30,	-20
12	100	-30,	0
13	100	-100,	0

4. When you finished inputting all 13 point values, right-click on the working window and click **Finish Operation** in the pop-up menu.

Outline1 is created as shown below.

(If geometry of Outline1 is not as same as the picture below, open the properties dialog and modify the point values.)



To create Curve Sweep

1. Click **Fill** from **Curve** tab in the **Geometry** group.

2. Select **Outline1**.

FilledSurface1 is created.

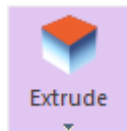
3. Click **Extrude** from **Geometry** tab in the **Solid** group

4. Set the **Creation Method** toolbar to **Surface, Direction, Distance**.

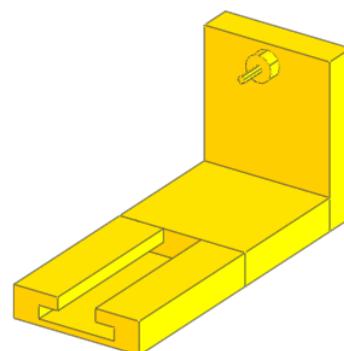
5. Create extrude using following information.

- **Surface:** FilledSurface1
- **Direction:** 1,0,0
- **Distance:** 250

Extrude1 is created.



Finished **Bracket** will look like a picture shown at right. Check if there is a problem by changing a model view.

**Tip: Changing Model View**

You can use **View Control Toolbar** to change the view.

- Translate or Rotate the model view by using methods below.



- Click **Translate** in the **View Control Toolbar** to translate the model view. (Shortcut for this operation is **'T' Key**)



- Click **Rotate** in the **View Control Toolbar** to rotate the model view. (Shortcut for this operation is **'R' Key**).

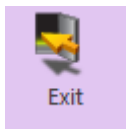
- Zoom the model view using methods below.



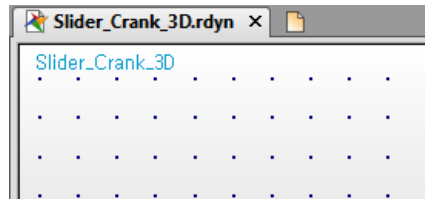
- Click **Select Zoom** in **View Control Toolbar**, drag the area you want to zoom. (Shortcut for this operation is **'S' Key**).
- Zoom the model view by turning **Mouse Wheel** button.

To exit body edit mode.

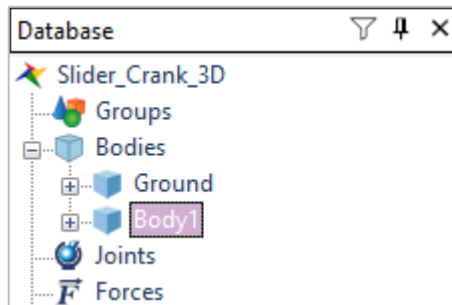
In Body Edit Mode, you have created all of geometries for Bracket. Now we change to Model edit mode by exiting Body Edit Mode.



- Click **Exit** from **Exit** group in the **Geometry** tab.
Upper-Left side of Working Window, you can see the title **Slider_Crank_3D**.

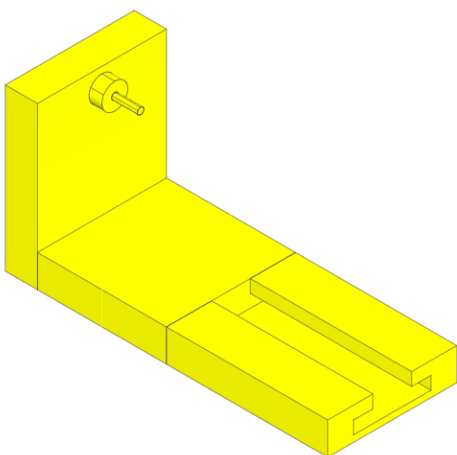
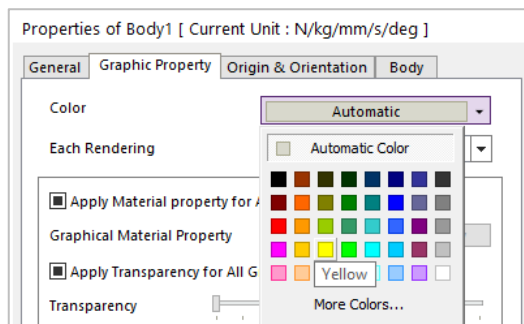
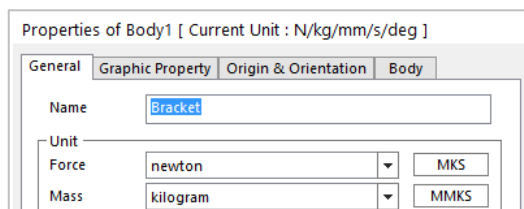


In **Database**, you can check that **Body1** is created which contains Bracket Geometry.



To change name and color of the Body.

- Open Property dialog of **Body1**.
- Click **General** Tab in Property dialog.
- Change **Name** to **Bracket**
- Click **Graphic Property** tab.
- Change **Color** to **Yellow**.
- Click **OK**.



Modeling the Crank Body

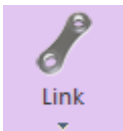
You will create Link, Ellipsoid and Cylinder geometry and do Boolean operation to create Crank Body.

To change the working plane.



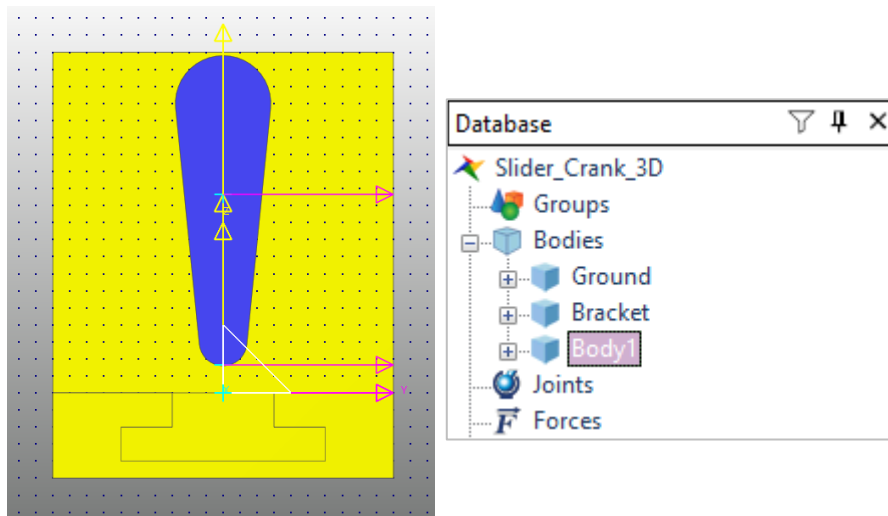
1. Select **Change to YZ** in **View Control Toolbar**.

To create the crank body:



1. From the **Body** group in the **Professional** tab, click **Link**.
2. Set **Creation Method** to **Point, Point, Depth**.
3. Click these points:
 - **Point1:** 0, 0, 30
 - **Point2:** 0, 0, 170
 - **Depth:** 20

Your **link** geometry should now look like the one shown below.



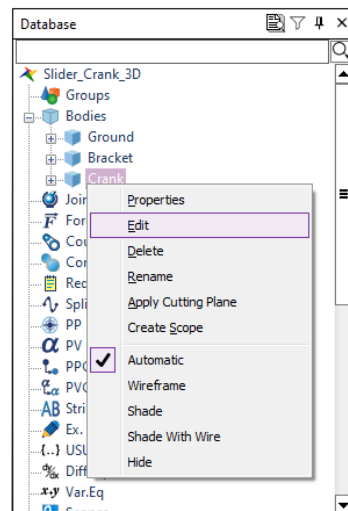
To change the name of the body:

1. Right-click the working window over the model **Body1**, then click **Properties**.
2. Click the **General** tab in Property dialog.
3. Change the body name from **Body1** to **Crank**.
4. Click **OK**.

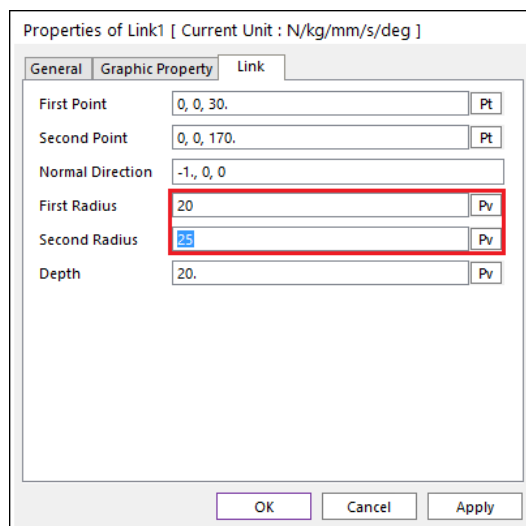
Modifying the Link Geometry

You will modify Property of Link geometry after entering Body Edit Mode of Crank.

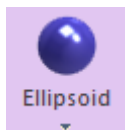
- In the **Database** window, right-click Crank and click **Edit**.
After entering edit mode of **Crank** body, the **Link** geometry is now the only geometry in the Working Window.



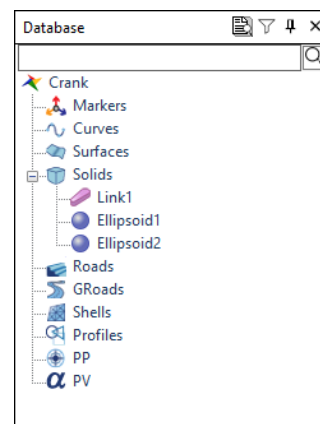
- Open the Property dialog of **Link1**, change the values as below.
 - First Radius:** 20
 - Second Radius:** 25



To create Ellipsoid geometry

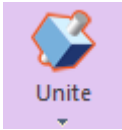


- Select **Ellipsoid** from **Marker and Geometry** group in the **Geometry** tab.
- Input values using information below.
 - Point:** 0,0,30
 - Distance:** 15
- Repeat **1-2** steps using information below.
 - Point:** 5,0,30
 - Distance:** 15



To do Boolean Unite.

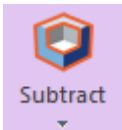
You will create Ellipsoid geometry and unite it with Link geometry by using Boolean Unite.



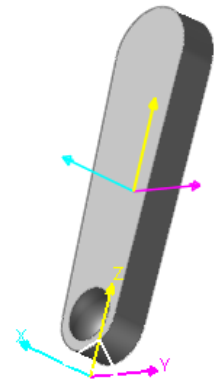
1. Click **Unite** from the **Boolean** group in the **Geometry** tab.
2. Select the **Link1** geometry and then the **Ellipsoid1** geometry.
Selected two geometries (**Link1** and **Ellipsoid1**) disappear and **Unite1** is created.

To do Boolean Subtract.

You will scoop out the part of Link geometry with Ellipsoid geometry using Boolean Subtract.

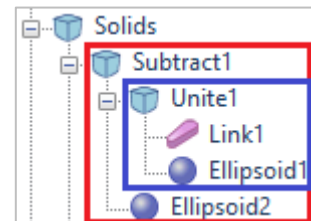


1. Click **Subtract** from **Boolean** group in the **Geometry** tab.
2. Select **Unite1** and then select **Ellipsoid2**.
Selected two Geometries (**Unite1** and **Ellipsoid2**) disappear and **Subtract1** is created.

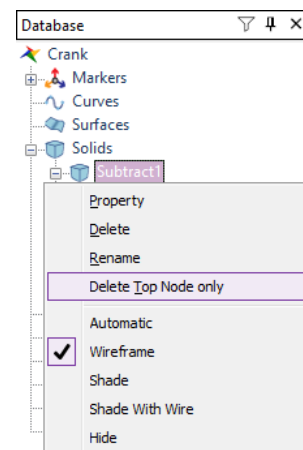


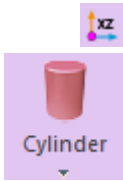
Tip: How to undo a Boolean Unite Operation

Entity created by Boolean operation has hierarchy in Database. Inside of hierarchy, there is history of Boolean operation.

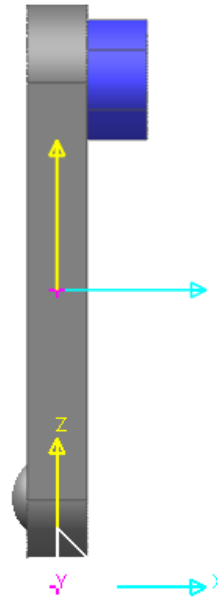
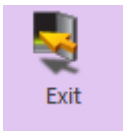


You can restore the united geometry to its previous state using the **Delete Top Node only** menu shown below. In this case, the top node would be the Unite1.



To create a cylinder:

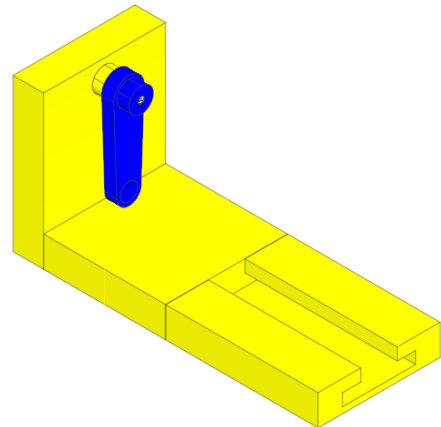
1. Select **Change to XZ** in **View Control Toolbar**.
2. Click **Cylinder** from **Marker and Geometry** group in the **Geometry** tab.
3. Set the **Creation Method** to **Point, Point, Radius**.
4. Input values using information below.
 - **Point1:** 10, 0, 170
 - **Point2:** 30, 0, 170
 - **Radius:** 20

**To exit the edit mode of crank body**

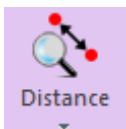
- Click **Exit** from the **Exit** group in the **Geometry** tab.

To change the color of crank body.

- Open the **Properties** dialog of **Crank** body and change **Color** to **Blue**.

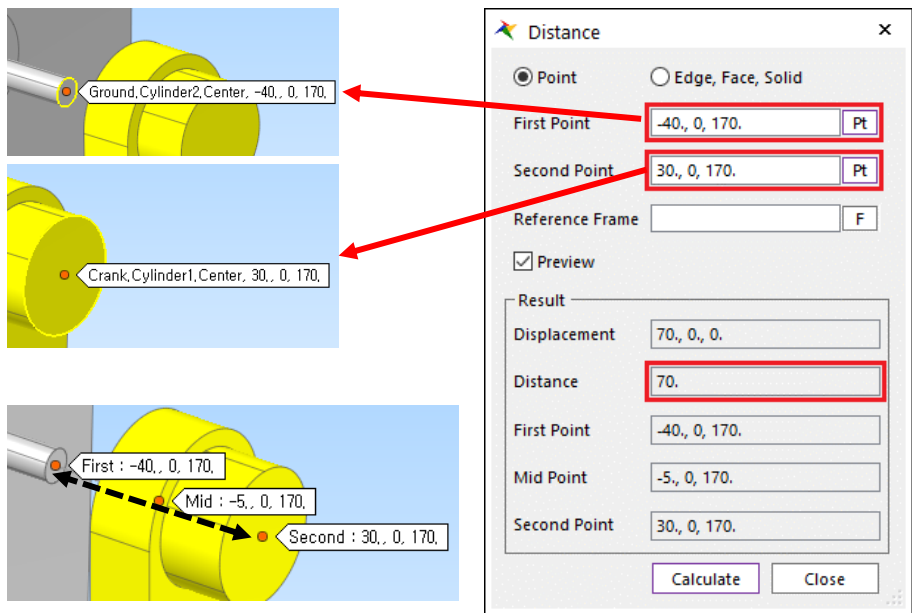
**To translate the crank body**

Crank is separated from Bracket. You will measure the distance between Crank and Bracket and translate Crank body according to the result.

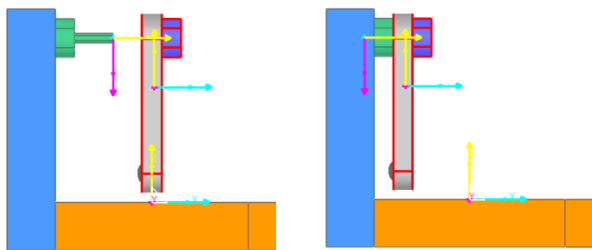
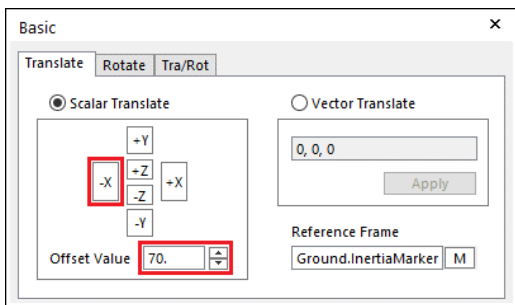


1. Click **Distance** from **Measure** group in the **Home** tab.
2. When Distance dialog appears, click **Pt** button located next to **First Point** and select as picture shown below.
3. Click **Pt** button located next to **Second Point** and select as picture shown below.
4. Click **Calculate**.

Result of **Distance Measure** is **70**.

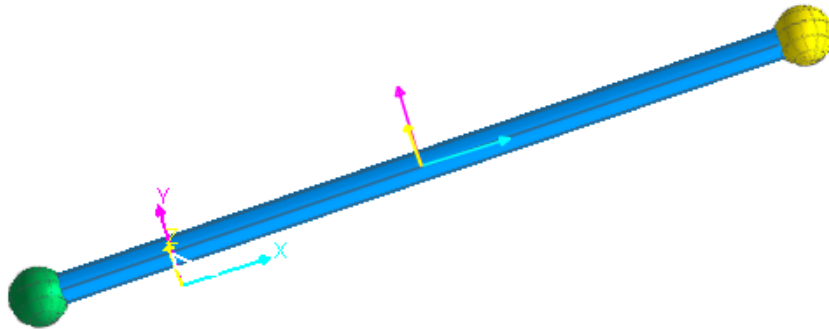


5. Click **Basic Object Control** in the **Advanced Toolbar**.
When the **Basic Object Control** dialog appears, change **Offset Value** to **70** in **Translate** tab.
6. Select **Crank** in the Working Window.
7. After **Crank** is selected, click **-X** button in the **Basic Object Control** dialog.
8. Close the **Basic Object Control** dialog.



Creating the Connecting Rod

Now you will create the connecting rod by creating a cylinder and two ellipsoids and then unite them with Boolean operations.



To create the cylinder:



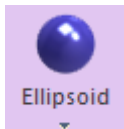
1. From the **Body** group in the **Professional** tab, click the **Cylinder**.
2. Set the **Creation Method** toolbar to **Point, Point, Radius**.
3. Create the cylinder body:
 - **Point1:** -60, 0, 30
 - **Point2:** 290, 0, 50
 - **Radius:** 7

To change name of the body

1. Open the **Property** dialog of **Body1**.
2. Click **General** tab in the Property dialog.
3. Change **Name** to **Connecting_Rod**.
4. Click **OK**.

To create Ellipsoid Geometry

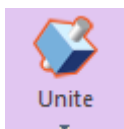
1. In **Database**, right-click **Connecting_Rod** and click Edit.
After entering edit mode of **Connecting_Rod** body, the **Cylinder** geometry is now the only geometry in the Working Window.



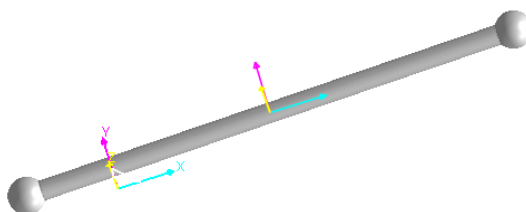
2. From the **Marker and Geometry** group in the **Geometry** tab, click **Ellipsoid**
3. To create the ellipsoid geometry, input values using information below.
 - **Point:** -60, 0, 30
 - **Distance:** 13
4. Repeat the steps from **2 to 3** by referring below values.
 - **Point:** 290, 0, 50
 - **Distance:** 13

To do Boolean Unite

After creating **Ellipsoid** geometry, you will unite **Cylinder** Geometry by using **Boolean Unite**. If you don't unite those geometries, RecurDyn will calculate the unnecessary mass of overlapped area.



1. Click **Unite** from the **Boolean** group in the **Geometry** tab.
2. Select **Cylinder1** and then select **Ellipsoid1**.
Selected two geometries (**Cylinder1** and **Ellipsoid1**) disappear and **Unite1** is created.
3. Click **Unite** again from the **Boolean** group in the **Geometry** tab.
4. Select **Unite1** and then select **Ellipsoid2**.
Unite2 is created as shown below.

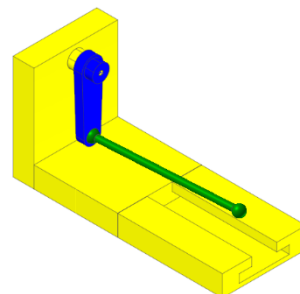


To exit body editing mode.

Click **Exit** button from the **Exit** group in the **Geometry** tab.

To change color of **Connecting_Rod**

- Open the Property dialog of **Connecting_Rod** Body and change **Color** to **Green**.



Modeling the Slider

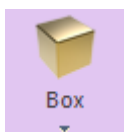
To model the Slider body, you will create a base box, an upper center box, and link geometry, and then subtract a sphere from the link to make a contacting point with the connecting rod.

To change working plane.



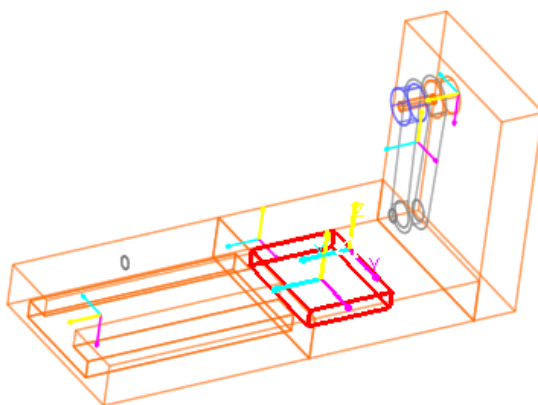
- Select **Change to YZ** in **View Control Toolbar**.

To create the box:



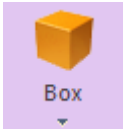
1. From the **Body** group in the **Professional** tab, click **Box**.
2. Set the **Creation Method** toolbar to **Point, Point, Depth**.
3. Create the box geometry:
 - **Point1:** 0, -60, -20
 - **Point2:** 0, 60, -40
 - **Depth:** 100

The box should appear as shown below. You may need to rotate the model to see the box (type **r** in the Working window) and you may need to set the rendering mode back to Wireframe with Silhouettes if you changed it earlier to Shade (from the **View Control Toolbar**, point to **Rendering Mode**, and click **Wireframe with Silhouettes**).

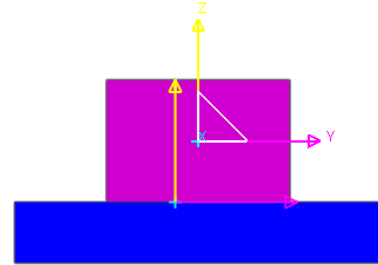
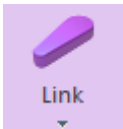


To change the body name.

1. Open the **Property Page** of **Body1**
2. Click **General** tab in the Property dialog.
3. Change Name to **Slider**.
4. Click **OK**.

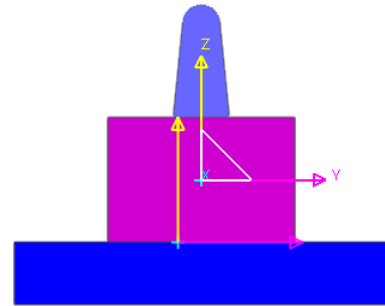
To add a box to the Slider body:

1. Enter the **Body-Editing Mode** of **Slider**.
2. In the **Marker and Geometry** group in the Geometry tab, click the **Box**.
3. Set the **Creation Method** toolbar to **Point, Point, Depth**.
4. Create **box** geometry:
 - **Point1:** 0, -30, 20
 - **Point2:** 0, 30, -20
 - **Depth:** 100

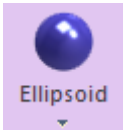
**To add link geometry to the Slider body:**

1. From the **Marker and Geometry** group in the Geometry tab, click the **Link**.
2. Set the **Creation Method** toolbar to **Point, Point, Depth**.
3. Create the **link** geometry:
 - **Point1:** 0, 0, 50
 - **Point2:** 0, 0, -10
 - **Depth:** 20

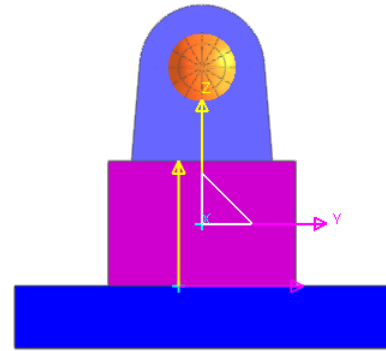
The link should appear as shown next.



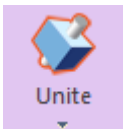
4. Modify the link geometry (**Tip:** In the Database window, right-click Link1, point to Property, and then click the Link tab):
 - **First Radius:** 20
 - **Second Radius:** 25

To create ellipsoid geometry:

1. From the **Marker and Geometry** group in the Geometry tab, click the **Ellipsoid**.
2. Create an **ellipsoid** geometry:
 - **Point:** 0, 0, 50
 - **Distance:** 15
3. Repeat 1-2 step using information below.
 - **Point:** -5, 0, 50
 - **Distance:** 15

**To do Unite Boolean.**

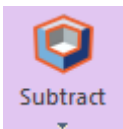
After creating **Ellipsoid** geometry, you will unite it with **Link** geometry by using Boolean **Unite**.



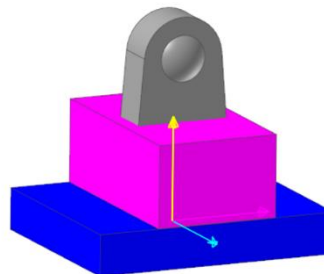
1. Click **Unite** from the **Boolean** group in the **Geometry** tab.
2. Select **Link1** and then select **Ellipsoid1**.
Selected two geometries (**Link1** and **Ellipsoid1**) disappear and **Unite1** is created.

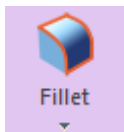
To do Subtract Boolean.

You will scoop out **Ellipsoid** geometry from united geometry by using **Boolean Subtract**.

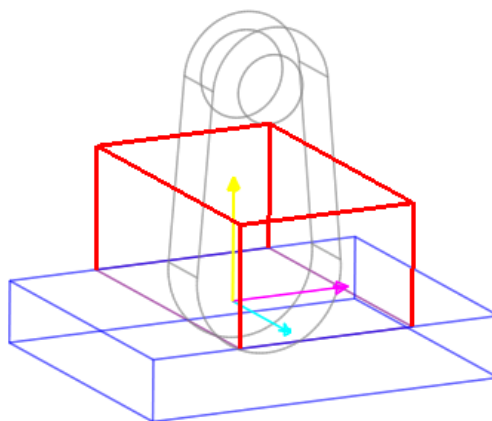
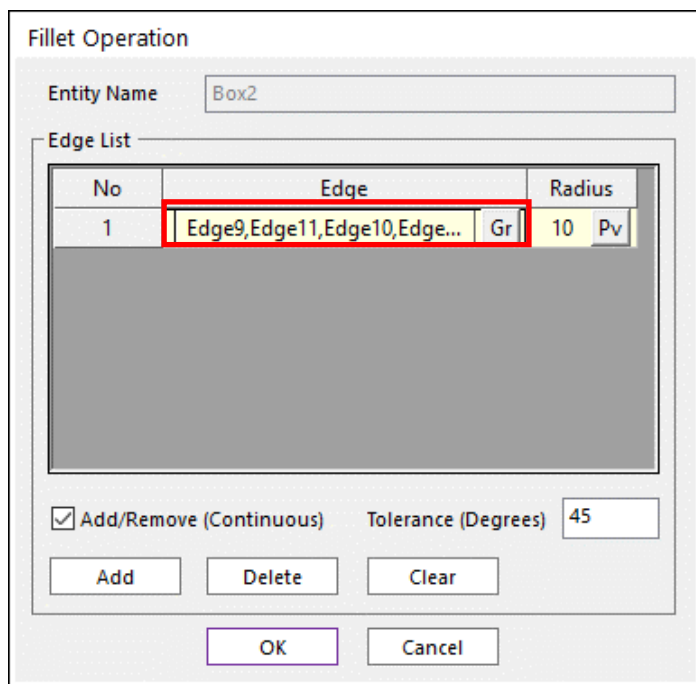


1. Click **Subtract** from the **Boolean** group in the **Geometry** tab.
2. Select **Unite1** and then select **Ellipsoid2**.
Selected two geometries (**Unite1** and **Ellipsoid2**) disappear and **Subtract1** is created.



To fillet the edges of the upper box geometry:

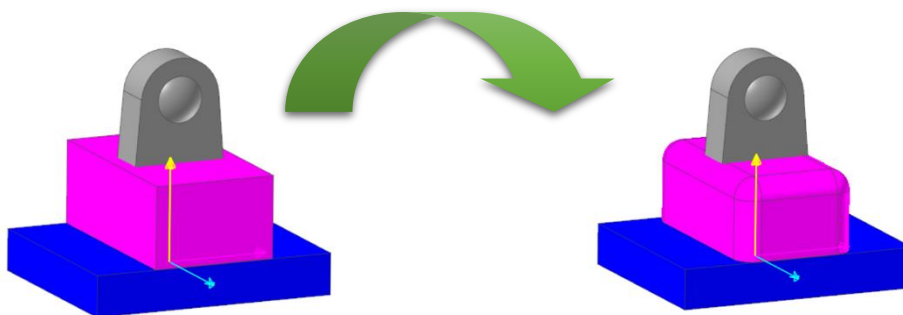
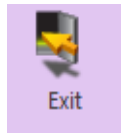
1. From the **Local** group in the **Geometry** tab, click the **Fillet**.
2. Select the upper **Box**. The **Fillet Operation** dialog box appears.
3. Click the **Add** button and select the 8 edges of the Box except for the bottom edges of the Box as shown in the picture below. (MultiEdge is the Select Option, so you can select multiple edges at once.)
4. After selecting all 8 edges, right-click on the working window and click **Finish Operation** in the pop-up menu.
5. The edges from faces you select appear in the **Fillet Operation** dialog box, as shown below.



6. Change the **radius** for each edge to **10**, as shown in the Fillet Operation dialog box above.
7. Click **OK**.

The geometry changes as shown below.

(**Tip:** Undoing **Local** operation is same as **Boolean** Operation.)



To do Unite Boolean

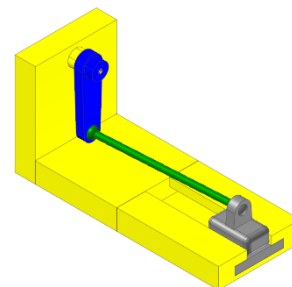
- Unite every geometry you worked on with **Unite**.

To exit the edit mode of slider body.

- Click **Exit** button from the **Exit** group in the **Geometry** tab.

To change color of slider body

Open the Property dialog of **Slider** body and change **Color** to **Grey**.



To change Working Plane



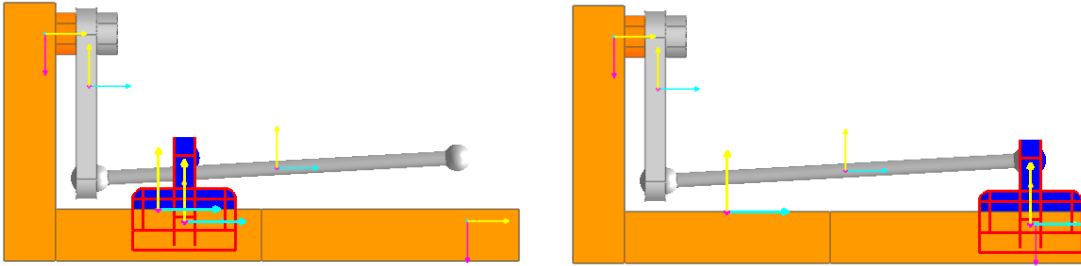
1. Select **Change to XZ** in **View Control Toolbar**.

To translate the slider body.



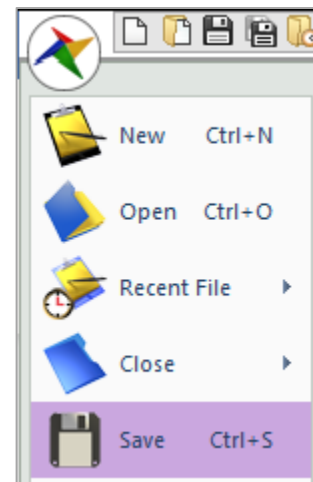
1. Click **Basic Object Control** in the **Advanced Toolbar**.
When the **Basic Object Control** dialog appears, change **Offset Value** to **300** in **Translate** tab.
2. Select **Slider** in the Working Window.
3. After **Slider** is selected, click **+X** button in the **Basic Object Control** dialog.
Slider is translated by 300mm along +X direction.

4. Close the **Basic Object Control** dialog.



Saving Your Model

1. From the **File** menu, click **Save**.
2. Decide saving location and save file name.
3. Click **OK** to save.



Chapter

4

Creating Joints

Task Objective

In this chapter, you will create several joints. You will create a:

- Revolute joint between the Grounded Bracket and the Crank
- Spherical joint between the Crank and the Connecting Rod
- Spherical joint between the Connecting Rod and the Slider
- Translational joint between the Slider and the Grounded Bracket

You will also define the input motion of the crank.



Estimated Time to Complete

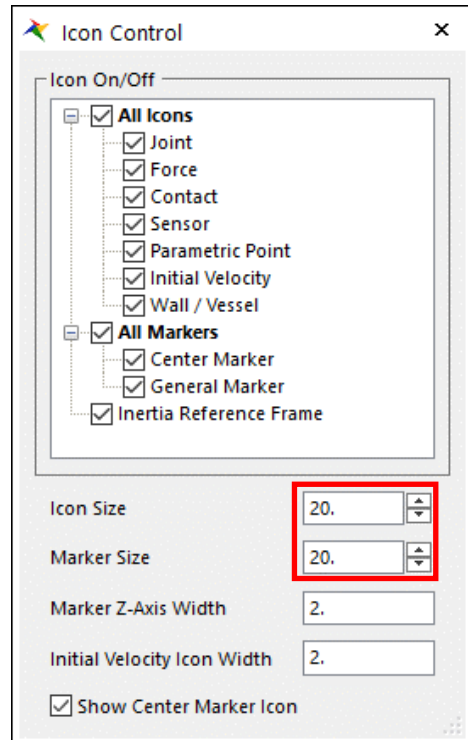
10 minutes

Adjusting the Icon and Marker Size

You are now going to change the icon and marker size to 20 pixels so you can view the model better.

To change the icon and marker size:

1. From the **Render Toolbar**, click **Icon Control**. The Icon Control dialog box appears.
2. Set **Icon Size** and **Marker Size** to **20**.
3. Close the **Icon Control** dialog box (use the **x** in the upper right corner).



Creating Joints between the Bodies

To create fixed joint

You will fix **Bracket** to **Ground** to keep Bracket from moving

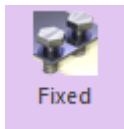
Tip: How to use Snap To Geometry in Select Toolbar.

While creating a Joint, it is sometimes hard to find desired point with mouse navigation in working window. In this case, **Snap To Geometry** function will help you find the desired points.



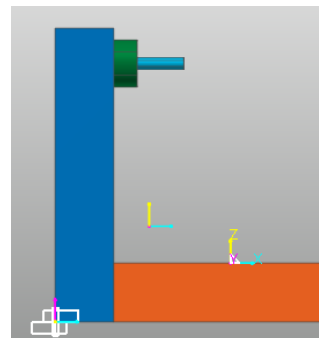
- **Snap To Grid:** Find grid point
- **Snap To Geometry:** Find geometric point like Vertex, Center of Circle, etc.
- **Snap To Node:** Find node point of FE Body.

1. Disable **Snap To Geometry** in **Select Toolbar**.
2. Click **Fixed** from the **Joint** group in the **Professional** Tab.
3. Select creation method to **Body, Body, Point**.
4. Click entities and point using below information.



- **Body:** Ground
- **Body:** Bracket
- **Point:** -150, 0, -50

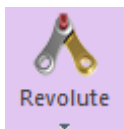
Fixed1 is created as shown at right.



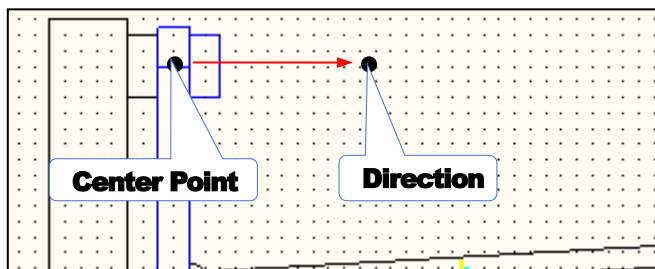
To create the revolute joint:

In this section, you'll create the revolute joint between the grounded bracket and the crank.

1. From the **Joint** group in the **Professional** tab, click the **Revolute**.
2. Set the creation method to **Body, Body, Point, Direction**.
3. Click two bodies and two points using information below. (**Point** is center of rotation of Revolute Joint and **Direction** is direction of rotation axis)



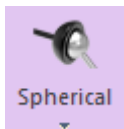
- **Body:** Bracket
- **Body:** Crank
- **Point:** -70, 0, 170
- **Direction:** 1, 0, 0



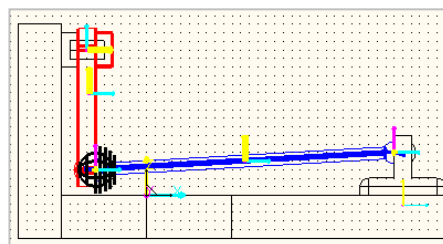
To create spherical joints

Now you will create the two spherical joints that connect between the crank and the connecting rod and between the connecting rod and the slider

1. From the **Joint** group in the **Professional** tab, click **Spherical**.
2. Set the Creation Method toolbar to **Body, Body, Point**.
3. Click two bodies and one point.



- **Body:** Crank
- **Body:** Connecting_Rod
- **Point:** -60, 0, 30

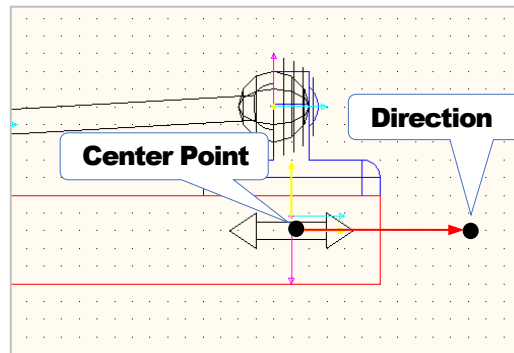


To create the translational joint:

Now you will create the translational joint between the slider and the grounded bracket.



1. From the **Joint** group in the **Professional** tab, click **Translate**.
2. Set the Creation Method toolbar to **Body, Body, Point, Direction**.
3. Click two bodies and two points in the Working Window. (**Point** will be center of translation and **Direction** will be axis of translation)
 - **Body:** Bracket
 - **Body:** Slider
 - **Point1:** 300, 0, -20
 - **Direction:** 1, 0, 0

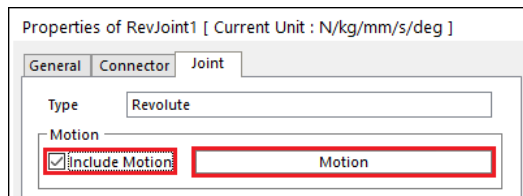


Creating a Motion on the Revolute Joint

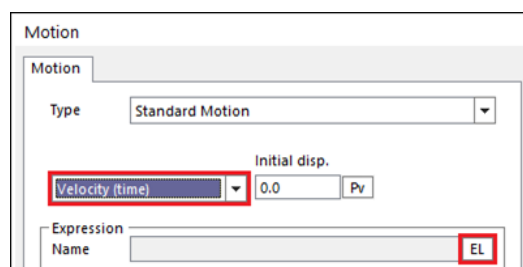
Now you will define a motion on the revolute joint you just created.

To define a motion:

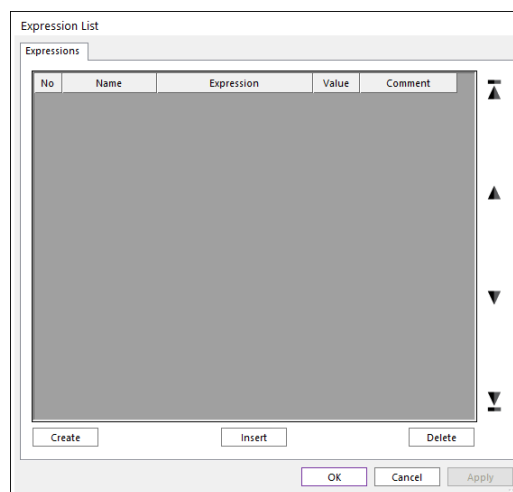
1. Display the property dialog box of **RevJoint1**.
Click the **Joint** tab and check the **Include Motion** box.



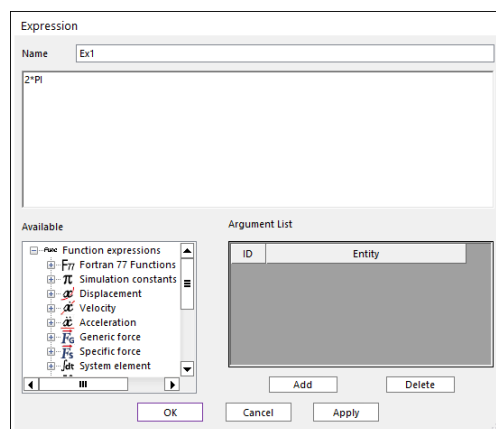
2. Click **Motion**.
3. The Motion dialog box appears. Pull down on the second pull-down menu and set the motion type to **Velocity (time)**.



4. Click **EL** in the **Motion** dialog.
5. When the Expression List dialog box appears. Click **Create**.

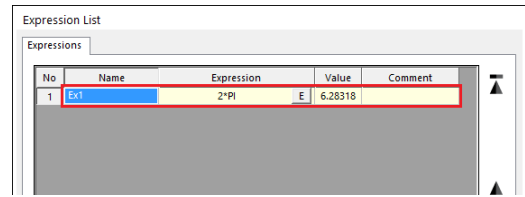


6. When the Expression dialog box appears. Input expression below.
 - **2*PI**

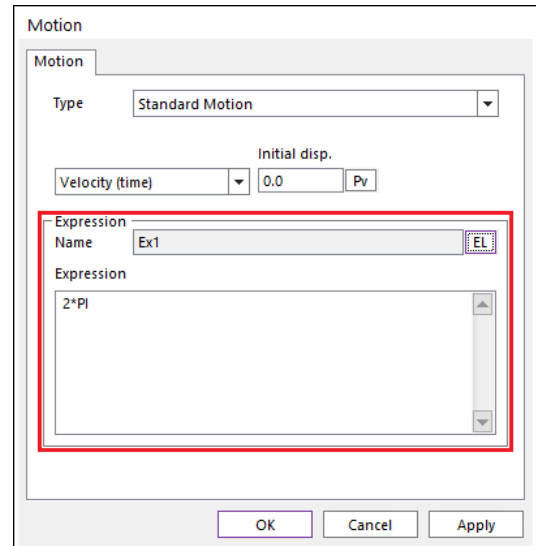


7. Click **OK** in **Expression** dialog.

8. When the **Expression List** dialog box reappears, click **Ex1** once to and **OK**.



9. In the **Motion** dialog box, check if Expression is displayed and click **OK**.



10. In the Joint dialog box, click **OK**.



Performing Analysis

Task Objective

In this chapter, you'll run a simulation of the model you just created.



Estimated Time to Complete

5 minutes

Performing Dynamic/Kinematic Analysis

In this section, you will run a dynamic/kinematic analysis to view the effect of forces and motion on the model you just created.

To perform a dynamic/kinematic analysis:

1. From the **Simulate Type** group in the **Analysis** tab, click **Dyn/Kin**. The **Dynamic/Kinematic** dialog box appears.



2. Define the end time of the simulation and the number of steps:
 - **End Time:** 1
 - **Step:** 200
 - **Plot Multiplier Step Factor:** 5

3. Click **Simulate**.

RecurDyn calculates the motions and forces acting on the slider crank.

Tip: Meaning of Options in Simulate dialog box

Here is a quick list of the most commonly used options in the Dynamic/Kinematic dialog box:

- **End Time:** Defines the length of the Simulation Time.
- **Step:** Defines the number of animation frames to store throughout the simulation time.
- **Plot Multiplier Step Factor:** Defines the number of data points that are saved for plotting. The number of the plot data points that are stored is defined as:
- **Step * Plot Multiplier Step Factor**

Chapter**6**

Working with Animations

Task Objective

In this chapter, you will learn how to animate the motion of the model and how to create an AVI file of the animation for use in presentations. You will also learn how to trace the paths of points on the moving bodies.

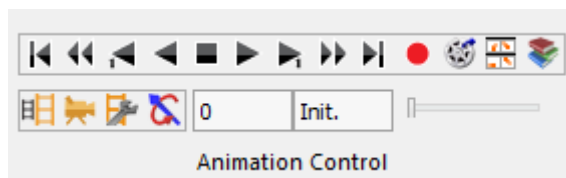



















Estimated Time to Complete

10 minutes

About the Animation Toolbar

You can animate your model after simulating. When you work with animations after loading the model in RecurDyn/Plot you can play the animations as you display the plots to more completely analyze the data. The animation toolbar from **Animation Control** group in the **Analysis** tab is shown below. Each of its tools are explained in the table below.



The tool	Does the following:
	Go to the first frame.
	Fast Reverse Play/Pause
	Go back one frame
	Reverse Play/Pause
	Stop
	Play/Pause
	Go forward one frame
	Fast Play/Pause
	Go to last frame.
	Record (must be stopped)
	Reload the last animation file
	Multi Animation
	Scenario output control
	Animation Scaling
	Select camera
	Animation control configuration
	Force display setting

Playing Animations

- ▶ From the **Animation Control** group in the **Analysis** tab, click **Play**.

Saving the Animation Data as an AVI File

Now you will save the animation you just viewed as an AVI file so you could post it to the Web or play it in a PowerPoint presentation.

To save an animation as an AVI file:

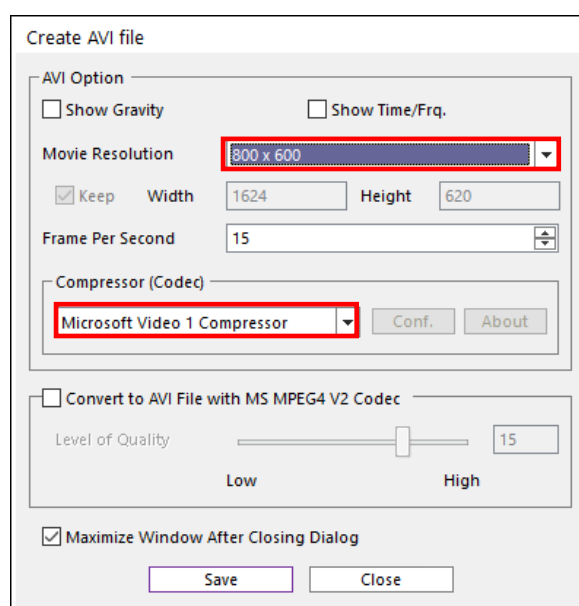
1. From the **Animation Control** group in the **Analysis** tab, click the **Record**.

The Create AVI file dialog box appears.

2. Define the size of the image in the AVI file by clicking on the combo box for the **Movie Resolution** field and selecting **800 x 600**.

3. Click on the combo box in **Compressor (Codec)** and select **Microsoft Video 1**.

You can pick the compression scheme that will be used to keep your AVI file at a reasonable size. The image quality, AVI file size and playback speed can entirely depend upon the compression scheme that you select. If you move the AVI file to another computer, that computer must support the selected compression scheme, or the user will not be able to play back the AVI file.



4. Click **Save**. The Save As dialog box appears.
5. Enter the file name and location for the AVI file.
6. Click **Save**.

Tracing the Paths of Points on the Moving Bodies

In the animation you saw that the motion of the crank, connection rod and slider bodies seem to move simply but it is not simple. Now you will trace out the path of a point on each body to better understand its motion. The point on each body will be defined by a marker. A marker is a coordinate system. It has an origin and an orientation. You will use some existing markers to trace some paths.

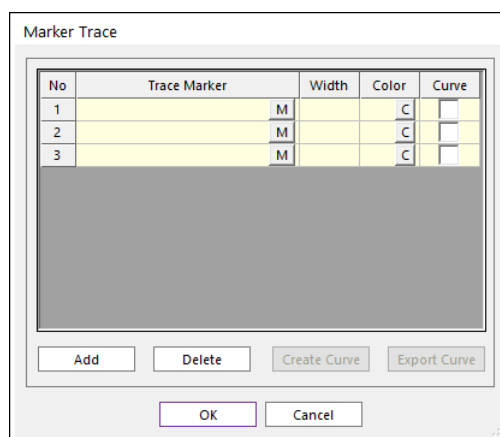
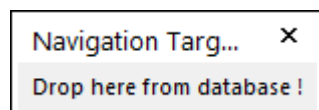
To trace the path of a point:



1. From the **Post Tool** group in the **Analysis** tab, click **Marker Trace**.

The Marker Trace dialog box appears.

2. Click the **Add** button three times to create three lines in the dialog box.
3. Each line will have a marker button. Click on the **Marker** button for the first line. The Navigation Target window will appear in the upper right of the Working window.



4. Expand the **Crank**, **Connecting Rod**, and **Slider Body** names in the Database window. Expand the **Markers** headings for the **Crank**, **Connecting_Rod**, and **Slider Bodies**. The Database Window should appear as shown on the right.
5. Select the **Marker2** name under the Crank body and drag it to the Navigation Target Window.

You should see the name Crank.Marker2 appears in the first row of the Trace Marker column.

6. Click on the **Marker** button for the second line.

7. Select the **CM** name under the Connecting_Rod body and drag it to the Navigation Target Window.

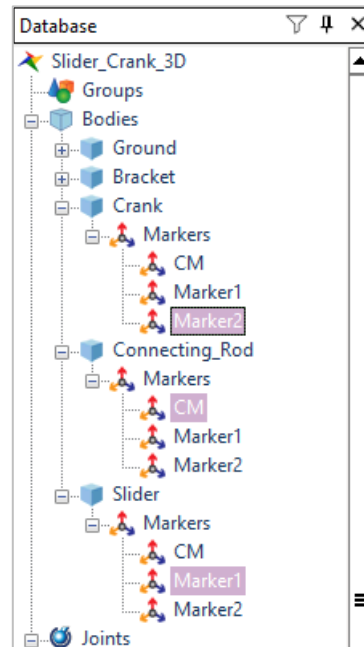
You should see the name Connecting_Rod.CM appears in the second row of the Trace Marker column.

8. Click on the **Marker** button for the third line.

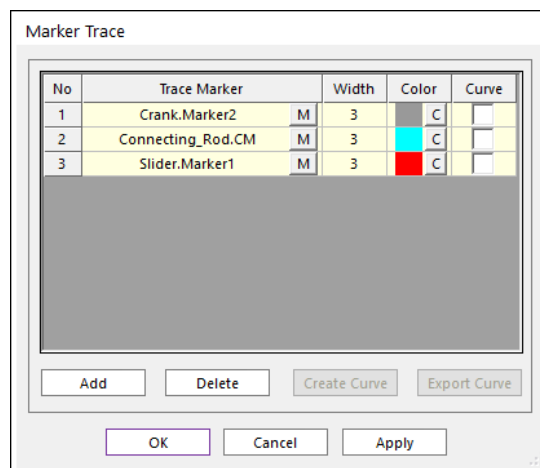
9. Select the **Marker1** name under the Slider body and drag it to the Navigation Target Window.

You should see the name Slider.Marker1 appears in the third row of the Trace Marker column.

10. Set the **Width** in all three rows to 3.

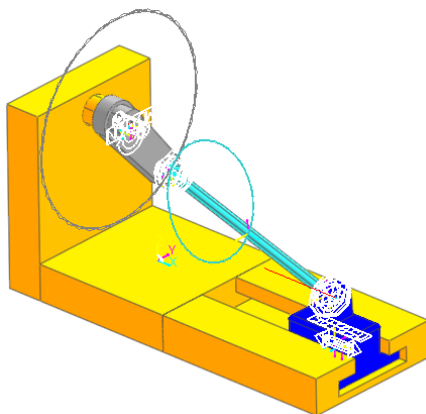


11. Set the Color in the first row to light **Gray** by clicking on the **C button** and selecting the color in the second row and the second column of the palette.
12. Set the Color in the second row to cyan by clicking on the **C button** and selecting the **Turquoise** cell.
13. Set the Color in the third row to red by clicking on the **C button** and selecting the **Red** cell.



The **Marker Trace** dialog box should appear as in the figure.

14. Click **OK** to close the Marker Trace dialog box.
15. Play the animation again by clicking on the play button.
You should see the three traces as shown in the figure.



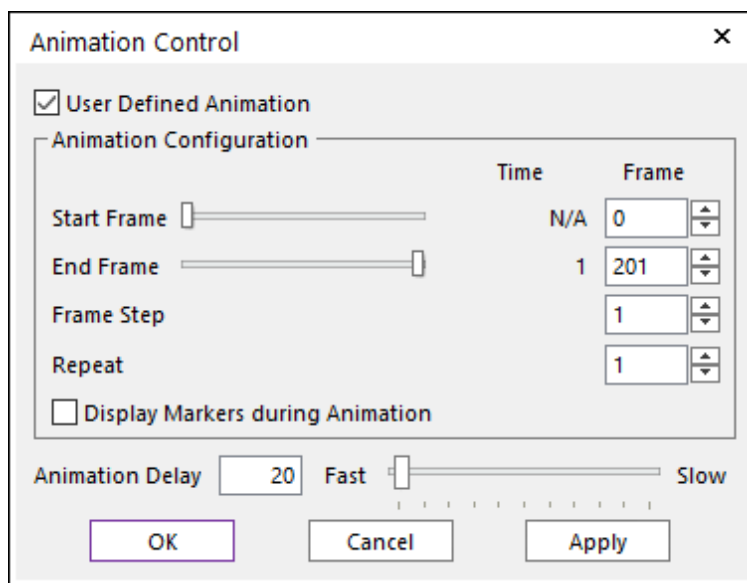
The traces suggest the type of motion that each body is experiencing.

- The trace of the slider is the red line, suggesting motion in a single degree of freedom.
- The trace of the crank is a circle, suggesting a rotational motion with translations in two directions.
- The trace of the connecting rod is a slanted circle, suggesting that the connecting rod is undergoing both a rotational motion and a translational motion. The CM marker in the Connecting Rod is translating in all three degrees of freedom.

Tip How to use the Animation control configuration

There are several configuration settings for animations that you can set when you select the Animation Configuration tool From the Animation Control in the Analysis tab.

- **Start Frame** and **End Frame**: Defines the start frame and the end frame of an animation.
- **Frame Step**: Increment frame of an animation.
- **Repeat**: Defines the number of times to replay the animation.
- **Display Markers during Animation**: If you check this option, you can see the markers during an animation.



Chapter**7**

Plotting

Task Objective

In this chapter, you will plot the analysis data that RecurDyn calculated in the dynamic/kinematic simulation you ran in the previous chapter. You will plot the motion of the slider body, using RecurDyn/Plot, a powerful post-processing tool, which is built into RecurDyn. It lets you plot and animate the results of simulations.



Estimated Time to Complete

5 minutes

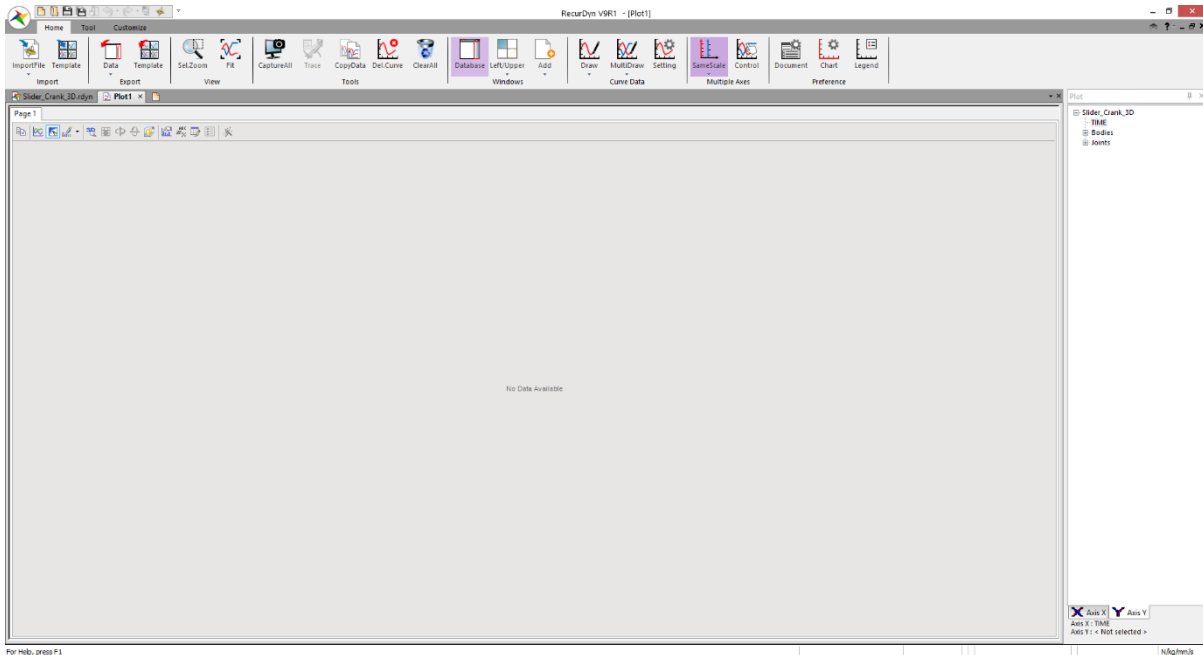
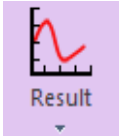
Creating a Plot

In this section, you'll start RecurDyn/Plot and view a plot of the motion of the slider.

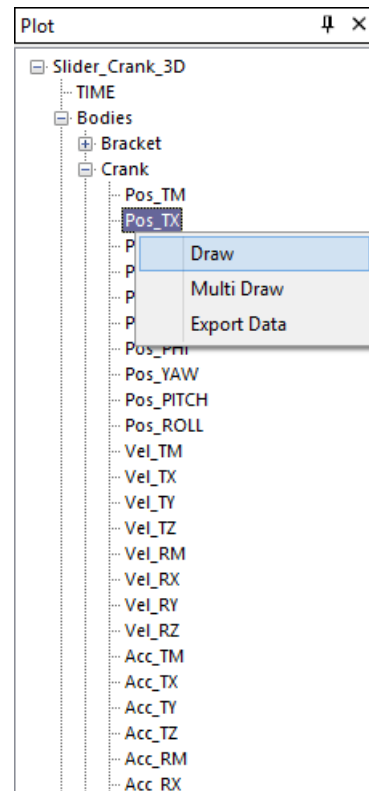
To start RecurDyn/Plot and plot the motion of the slider body:

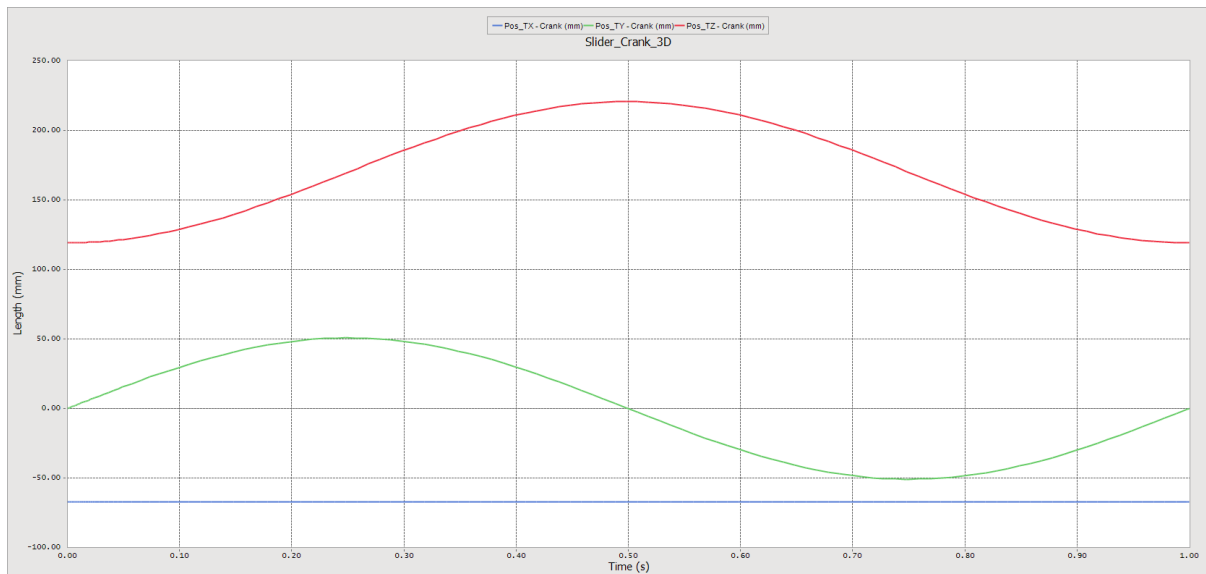
1. From the **Plot** group in the **Analysis** tab, click the **Result**.

The Plotting window appears with all the tools and data you need.



2. In the Database window, expand the **Bodies** heading, expand the **Crank** heading
 3. Right-click on **Pos_TX**. **Pos_TX** is an abbreviation for "Position in Translation along the X direction."
 4. Select **Draw** from the pop-up menu that appears.
 5. Now double-click on **Pos_TY** and **Pos_TZ**. You can see that double-clicking has the same effect as Steps 3 and 4.
- The plot should appear as in the figure.





Note that the plot gives us the same feedback as the Trace Curve for the Crank body (presented in the previous chapter), which is that the motion of the Crank included translations in two directions. There is no translation in the Z direction.

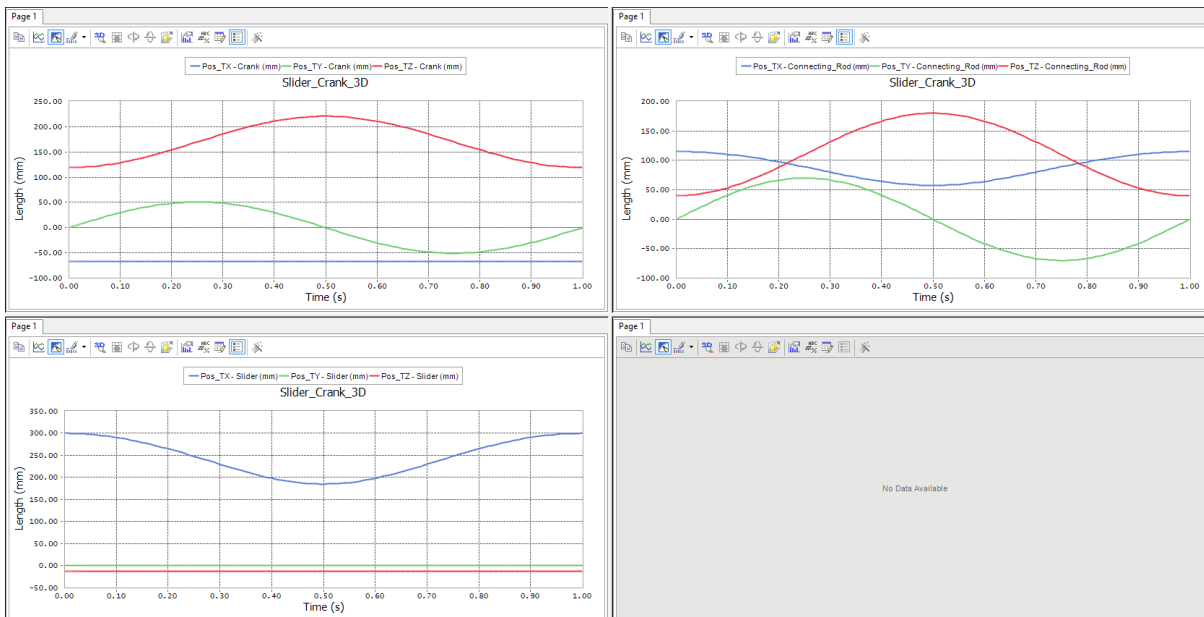
Plotting in Multiple Panes

In this section, you'll learn how to use multiple panes in the Plotting Window to understand your model behavior more completely.

To switch the Plotting Window to display multiple panes:



1. From the **Windows** group in the **Home** tab, click **Show All Windows**. You should now see four plotting areas within the Plot Window.
2. Set the upper-right pane to be the active pane by clicking on any point within it.
3. In the Database window, expand the **Connecting_Rod** heading under the Bodies heading
4. Double-click on **Pos_TX**, then **Pos_TY**, then **Pos_TZ** as you did with the previous plot.
5. Set the lower-left pane to be the active pane by clicking on any point within it.
6. In the Database window, expand the **Slider** heading under the Bodies heading



7. Double-click on **Pos_TX**, then **Pos_TY**, then **Pos_TZ** as you did with the previous plot.

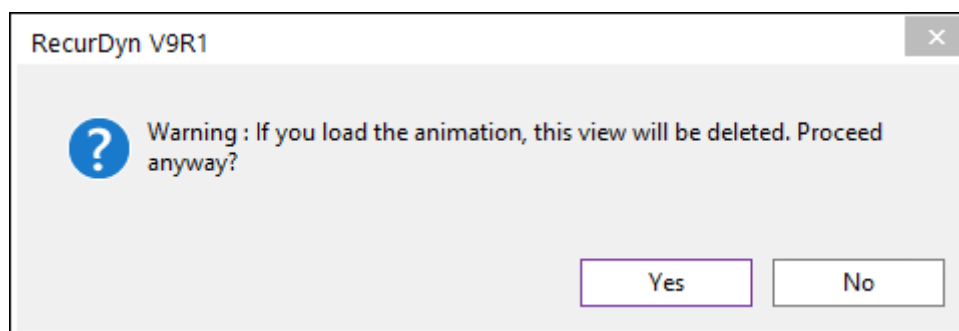
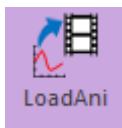
The plot should appear as in the figure. The curves in the plot for the slider body show us that the body is moving in one translational degree of freedom. The curves in the plot for the connecting rod body show us that the body is moving in all three translational degree of freedom.

Loading an Animation

In this section, you'll load an animation into one of the pane in the Plotting Window in order to display a coordinated view of output values and the motion of the mechanical system. Note that an AVI file of the combined plots and animation can be created by following the same steps that were outlined in the previous chapter.

To load an animation in a pane of the Plotting Window:

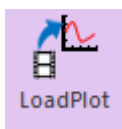
1. Set the lower-right pane to be the active pane by clicking on any point within it.
2. From the **Animation** group in the **Tool** tab, click **Load Animation**. The following alert box appears:



3. Click **Yes** and the animation will be loaded in the lower-right pane.
4. Change to the **XZ** plane.
5. Type **f** to fit the model within the pane.
6. Type **r** and drag the cursor in the pane to rotate the model into a better viewing position. Repeat the fit command as needed.

The Plotting Window should appear to be similar to the figure shown on the cover of this tutorial.

7. Play the animation by clicking the **Play** button.



Tip: If you want to restore Animation section to Plot section, use **Load Plot** from the **Animation** group in the **Tool** tab

Thanks for participating in this tutorial