ME 24-688 – Week 4

Project 1 – Assemblies and Constraints

1 Introduction to Assembly Design

The following section will give an overview of bring individual components into a common environment and use various tools to assemble them.

1.1 Definition of an Assembly Model

You create an assembly by combining multiple components and/or assemblies into a single environment. Parametric relationships are created between each component that determines component behavior in the assembly.

These relationships can range from simple constraint-based relationships that determine a component's position in the assembly, to advanced relationships such as adaptivity. Adaptivity enables a component to change size based upon its relationship to other components in the assembly.

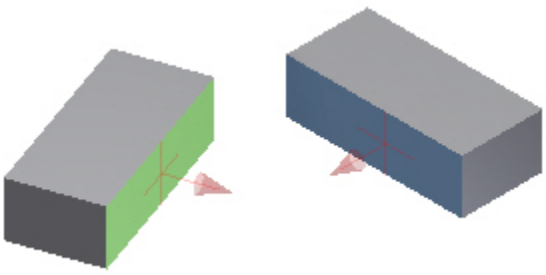
1.2 Assembly Constraints

You use assembly constraints to create parametric relationships between parts in the assembly. Just as you use 2D constraints to control 2D geometry, you use 3D constraints in an assembly to position parts in relation to other parts. There are four basic assembly constraints, each with unique solutions and options.

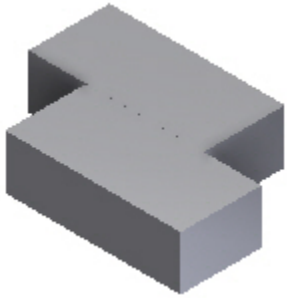
Mate/Flush Constraint

The Mate/Flush constraint is used to align part features such as faces, edges, or axis.

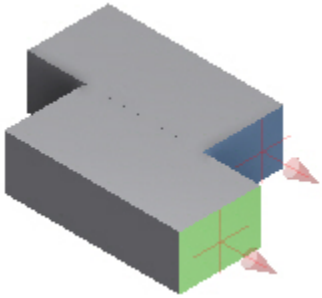
- Before Mate Constraint



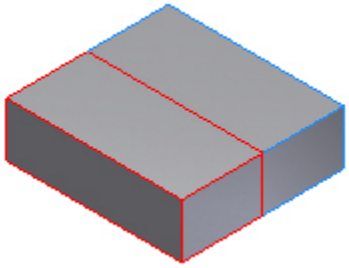
- After Mate Constraint



- Before Flush Constraint



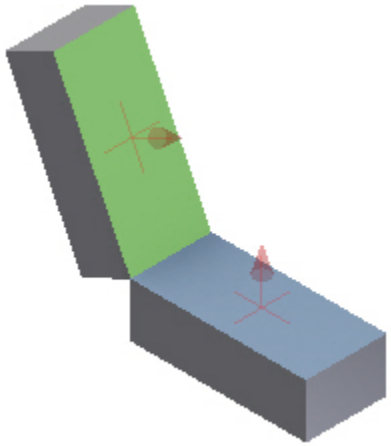
- After Flush Constraint



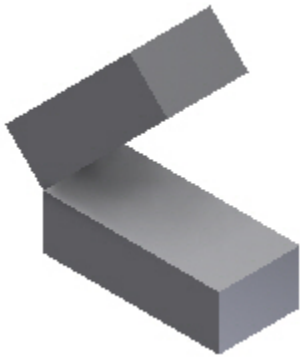
Angle Constraint

Used to specify an angle between two parts. The angle constraint is applied to faces, edges, or axes.

- Before Angle Constraint



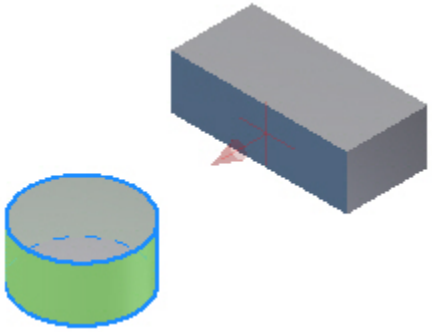
- After Angle Constraint



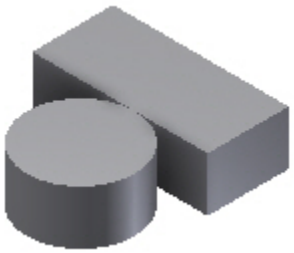
Tangent Constraint

Used to define a tangential relationship between two parts. The tangent constraint is generally applied to circular faces and planar faces. One of the selected faces must be circular.

- Before Tangent Constraint



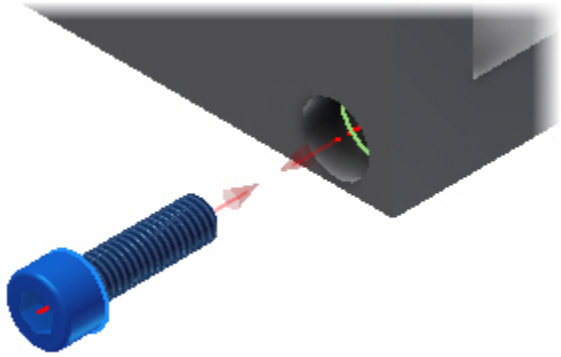
- After Tangent Constraint



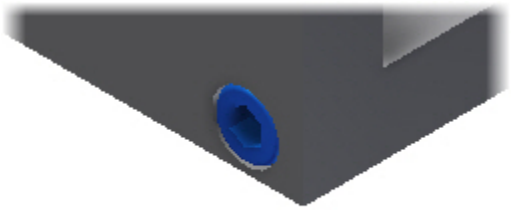
Insert Constraint

This constraint is used to insert one component into another. This constraint effectively combines a mate axis/axis and a mate face/face constraint. Generally the insert constraint is applied to bolts, or pins, or any part that needs to be inserted into a hole on another part. It is applied by selecting a circular edge on each part.

- Before Insert Constraint



- After Insert Constraint

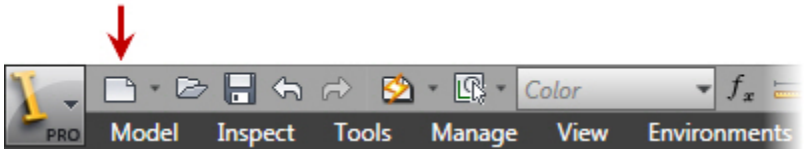


2 Robot Arm Assembly

2.1 Project 1

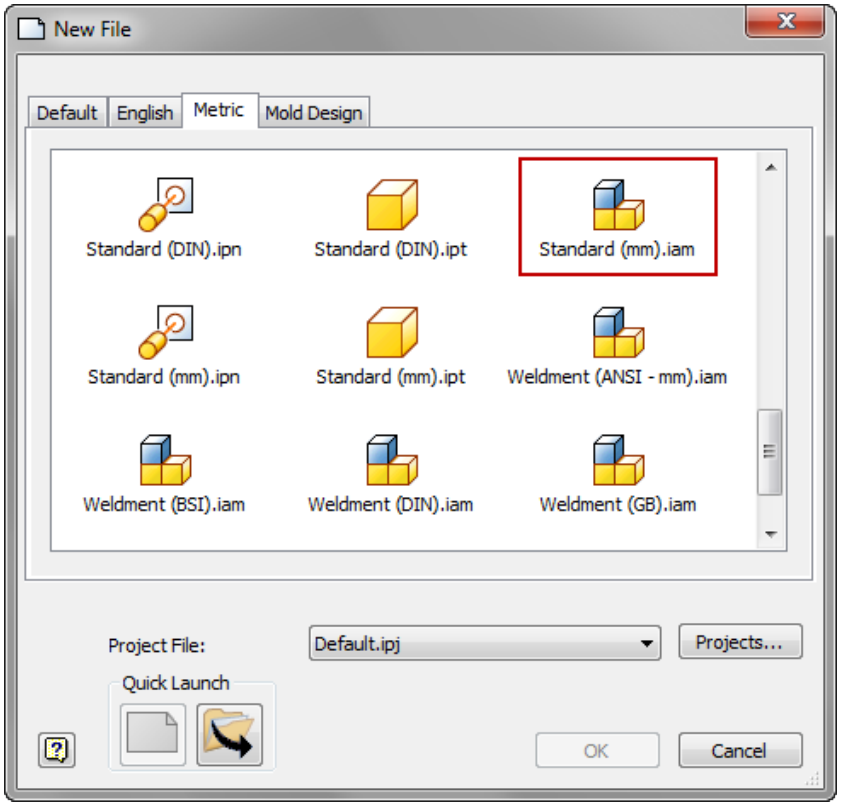
This project will introduce you to placing and assembling parts in Autodesk Inventor 2012. First you will insert several parts into a new assembly file using several different workflows. Then, using the 3D constraint tools, you will assemble the parts into a completed assembly.

1. Create a new part using the Standard (mm).iam template.
   - On the **Quick Access** toolbar, click **New**.



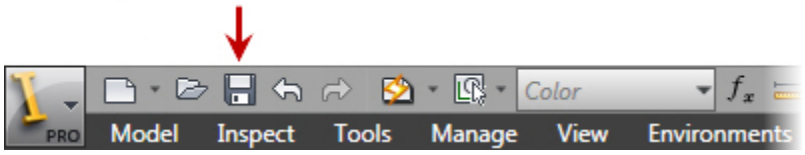
   - In the **New File** dialog box, click the **Metric** tab.

- Select *Standard (mm).iam*.



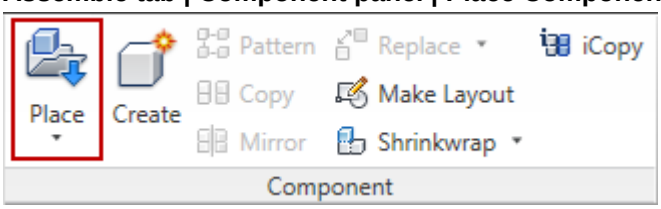
- Click **OK**.

2. On the **Quick Access** toolbar, click **Save** to save the assembly.

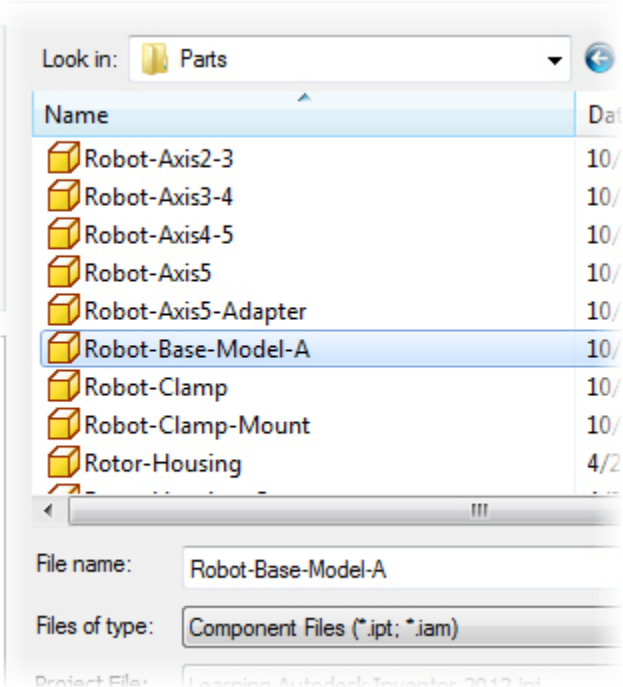


- In the **Save As** dialog box, enter *Robot-Assembly-A.iam*.
- Click **Save**.

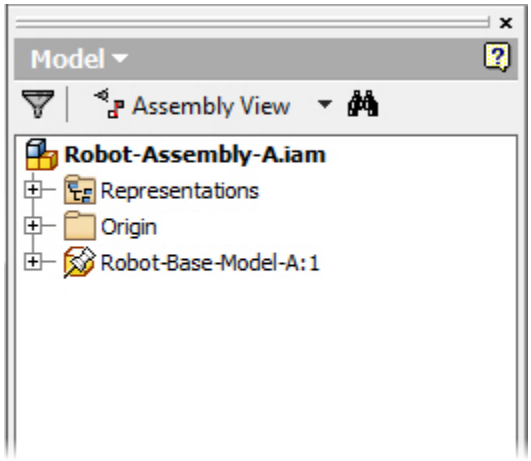
3. Place Component
   - Start the **Place Component** tool
     Assemble tab | Component panel | Place Component



- In the **Place Component** dialog box, locate and double-click *Robot-Base-Model-A.ipt.*



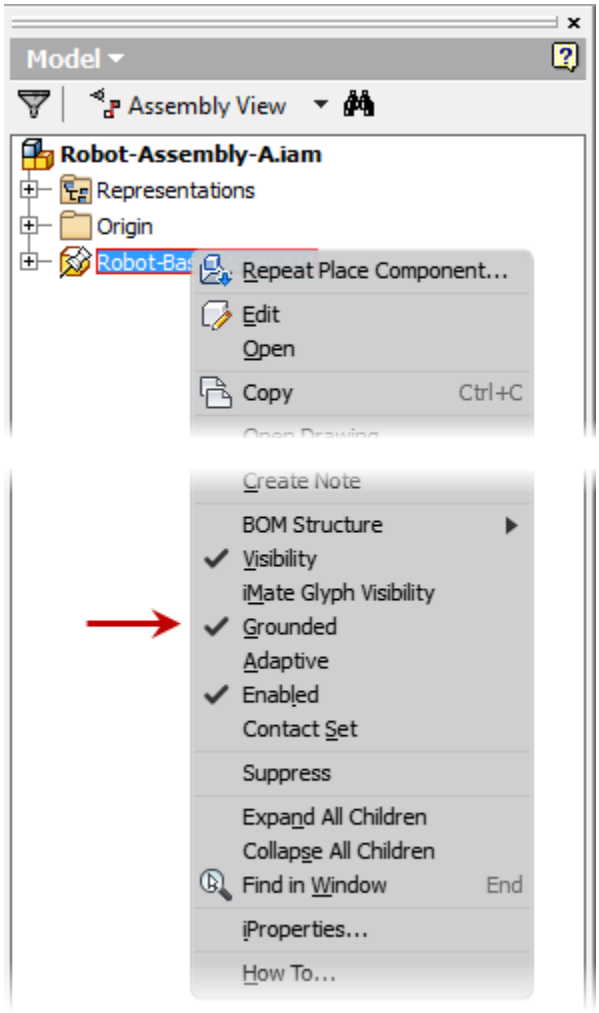
4. Press ESC to cancel the **Place Component** tool.



- The first occurrence is automatically placed at the assembly origin relative to the component origin.

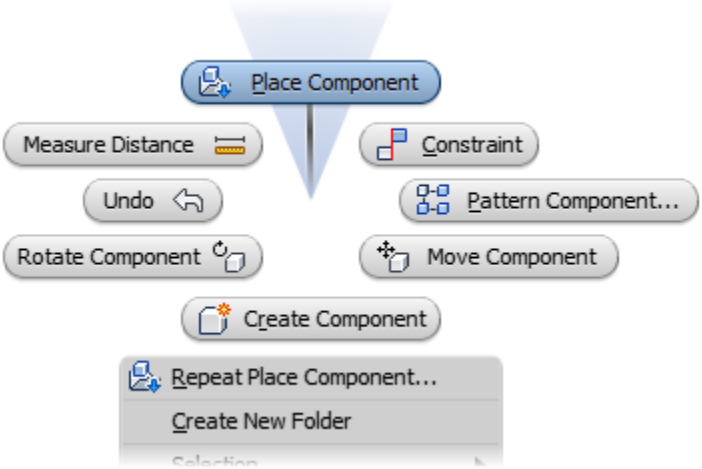
- In the browser, notice that the first component is automatically **Grounded**.
  A **Grounded** component is indicated by the pushpin icon .
  Any component can be **Grounded** or **Ungrounded** by right-clicking the component and clicking **Grounded** from the shortcut menu.

  NOTE: Typically only the first component in an assembly is **grounded**, more than one **grounded** component in an assembly can make it difficult to apply 3D constraints properly.

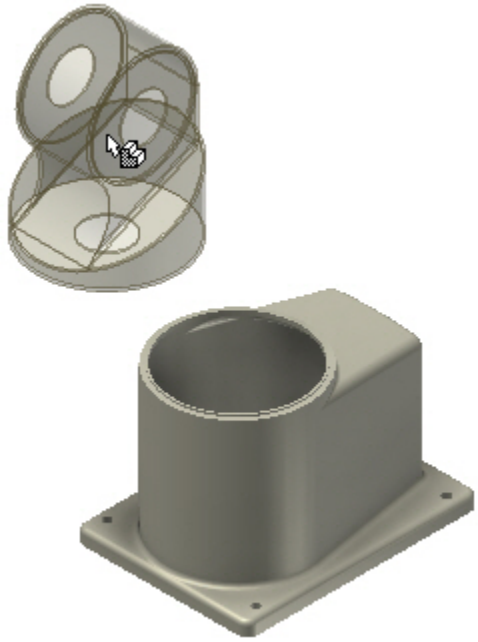


5. Place another component

- Right-click in the graphics window, select **Place Component** from the **Marking Menu**

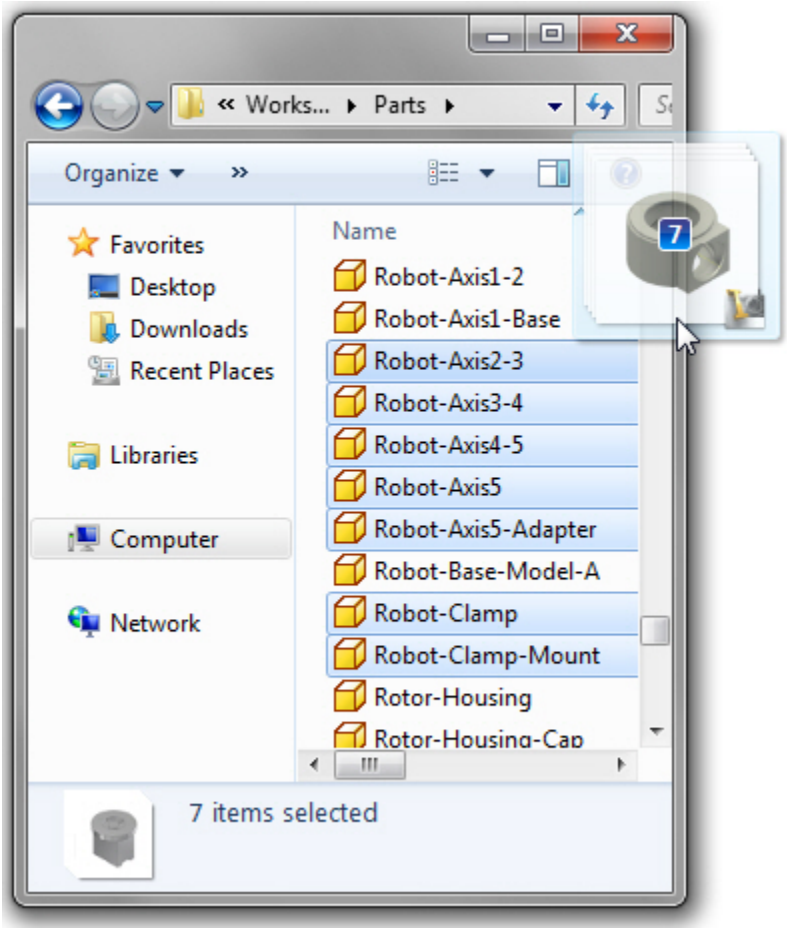


- In the **Place Component** dialog box, locate and double-click *Robot-Axis1-2.ipt*
- Position the component in the graphics window, Left mouse click to place the component as shown.



- Press ESC to cancel the command.

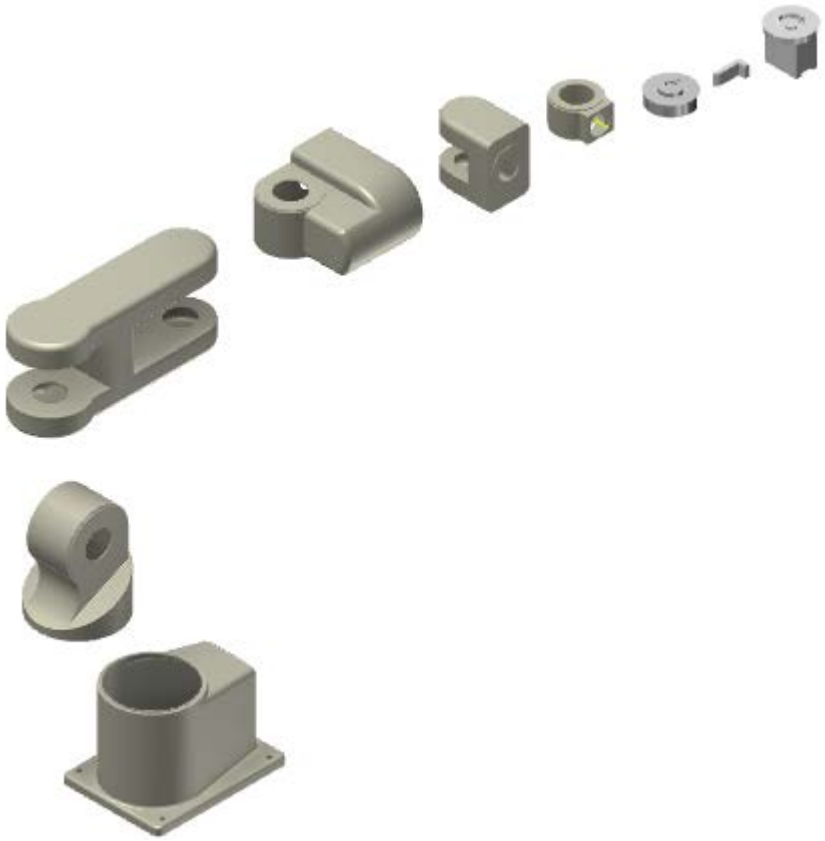
6. Drag components into an assembly:



- Open **Windows Explorer** and navigate to the folder where you installed the dataset.

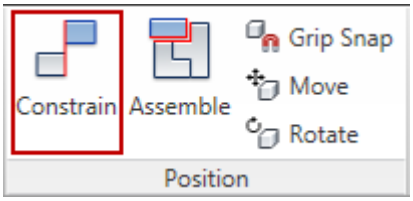
- Highlight the following part files and then click and drag them into the graphics window at the same time.
  - *Robot-Axis2-3.ipt*
  - *Robot-Axis3-4.ipt*
  - *Robot-Axis4-5.ipt*
  - *Robot-Axis5.ipt*
  - *Robot-Axis5-Adapter.ipt*
  - *Robot-Clamp.ipt*
  - *Robot-Clamp-Mount.ipt*

7. Notice how the components are spaced. The actual arrangement may differ on your screen depending on the order in which the components were selected.

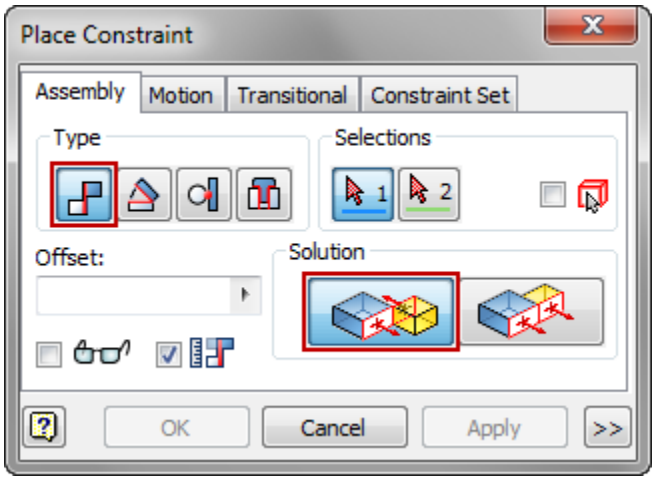


8. And 3D Constrains:

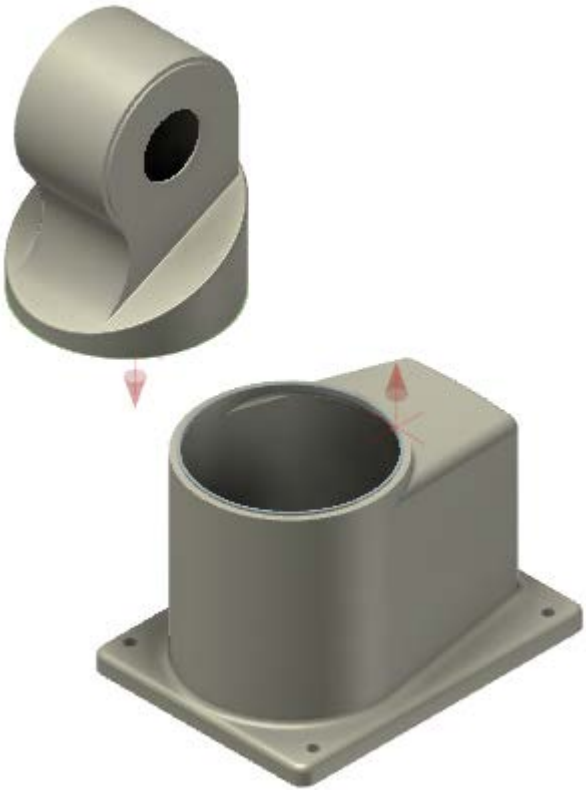
- Start the **Constrain** tool
  Assemble tab | Position panel | Constrain



- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**



- Pick the top surface of component *Robot-Base-Model-A* for **Selection 1** 
- Pick the bottom surface of component *Robot-Axis1-2* for **Selection 2** 



- Enter **0** into the **Offset** field.
- Click **OK** to accept the Face/Face Mate constraint

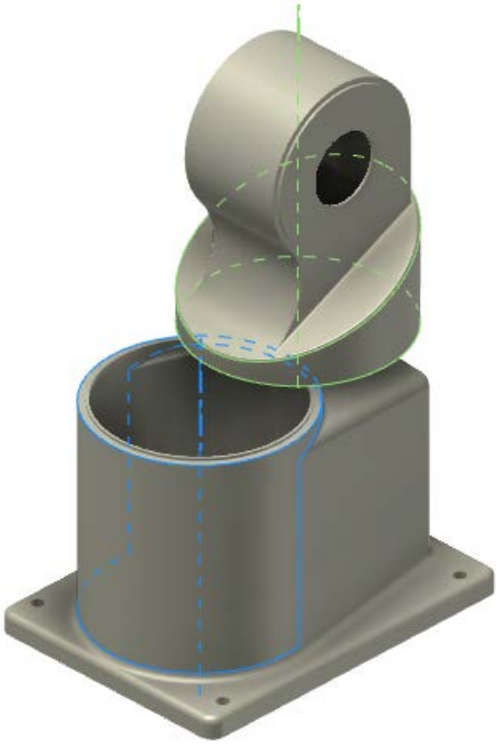
9. Click and drag component *Robot-Axis1-2*
Notice how the part moves around aligned to the top surface of component *Robot-Base-Model-A*

10. Start the Constrain tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick the outer cylindrical surface of component *Robot-Base-Model-A* for **Selection 1**

- Pick the outer cylindrical surface of component *Robot-Axis1-2* for **Selection 2**

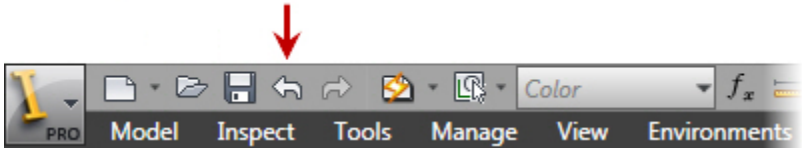


- Enter **0** into the **Offset** field.

- Click **OK** to accept the Axis/Axis Mate constraint

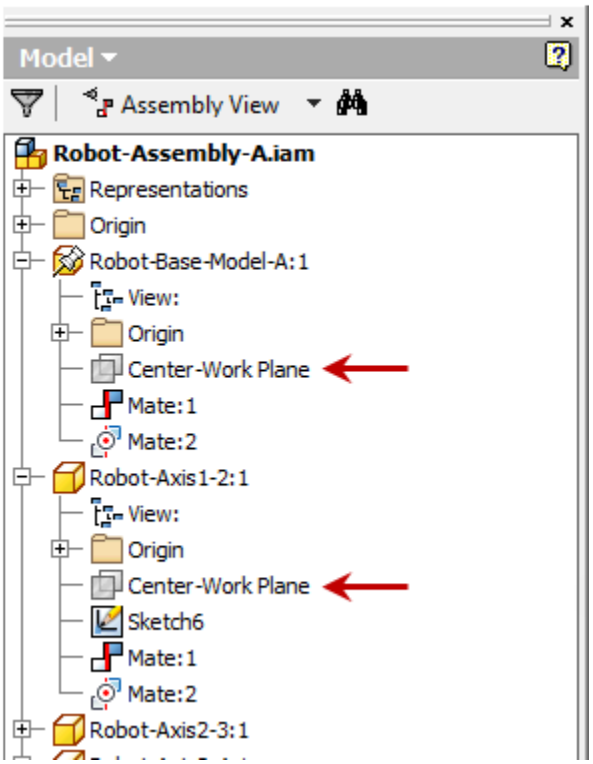
11. Click and drag component *Robot-Axis1-2*
Notice that now the part only pivots around the previously constrained axis.

- Click Undo from the **Quick Access** toolbar to revert back to the previous part position.



12. Start the Constrain tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Angle**
  Solution: **Directed Angle**



- Under component *Robot-Base-Model-A* pick work plane *Center-Work Plane* for **Selection 1**
- Under component *Robot-Axis1-2* pick work plane *Center-Work Plane* for **Selection 2**
- Enter **0.00 deg** into the **Angle** field.
- Click **OK** to accept the angle constraint.

13. Click and drag component *Robot-Axis1-2*
Notice that now the part is fully contained and will not move.

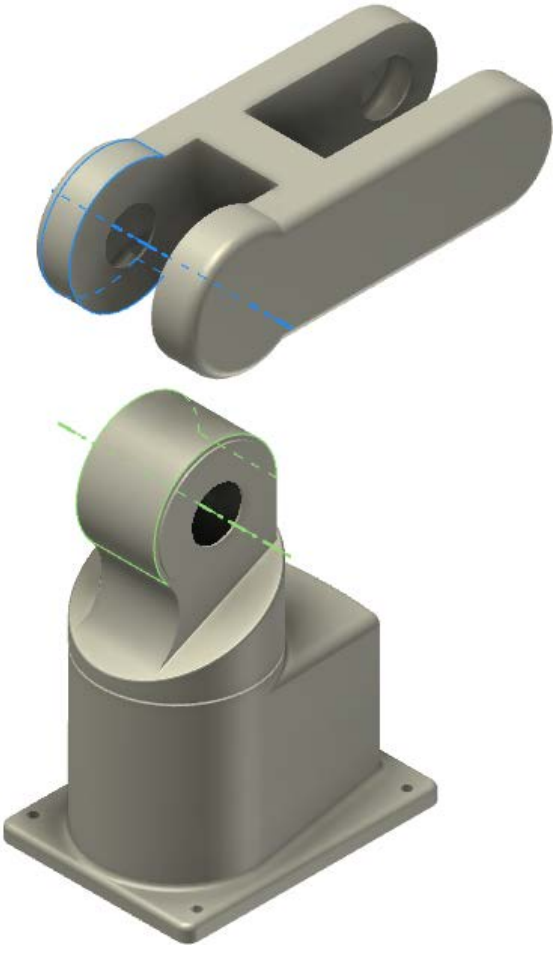
14. Start the Constrain tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**
- Pick the Origin **YZ Plane** of component *Robot-Axis1-2* for **Selection 1**

- Pick the Origin **XY Plane** of component *Robot-Axis2-3* for **Selection 2**
- Enter **0** into the **Offset** field.
- Click **Apply**
  NOTE: Clicking **Apply** accepts the constraint and leaves the command active to apply additional constraints.

15. Continue the **Constrain** tool.

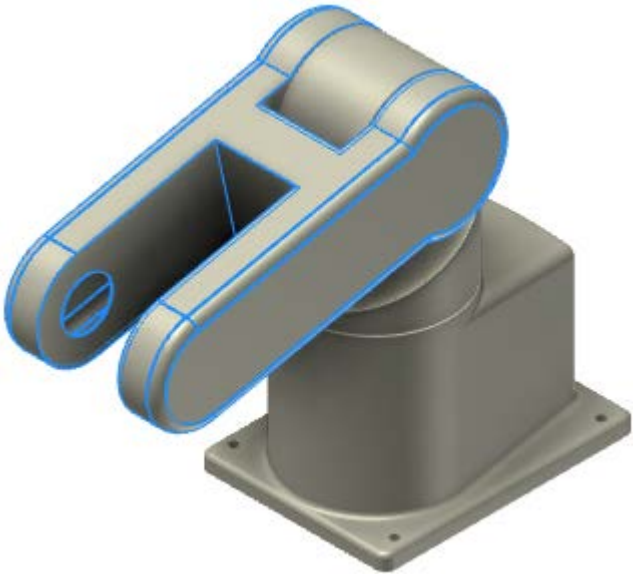
- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**
- Pick the cylindrical surface shown of component *Robot-Axis1-2* for **Selection 1**
- Pick the cylindrical surface shown of component *Robot-Axis2-3* for **Selection 2**



- Enter **0** into the **Offset** field.

- Click **OK**

16. Drag component *Robot-Axis2-3* to the position shown



17. Start the Constrain tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick the Origin **XY Plane** of component *Robot-Axis2-3* for **Selection 1**

- Pick the Origin **XY Plane** of component *Robot-Axis3-4* for **Selection 2**

- Enter **0** into the **Offset** field.

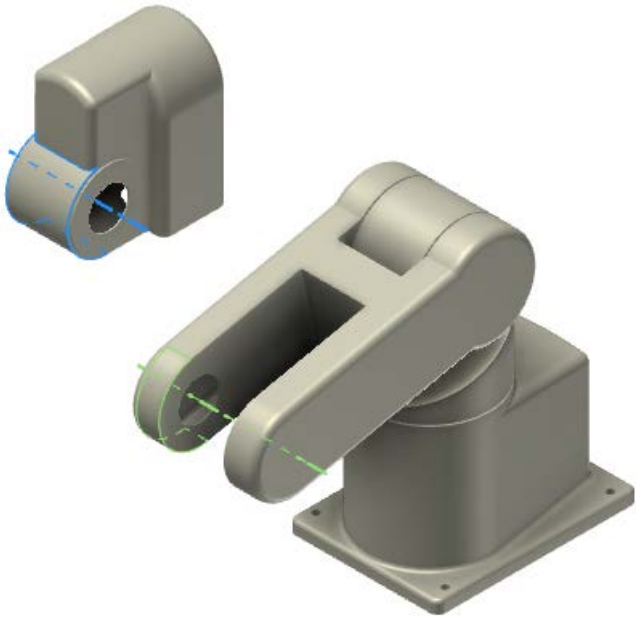
- Click **Apply**

18. Continue the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick the cylindrical surface shown of component *Robot-Axis2-3* for **Selection 1**

- Pick the cylindrical surface shown of component *Robot-Axis3-4* for **Selection 2**



- Enter **0** into the **Offset** field.
- Click **Apply**

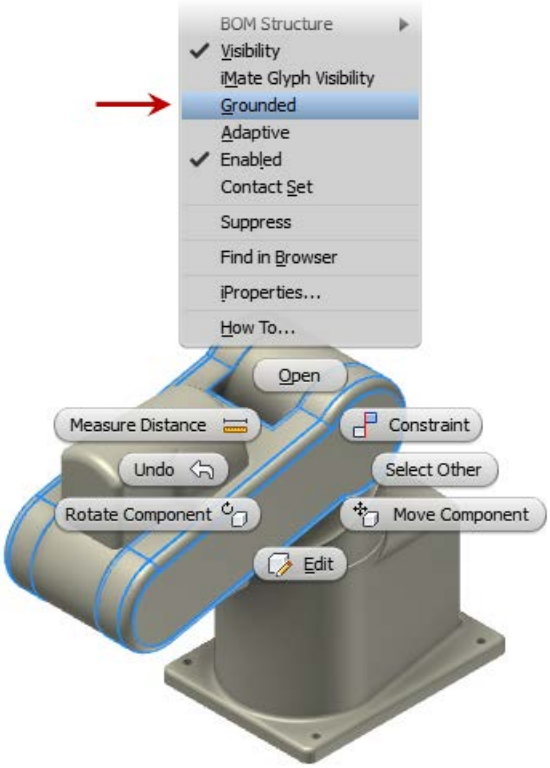
19. Drag component *Robot-Axis3-4* to change its angle.

- Notice that both *Robot-Axis2-3 & Robot-Axis3-4* move.
- Click **Undo** on the **Quick Access** toolbar to revert back to the previous position.

20. Ground component

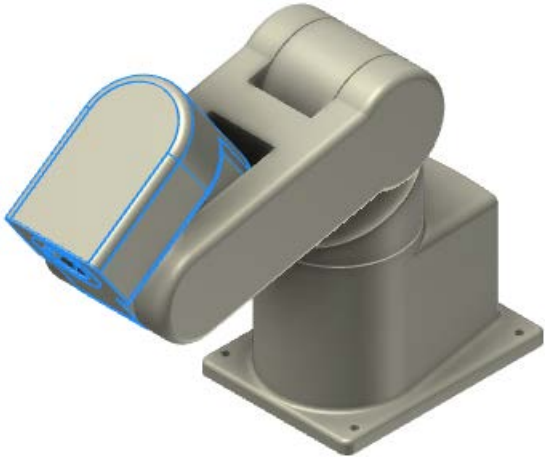
- Right-click component *Robot-Axis2-3* in the graphics window.

- Click **Grounded** from the **Overflow Menu**



21. Drag component *Robot-Axis3-4* to position shown to change its angle.

- Notice that only *Robot-Axis3-4* moves.



22. Start the **Constrain** tool.

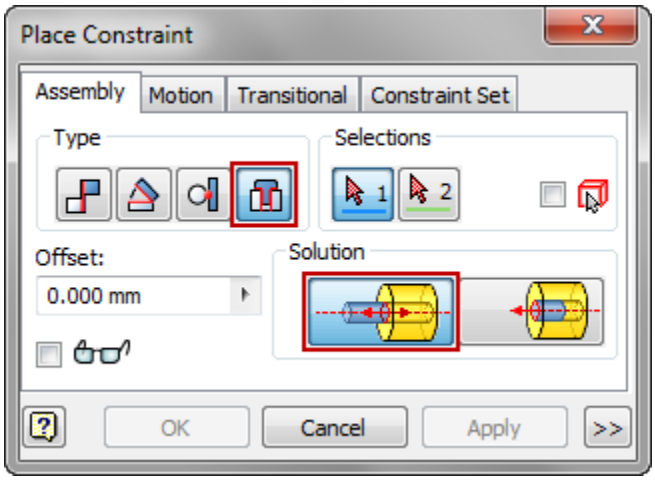
- On the **Place Constraint** dialog box set the following options
  Type: **Angle**
  Solution: **Directed Angle**

- Pick the top surface shown of *Robot-Axis3-4* for **Selection 1**
- Pick the top surface shown of *Robot-Axis2-3* for **Selection 2**

- Enter **-20.00 deg** into the **Angle** field.
- Click **OK**

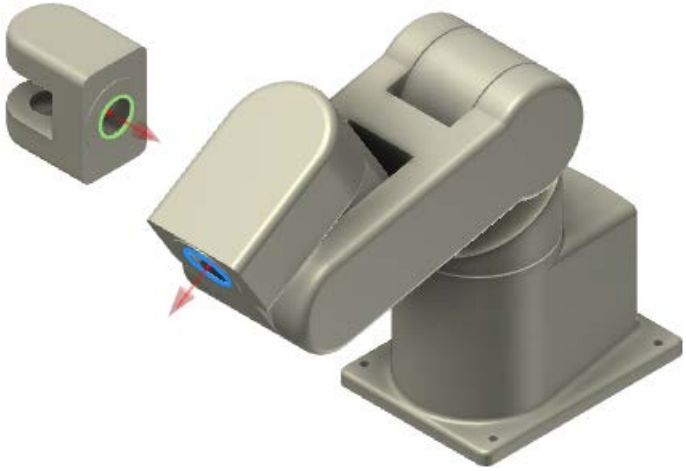
23. Start the Constrain tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Insert**
  Solution: **Opposed**



- Pick the circular edge shown of component *Robot-Axis3-4* for **Selection 1**

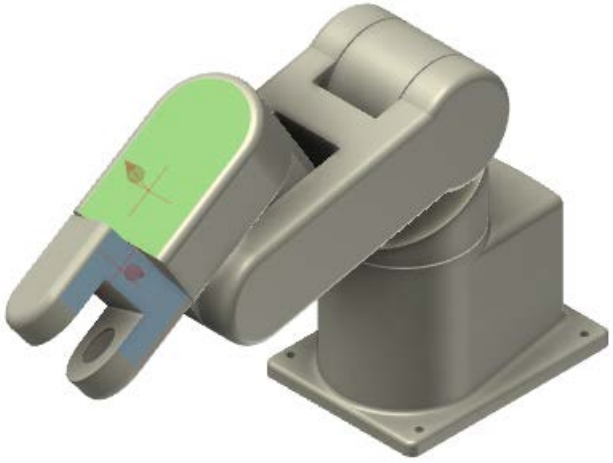
- Pick the circular edge shown of component *Robot-Axis4-5* for **Selection 2**



- Enter **0** into the **Offset** field.
- Click **Apply**

24. Continue the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Angle**
  Solution: **Directed Angle**
- Pick the top surface shown of *Robot-Axis4-5* for **Selection 1**
- Pick the top surface shown of *Robot-Axis3-4* for **Selection 2**



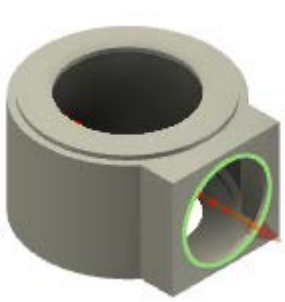
- Enter **0.00 deg** into the **Angle** field.
- Click **OK**

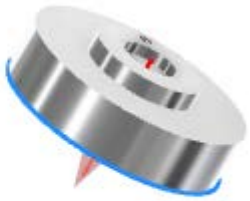
25. Start the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Insert**
  Solution: **Opposed**

- Pick the circular edge shown of component *Robot-Axis5* for **Selection 1**

- Pick the circular edge shown of component *Robot-Axis5-Adapter* for **Selection 2**





- Enter **0** into the **Offset** field.

- Click **OK**

26. Start the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick *Work Axis1* in component *Robot-Axis4-5* for **Selection 1**

- Pick the Origin **Z Axis** of component *Robot-Axis5* for **Selection 2**

- Enter **0** into the **Offset** field.

- Click **Apply**

27. Continue the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick *Work Plane1* of component *Robot-Axis4-5* for **Selection 1**

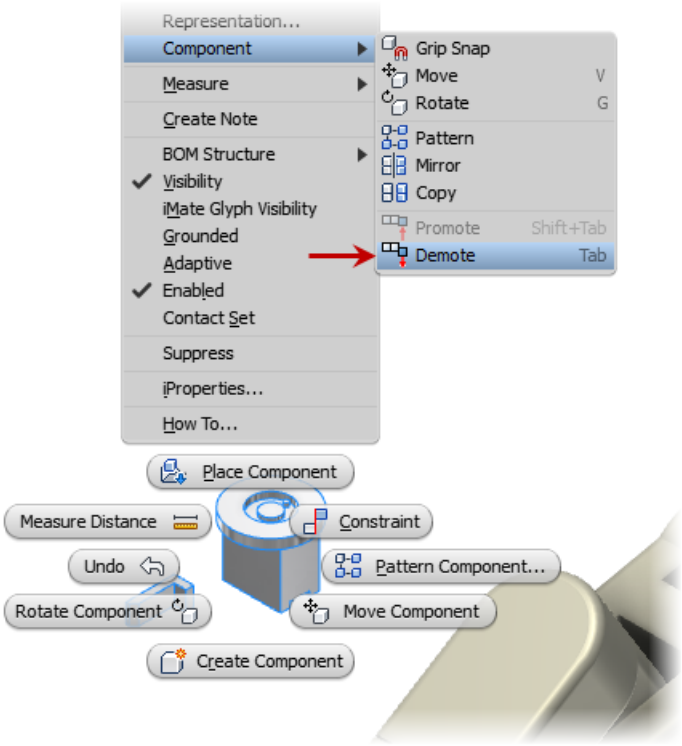
- Pick *Work Plane3* of component *Robot-Axis5* for **Selection 2**

- Enter **0** into the **Offset** field.
- Click **OK**

28. Create subassembly by creating an **In-Place Component**

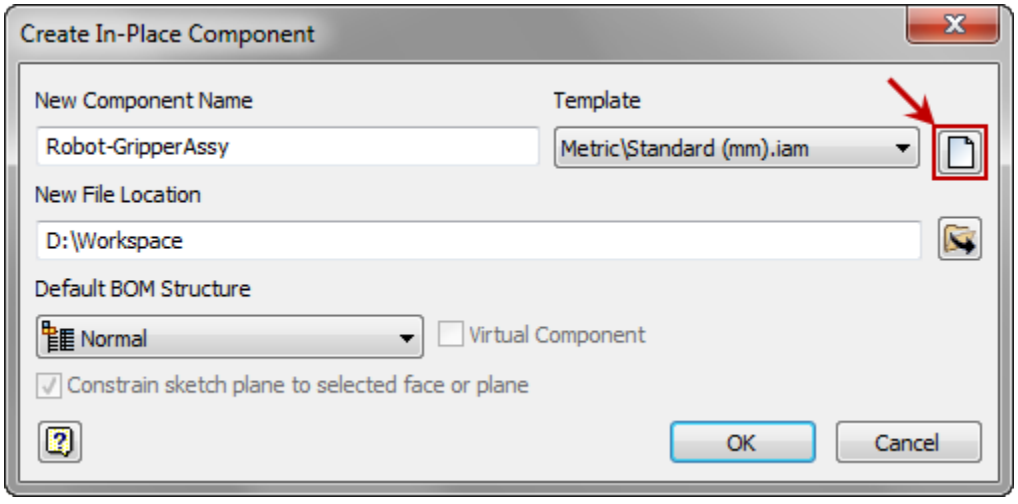
- Shift-select both *Robot-Clamp* and *Robot-Clamp-Mount* in the graphics window or in the browser.
- Right-click in the graphics window, select **Component** from the **Overflow Menu**

- Select **Demote** from the flyout



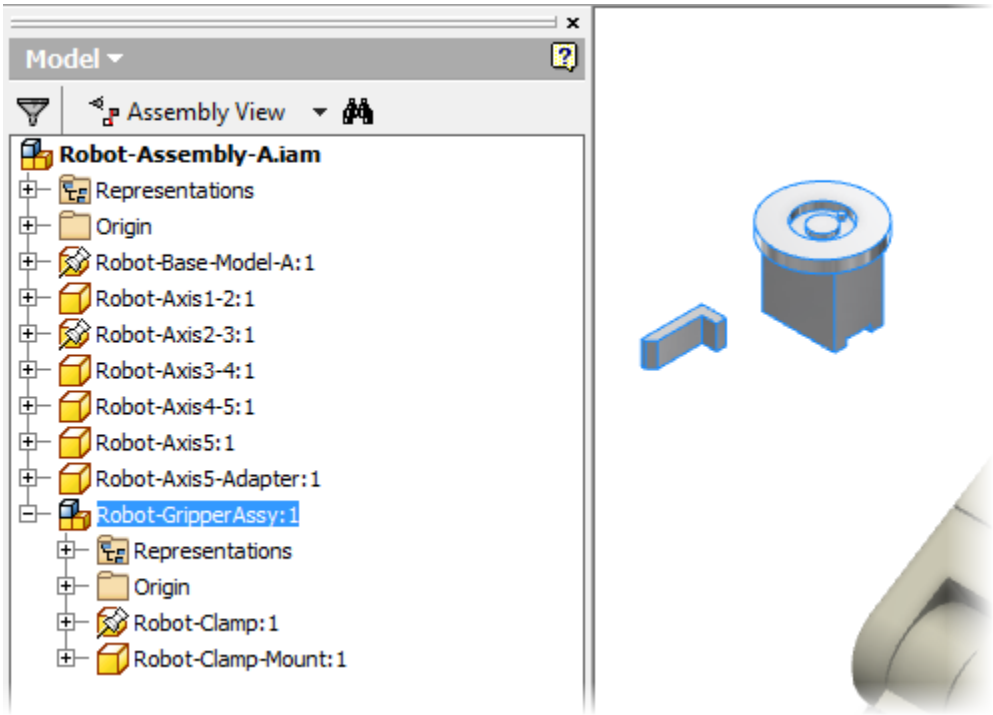
- On the **Create In-Place Component** dialog box enter *Robot-GripperAssy* for the **New Component Name**

- Click the **Browse Templates** to change the **Template** to **Metric\Standard (mm).iam**



- Click **OK**

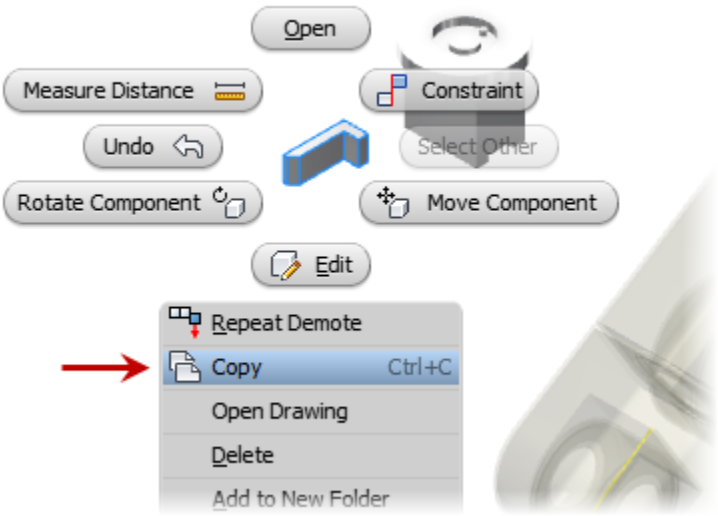
29. Notice in the browser that both components have been moved into an assembly file.



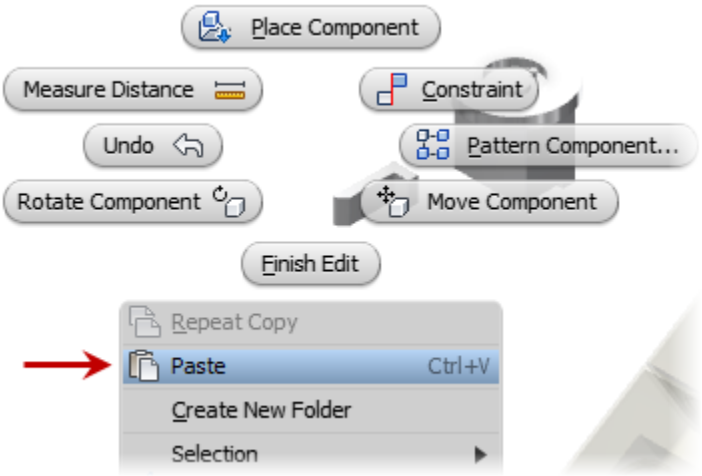
30. Double click assembly *Robot-GripperAssy* to edit it within the context of the main assembly.

31. Add a second occurrence of a component

- Right click on component *Robot-Clamp*
- Select **Copy** from the **Overflow Menu**



- Right-click the graphics window, select **Paste** from the **Overflow Menu**



- The copied component is placed in the assembly.

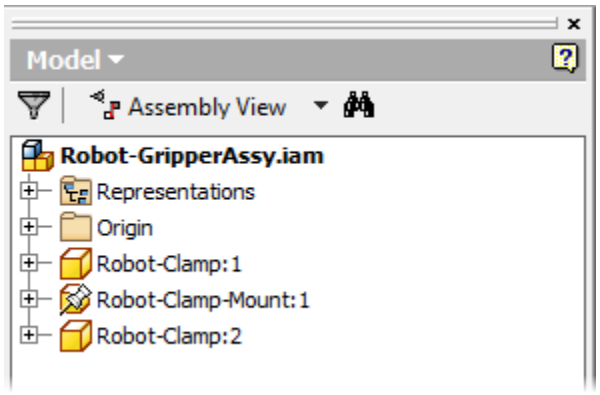
32. Exit in-context editing

- Click **Return** from the ribbon
  Assemble tab | Return panel | Return

33. Open subassembly

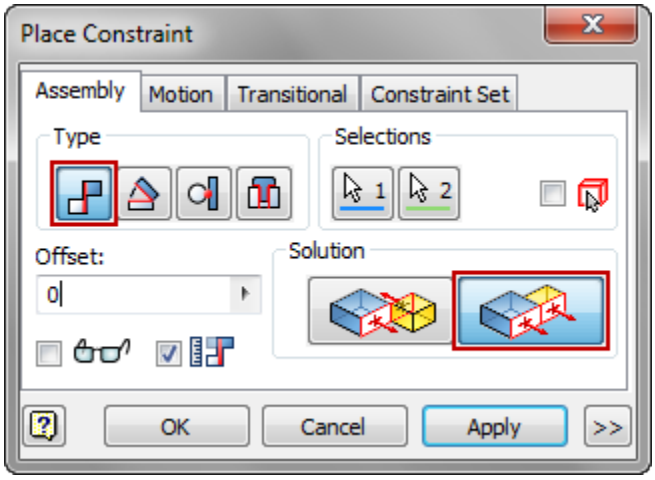
- Right-click subassembly *Robot-GripperAssy*
- Select **Open** from the **Marking Menu**
- *Robot-GripperAssy* is opened in its own window.
- If the assembly is not visible in the window, use the **Zoom All** tool from the **Navigation Toolbar**

34. Depending on the order in which the components were original placed in *Robot-Assembly-A.iam* it may be necessary to change which components are **grounded** in this new assembly. Make sure that *Robot-Clamp-Mount* is **grounded** and both occurrences of **Robot-Clamp** are NOT **grounded**.



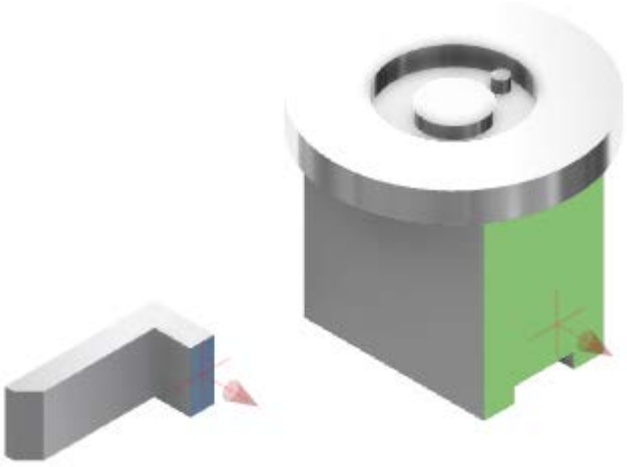
35. Start the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Flush**



- Pick the side face shown of component *Robot-Clamp:1* for **Selection 1**

- Pick the side face shown of component *Robot-Clamp-Mount* for **Selection 2**



- Enter **0** into the **Offset** field.
- Click **OK**

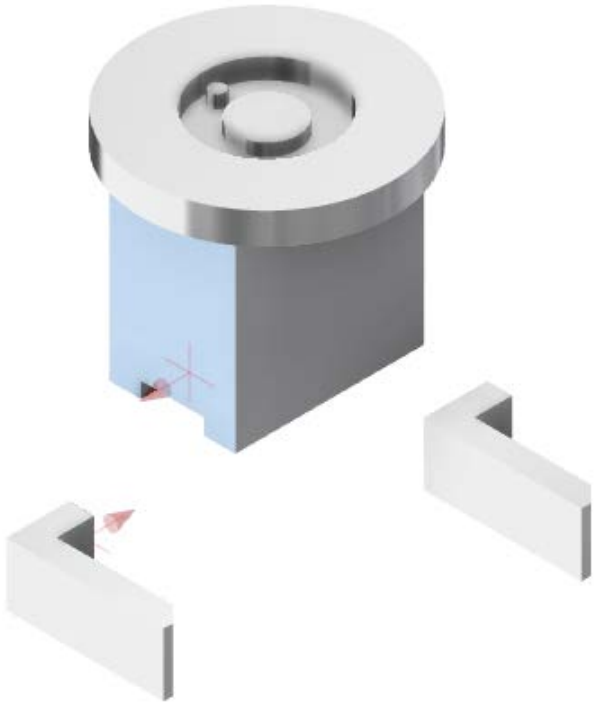
36. Change Parameter name

- Open the **Parameters** dialog box
  Assemble tab | Manage panel | Parameters
- Because you have only placed one constraint in assembly *Robot-GripperAssy*, this is only one parameter listed in the Parameters dialog box called *d0*.
- Single click on the parameter name and change it to *GripperOffset*
  NOTE: Parameter names cannot contain spaces
- Click **DONE**

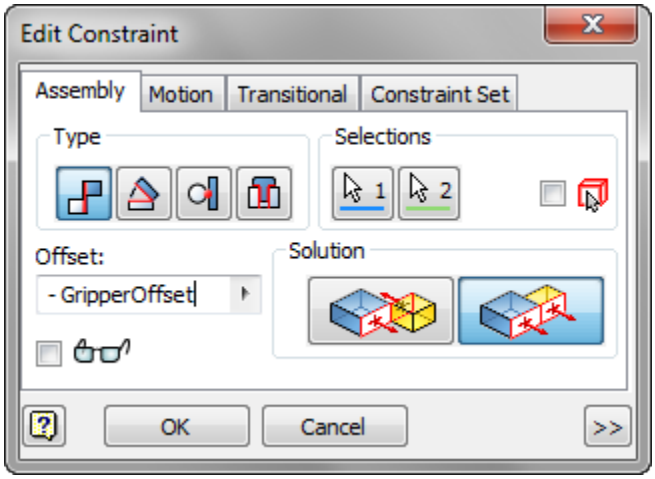
37. Start the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Flush**
- Pick the side face shown of component *Robot-Clamp:2* for **Selection 1**

- Pick the side face shown of component *Robot-Clamp-Mount* for **Selection 2**



- Enter **- GripperOffset** into the **Offset** field.



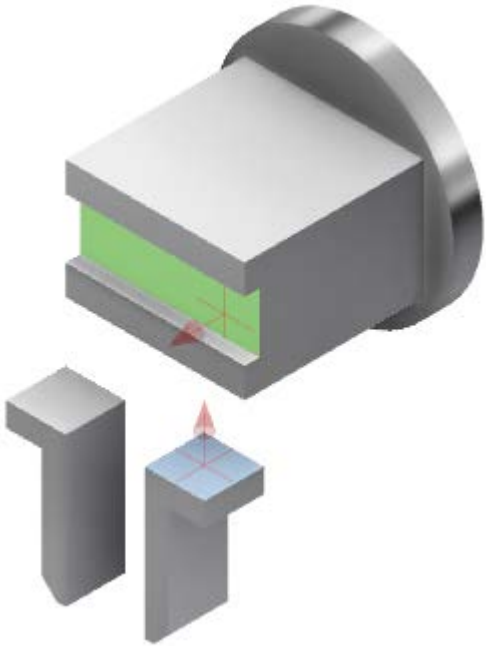
By adding a Negative " **-** " symbol before the parameter value, this will make the constraint offset value always be negative of the original.

- Click **OK**

38. Start the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick the face shown of component *Robot-Clamp:1* for **Selection 1**
- Pick the face shown of component *Robot-Clamp-Mount* for **Selection 2**

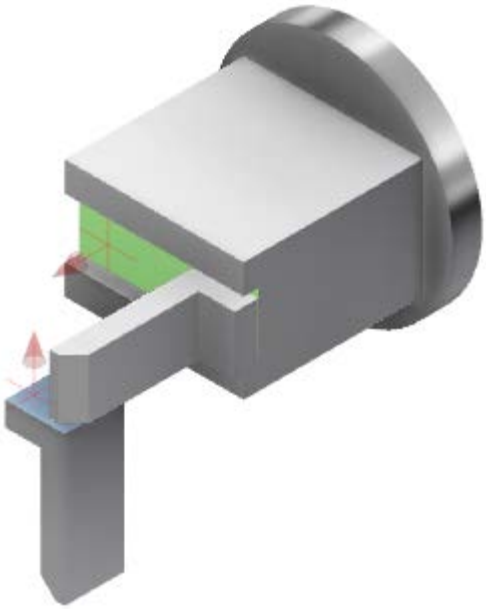


- Enter **0** into the **Offset** field.
- Click **Apply**

39. Continue the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**
- Pick the face shown of component *Robot-Clamp:2* for **Selection 1**

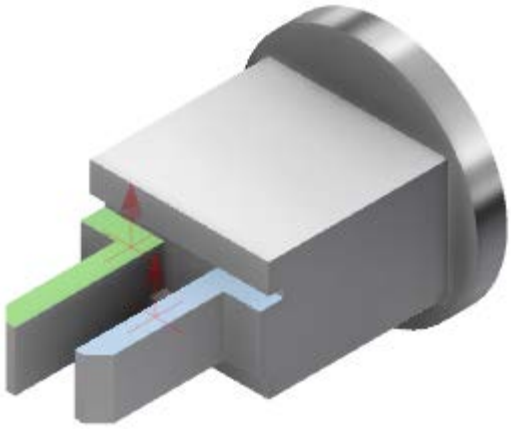
- Pick the face shown of component *Robot-Clamp-Mount* for **Selection 2**



- Enter **0** into the **Offset** field.
- Click **Apply**

40. Continue the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Flush**
- Pick the face shown of component *Robot-Clamp:1* for **Selection 1**
- Pick the face shown of component *Robot-Clamp:2* for **Selection 2**



- Enter **0** into the **Offset** field.

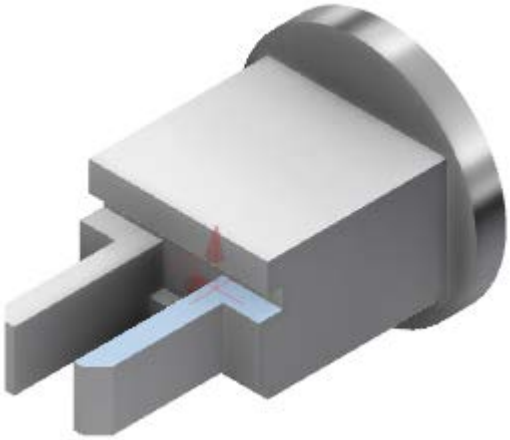
- Click **Apply**

41. Continue the **Constrain** tool

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**

- Pick the face shown of component *Robot-Clamp:1* for **Selection 1**

- Pick the inside face shown of component *Robot-Clamp-Mount* for **Selection 2**



- Enter **0** into the **Offset** field.

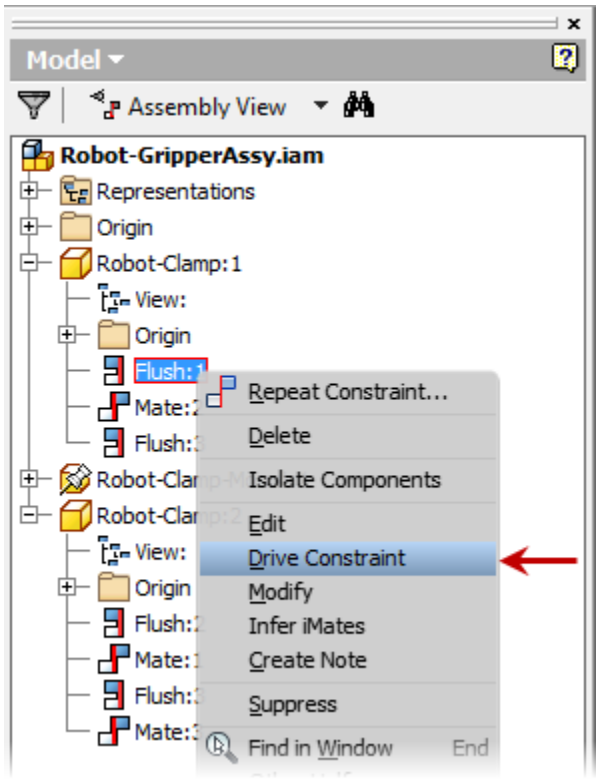
- Click **Apply**

42. Visualize gripper motion

- Expand *Robot-Clamp:1* in the browser

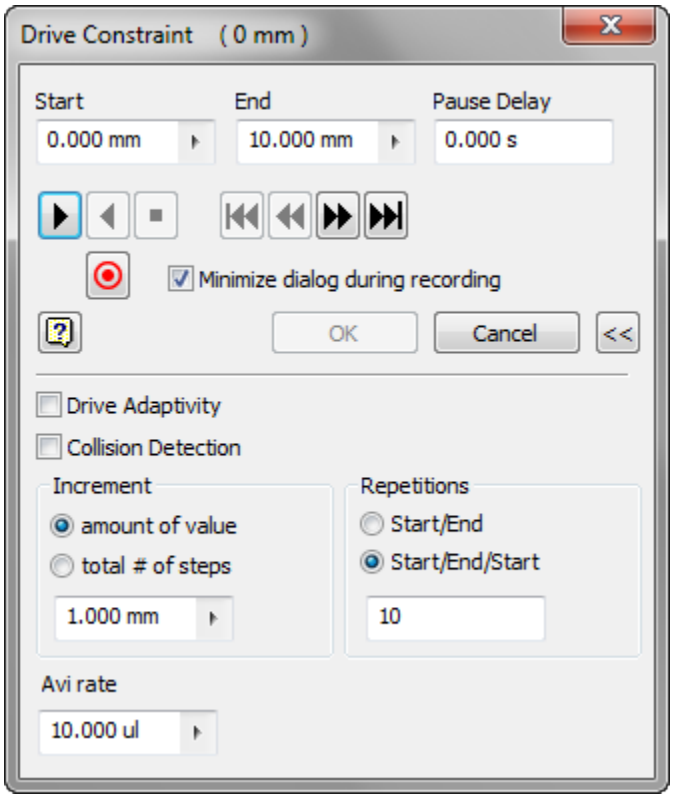
- Right-click in constraint *Flush:1* (Should be the first constraint placed in this assembly)

- Select **Drive Constraint** from the **Shortcut Menu**



- On the **Drive Constraint** dialog box click the expand button 

- Select Start/End/Start under Repetitions



- Enter **10** in the **Repetitions** field
- Click the **Play** button 
- *Robot-Clamp:1* & *Robot-Clamp:2* are animated in the graphics window
  Both parts move because *Robot-Clamp:2* was contained using the parameter value from *Robot-Clamp:1*

43. Click **Save** on the **Quick Access Toolbar**

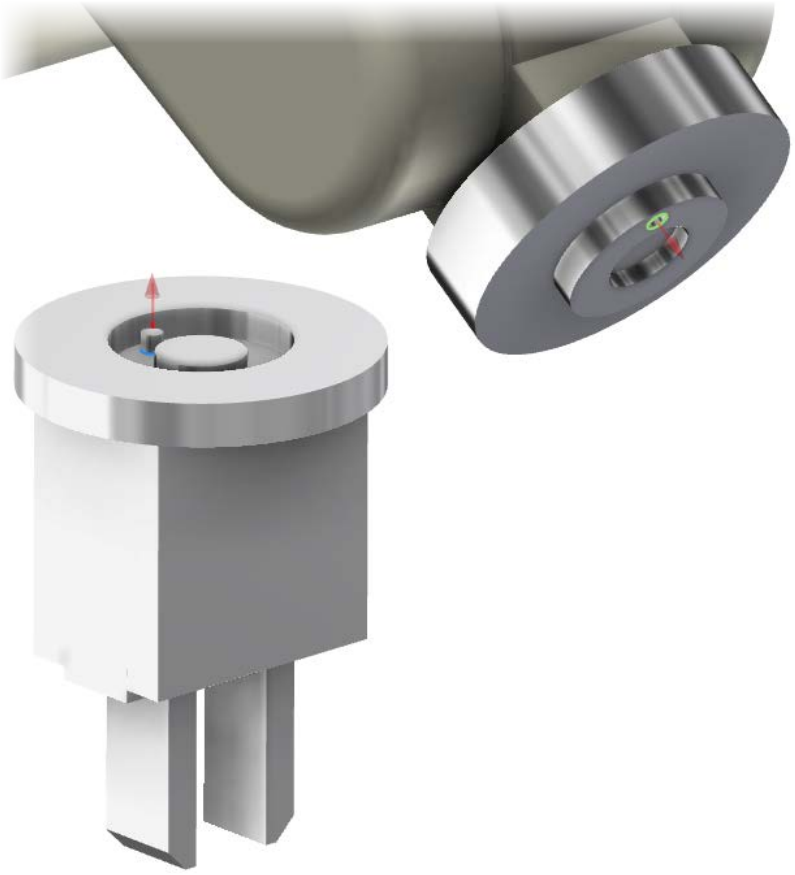
44. **Close** the window for *Robot-GripperAssy.iam*

45. Notice that all edits made to *Robot-GripperAssy.iam* are now shown in *Robot-Assembly-A.iam*

46. Start the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Insert**
  Solution: **Opposed**
- Pick the circular edge shown of component *Robot-GripperAssy* for **Selection 1**

- Pick the circular edge shown of component *Robot-Axis5-Adapter* for **Selection 2**

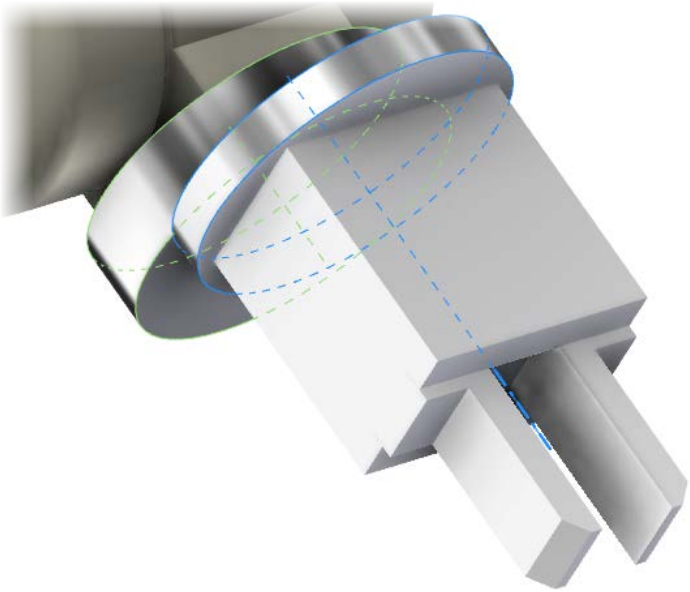


- Enter **0** into the **Offset** field.
- Click **Apply**

47. Continue the **Constrain** tool.

- On the **Place Constraint** dialog box set the following options
  Type: **Mate**
  Solution: **Mate**
- Pick the cylindrical surface shown of component *Robot-GripperAssy* for **Selection 1**

- Pick the cylindrical surface shown of component *Robot-Axis5-Adapter* for **Selection 2**



- Enter **0** into the **Offset** field.
- Click **Apply**

48. If you haven't already done so, **Unground** component *Robot-Axis2-3*

49. Click **Save** on the **Quick Access Toolbar**

50. **Close** all files