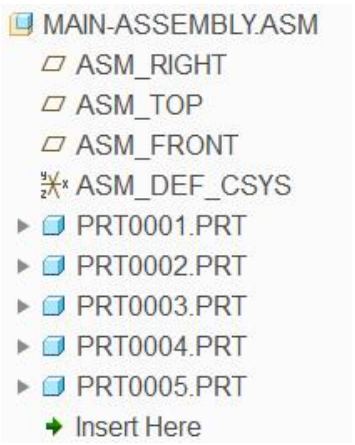
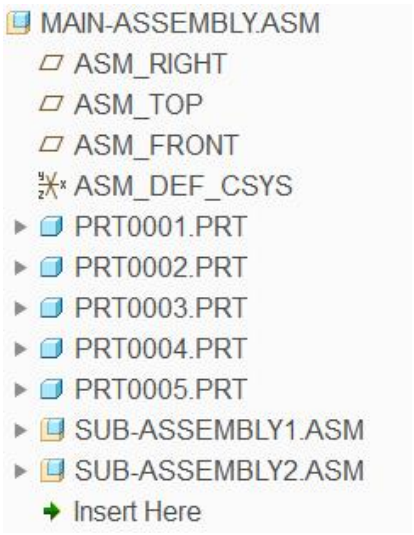
Multi-Level Assemblies

Multi-level assemblies can be defined as the assemblies consisting of at least one or more sub-assemblies within main assembly.



Single-Level Assembly



Multi-Level Assembly

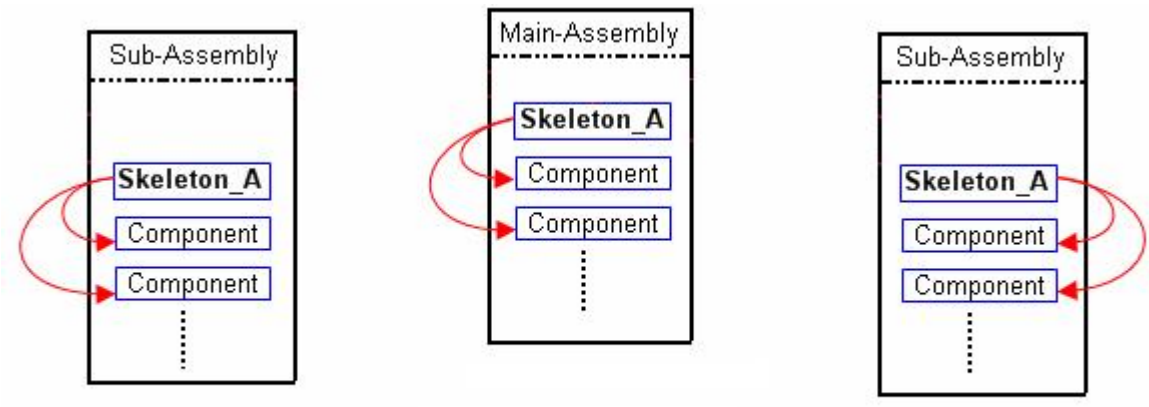
In the previous chapters, we have seen how to implement top-down design for single-level assemblies. But now we will see the different approaches for implementing top-down design to multi-level assemblies.

We will explore following two approaches for the multi-level assemblies

1. Single skeleton
2. Multiple skeletons

Single Skeleton

A single skeleton is used for the whole project. A typical example is shown below.

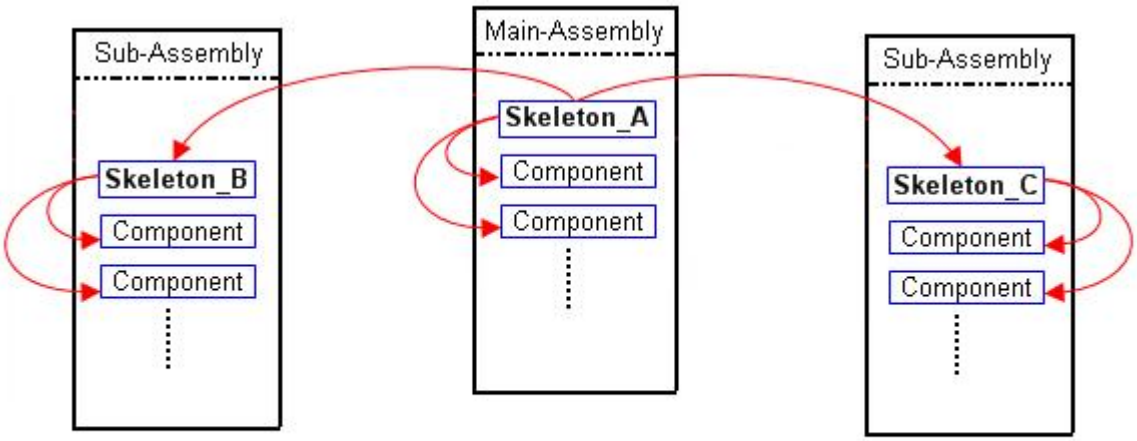


Single Skeleton Approach

You can see that a single skeleton is used in all sub-assemblies related to the project. The skeleton is assembled to each sub-assembly in the project (if the components need to reference the data in the skeleton). The data is communicated, to the components in a particular sub-assembly, from the skeleton lying in that sub-assembly without requiring the main assembly in session. So a designer can work on a specific sub-assembly without bringing into session the main assembly and all the components will regenerate successfully as the skeleton is in session.

Multiple Skeletons

More than one skeleton, placed at different levels of assembly, are used in a project. A typical example is shown below.



Multiple Skeleton Approach

In this case, the skeleton models in the sub-assemblies reference the geometry in main-assembly skeleton. It is highly recommended that External Copy Geometry feature is used to copy data from main-assembly skeleton to the skeleton models in individual sub-assemblies. This makes sure that skeletons in sub-assemblies are independent of main-assembly. The data is communicated, to the components in a particular sub-assembly, from the skeleton lying in that sub-assembly. So a designer can work on a specific sub-assembly without the need to bring main assembly in session. If you want to regenerate a sub-assembly completely, you only need main-assembly skeleton in session additionally.

Single Skeleton approach is usually used for small to medium size of projects where amount of data to be put in the skeleton is not too big. Usually but not necessarily a single designer or project manager is creating and modifying the geometry in the skeleton. So individual designers concentrate on specific assemblies or parts assigned to them

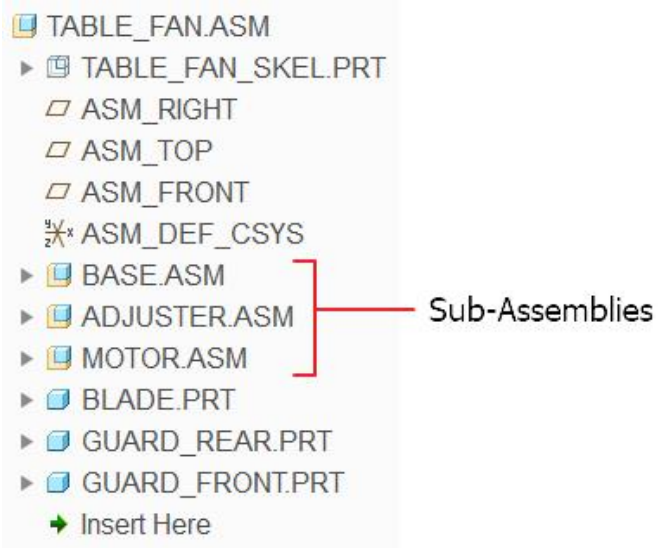
Multiple Skeletons approach is used for medium to large size of projects where all the top information of a project is difficult to manage in a single skeleton. The sub-assembly skeletons copy the design information from main skeleton; furthermore it has additional geometry that is related only to the components in that sub-assembly. Usually individual teams or designers, working on a sub-assembly, manage and create new geometry in the skeleton model relating to that assembly.

Exercise 1

In this exercise you will learn how to implement top-down design to a multi-level assembly by using single skeleton for whole project.

Set the working directory to TABLE_FAN folder and open the assembly TABLE_FAN.ASM

Notice that there are three sub-assemblies in the main assembly and all of them have been assembled by Default constraint.



In the following paragraphs, we will see how to communicate references from the skeleton to the parts, at different level in the assembly.

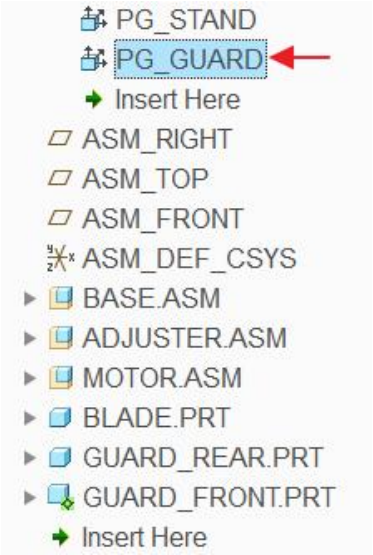
Communicating Design Information in the Main Assembly

First we will see how to create a Copy Geometry feature in a part that is located in the main assembly.

Pick the GUARD_FRONT.PRT in the model tree and select **Activate**.

To create a copy geometry feature, pick Copy Geometry on the Model tab.

As Publish Geometry reference collector is active by default so select the PG_GUARD feature in the skeleton part as shown below.



Pick  to apply the changes and exit the dashboard.

In the same way you can create external copy geometry in any part in the main assembly.

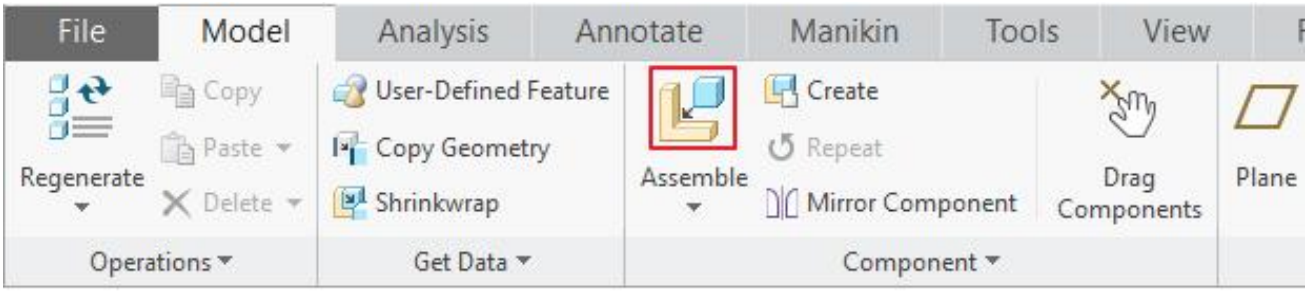
Communicating Design Information in a Sub-Assembly

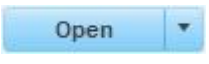
Now we will see how to communicate references from the skeleton to individual parts located in the sub-assemblies.

First we will assemble the skeleton model in the BASE assembly. So that parts in this assembly can reference the publish geometry features in skeleton.

So open the BASE.ASM in a new window.

Pick the Add component icon ()



Select the table_fan_skel.prt in the open dialog box then pick 

.

System will place the skeleton as the first feature in the model tree as shown below.

Now we will create the Copy Geometry feature in the BASE.PRT that is located in BASE.ASM

Select the BASE.PRT in the model tree and select **Activate**.

To create a copy geometry feature, pick 

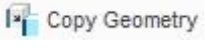
on the Model tab.

As Publish Geometry reference collector is active by default so select the PG_BASE feature in the skeleton part by picking it in the model tree as shown below.

Pick  to apply the changes and exit the dashboard.

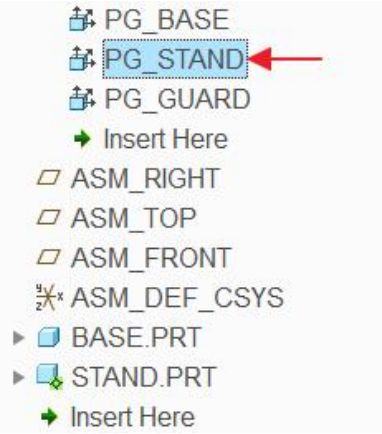
Now we will create the External Copy Geometry feature in the STAND.PRT

Select the STAND.PRT in the model tree and select **Activate**.

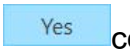
To create a copy geometry feature, pick 

on the Model tab.

As Publish Geometry reference collector is active by default so select the PG_STAND feature in the skeleton part as shown below.



Pick  icon in the dashboard to make this feature External.

System will ask you to confirm the conversion process. So pick to 

confirm.

Pick **Default** in the Placement dialog box.

Pick 

to proceed.

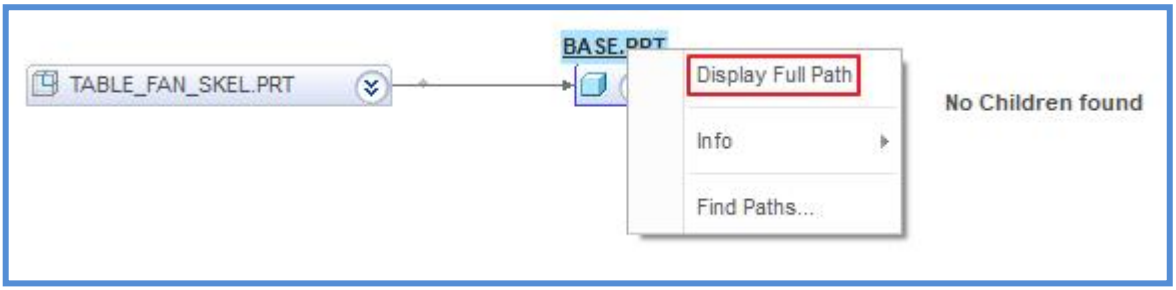
Pick  to apply the changes and exit the dashboard.

Investigating External References

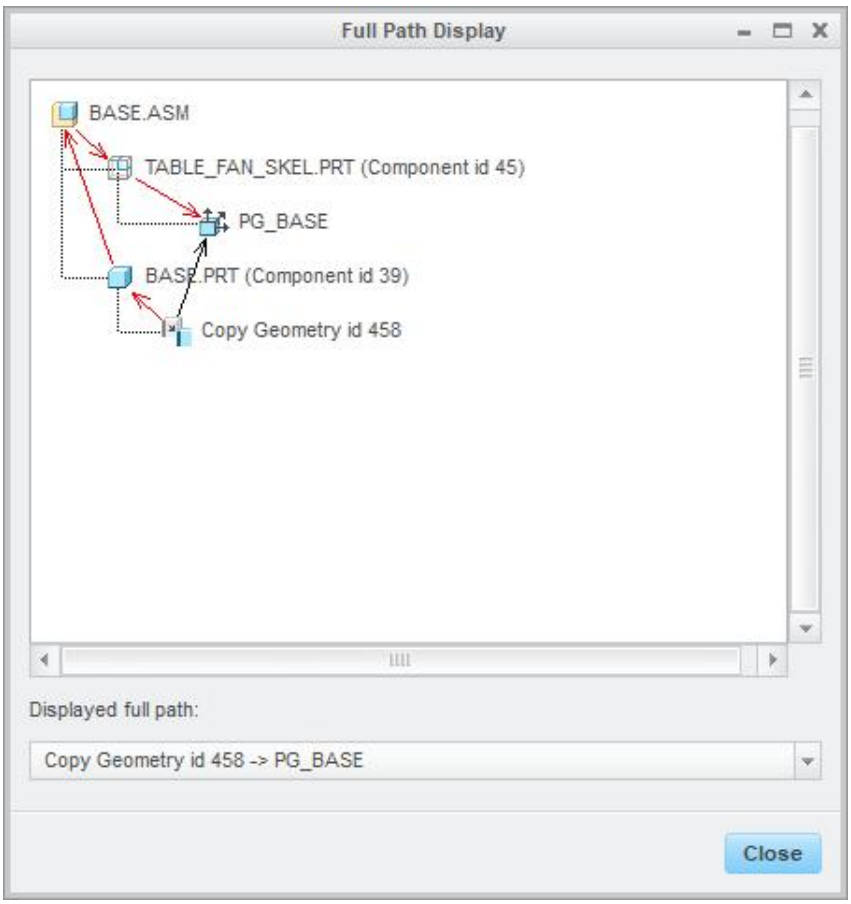
Now we will investigate the external references in the components located in BASE.ASM

Right-click over the BASE.PRT and pick **Information > Reference Viewer** to open the Reference Viewer.

Right-click the current object (BASE.PRT) and pick **Display Full Path** as shown below.



Full Path Display dialog box will appear as shown below.



It can be seen that the copy geometry is referencing published geometry feature in the skeleton model in the context of the assembly. So the system will need the skeleton and BASE assembly in session to update and regenerate this part when the skeleton is modified.

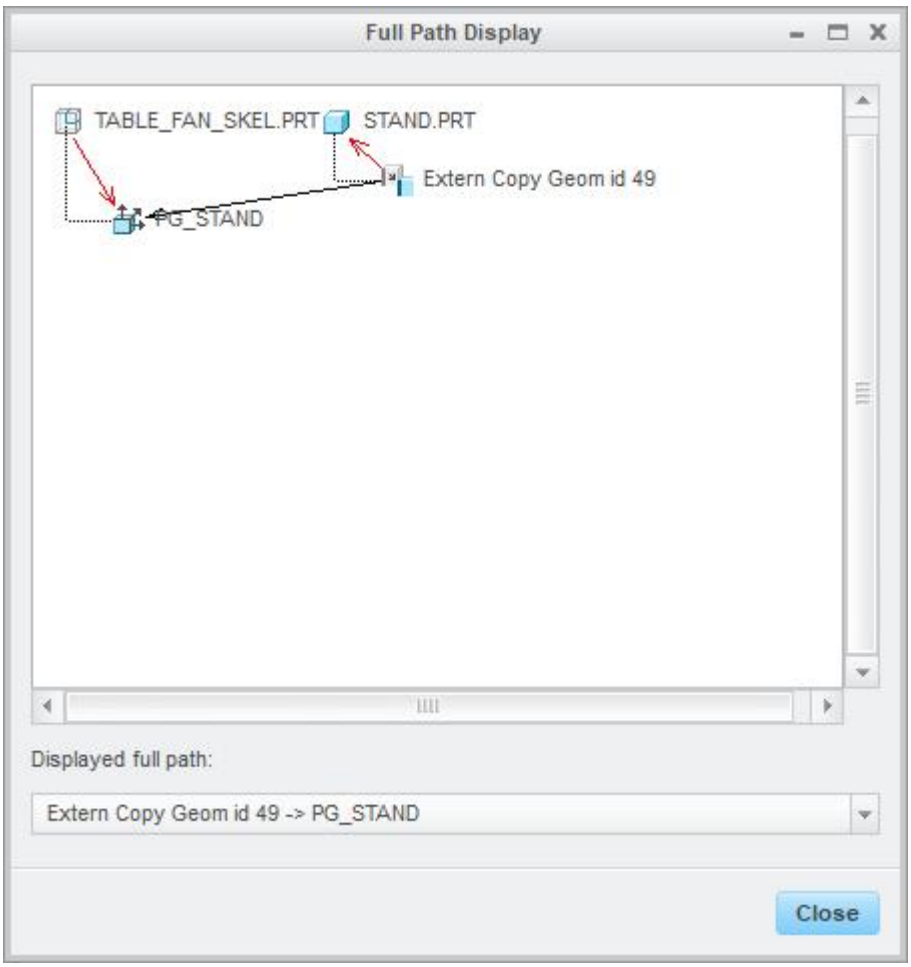
Pick Close to close the Full Path Display dialog box.

Pick Close to close the Reference Viewer.

Right-click over the STAND.PRT and pick **Information > Reference Viewer** to open the Reference Viewer.

Right-click the current object and pick **Display Full Path**.

Full Path Display dialog box will appear as shown below.



It can be seen that STAND.PRT has no dependency on the assembly. So the system will only need the skeleton in session to update and regenerate this part when the skeleton is modified.

Pick Close to close the Full Path Display dialog box.

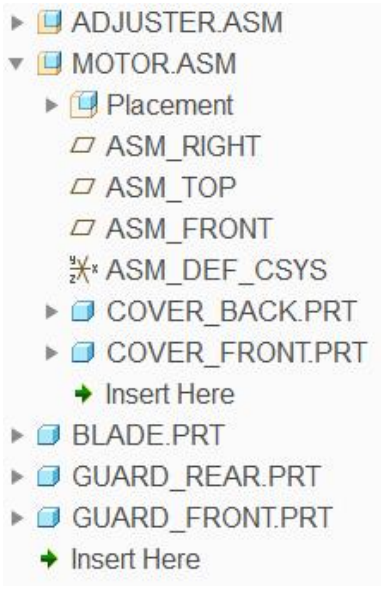
Pick Close to close the Reference Viewer.

Communicating Design Information in a Sub-Assembly

In the following section we will discuss another way of copying references from skeleton to the components.

Above, we copied the references in parts from skeleton model that is located in the same assembly in which target part is located. But now we will copy the references from skeleton (located in main assembly) to the parts in the sub-assembly. This method of copying references is often tempting for a new user so you should understand the pros and cons completely.

Switch to the TABLE_FAN.ASM and expand the MOTOR.ASM node as shown below.

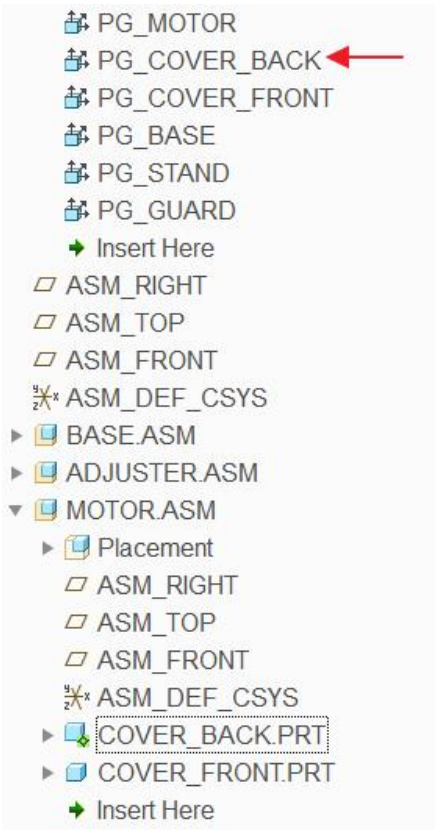


Select the COVER_BACK.PRT (located in MOTOR.ASM) in the model tree and select **Activate**.

To create a copy geometry feature, pick 

on the Model tab.

As Publish Geometry reference collector is active by default so select the PG_COVER_BACK feature in the skeleton part as shown below.



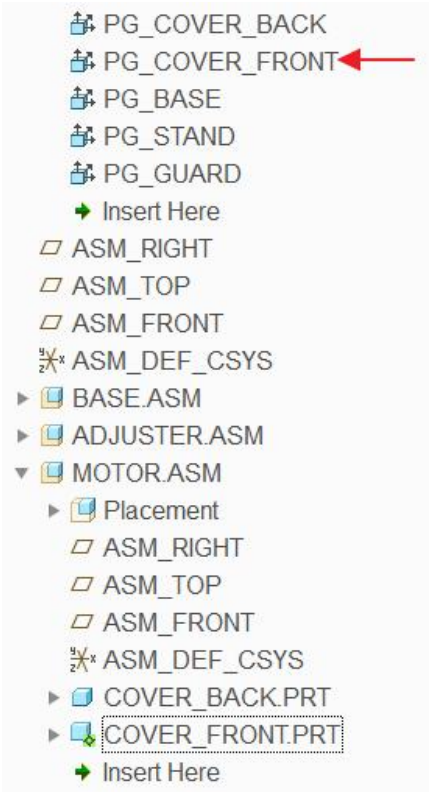
Pick  to apply the changes and exit the dashboard.

Now we will create the External Copy Geometry feature in the COVER_FRONT.PRT

Select the COVER_FRONT.PRT in the model tree and select **Activate**.

To create a copy geometry feature, pick Copy Geometry on the Model tab.

As Publish Geometry reference collector is active by default so select the PG_COVER_FRONT feature in the skeleton part as shown below.



Pick icon in the dashboard to make this feature External.

System will ask you to confirm the conversion process. So pick Yes to confirm.

Pick **Default** in the Placement dialog box.

Pick OK to proceed.

Pick to apply the changes and exit the dashboard.

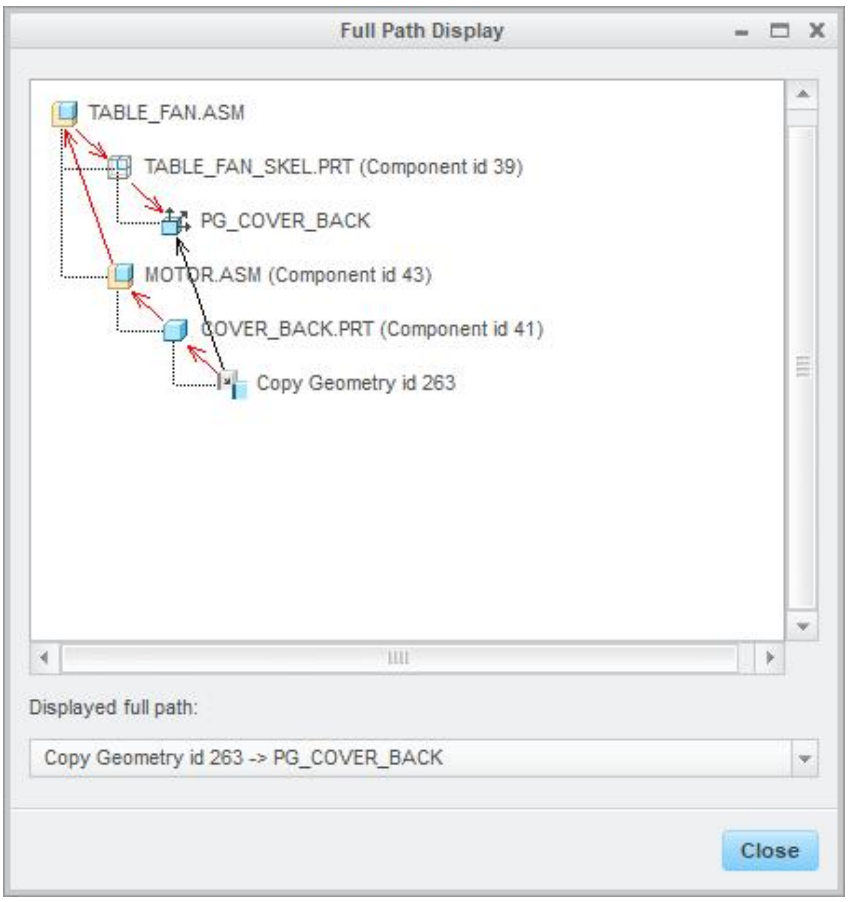
Investigating External References

Now we will analyze the external dependencies due to copying external references in these parts.

Right-click over the COVER_BACK.PRT and pick **Information > Reference Viewer** to open the Reference Viewer.

Right-click the current object and pick **Display Full Path**.

Full Path Display dialog box will appear as shown below.



It can be seen that the parent of the copy geometry feature in COVER_BACK is the Publish Geometry feature in the TABLE_FAN_SKEL part in the context of the TABLE_FAN.ASM. So the system will need the skeleton and TABLE_FAN assembly in session to update and regenerate this part when the skeleton is modified. Therefore this method should never be used to copy references to a part as it requires the complete main assembly in session to propagate a change from skeleton.

Never use an Internal Copy Geometry feature to copy the references from the skeleton in main-assembly to a part in sub-assembly. System needs all the assemblies, in the path of source and target parts, in session to regenerate the Internal Copy Geometry feature.

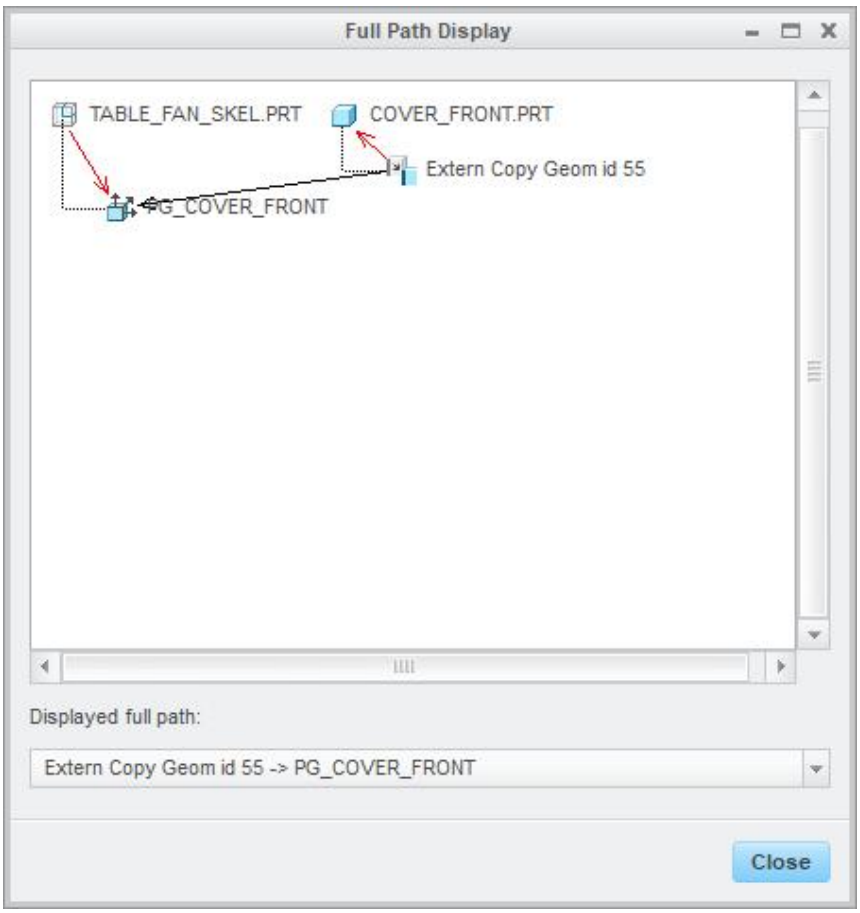
Pick Close to close the Full Path Display dialog box.

Pick Close to close the Reference Viewer.

Right-click over the COVER_ FRONT.PRT and pick **Information > Reference Viewer** to open the Reference Viewer.

Right-click the current object and pick **Display Full Path**.

Full Path Display dialog box will appear as shown below.



It can be seen that the external copy geometry feature in COVER_FRONT is referencing the Publish Geometry feature in the TABLE_FAN_SKEL part without assembly context. So the system will only need the skeleton in session to update and regenerate this part when the skeleton is modified. Therefore we can use this method without pulling all parts and assemblies into session. So a part using external copy geometry will require very few resources of the computer to update and regenerate it.

Pick Close to close the Full Path Display dialog box.

Pick Close to close the Reference Viewer.

Creating Model Geometry

Now you can create geometry in individual parts. In single skeleton approach, you will create features in a single skeleton that you need to reference in multiple parts.

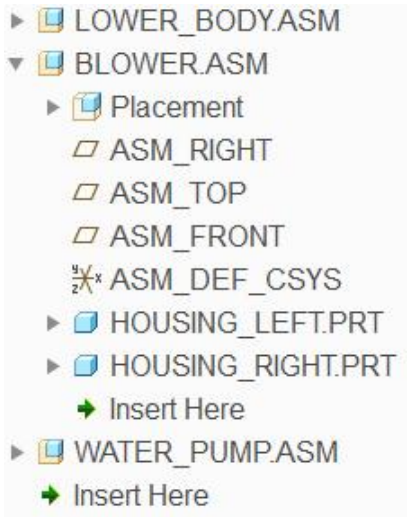
Exercise 2

In this exercise you will learn how to implement top-down design to a multi-level assembly by using separate skeleton at each assembly level.

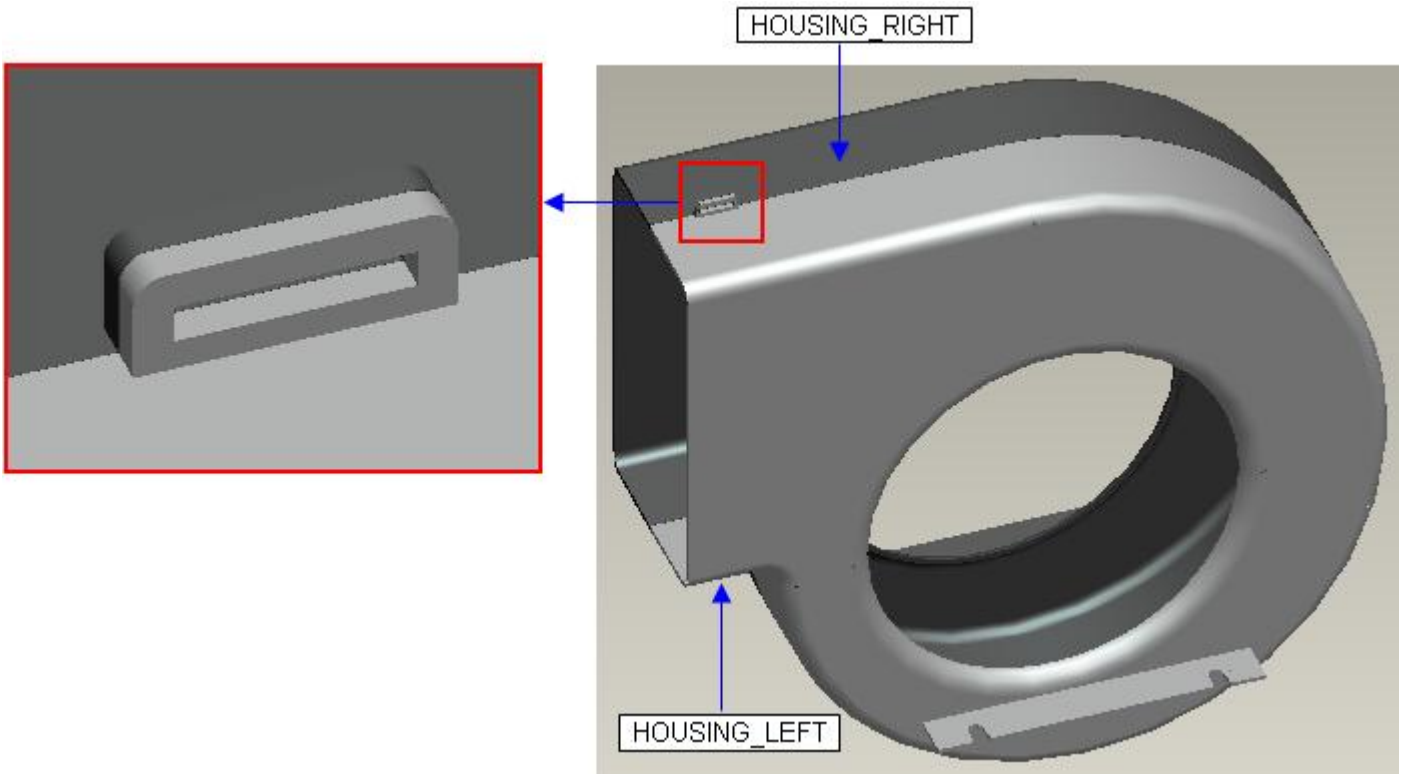
Set the working directory to AIR_COOLER folder and open the assembly AIR_COOLER.ASM

Notice that there are four sub-assemblies in the main assembly and all of them have been assembled by Default constraint.

There are two empty parts already assembled in the BLOWER.ASM as shown below.



These parts constitute the housing for blower and are shown in the figure below (after completing this exercise).

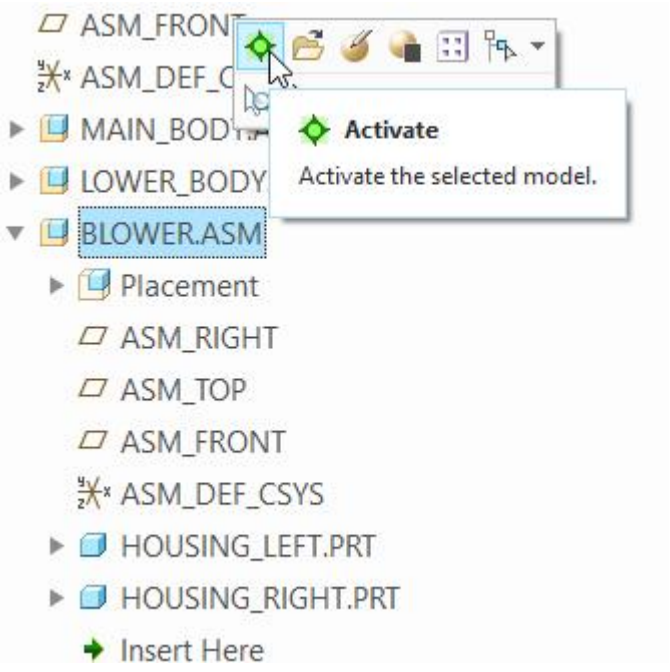


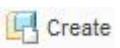
In the following paragraphs, we will create the geometry for HOUSING_LEFT that will be driven by the skeleton models.

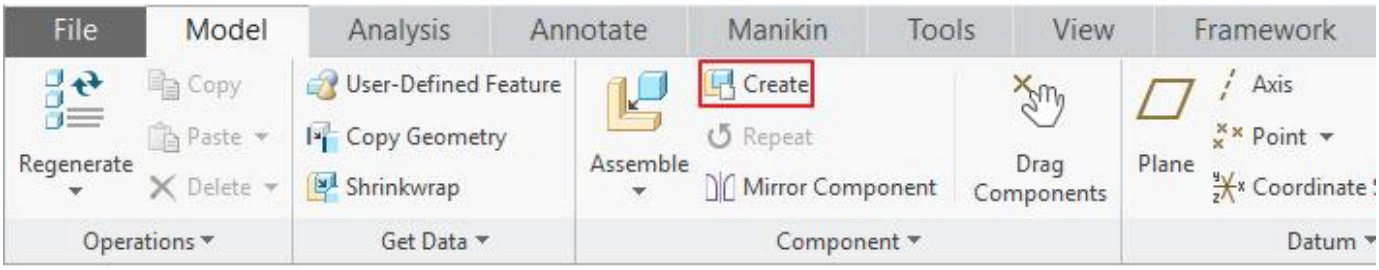
Creating the Skeleton

First we will create a skeleton model in the BLOWER.ASM

Select the BLOWER.ASM and pick **Activate**

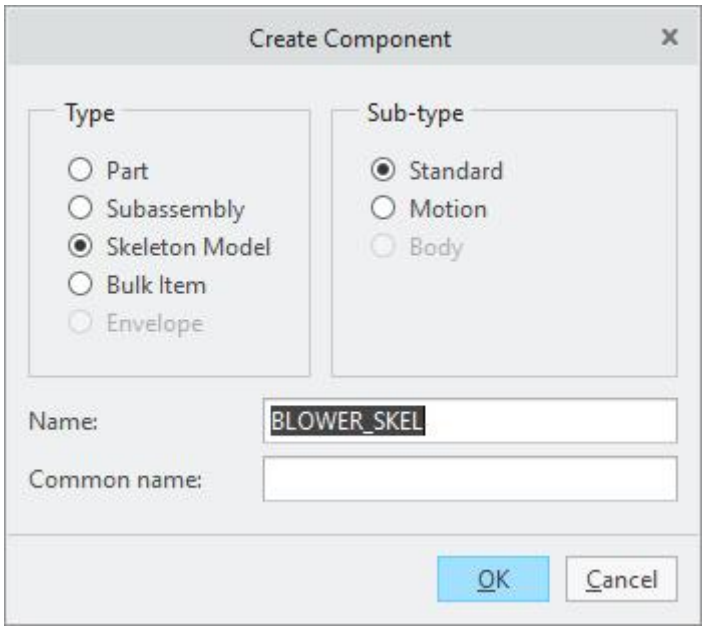


Pick the Create a component icon ()



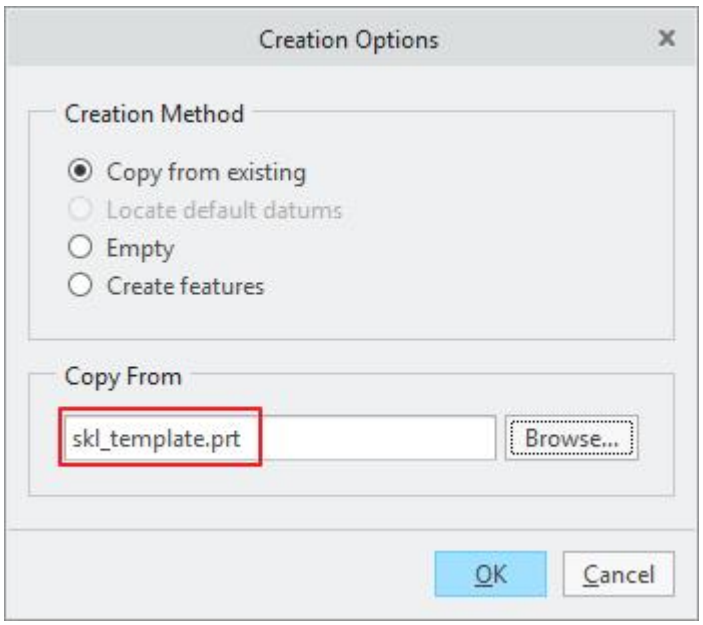
Skeletons models can only be created in an assembly

Component Create dialog box will appear. Here change the Type to **Skeleton Model** and Sub-type to **Standard** as shown below.



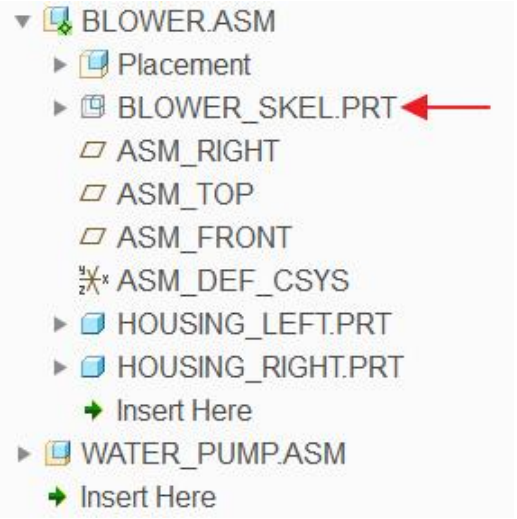
Notice that system automatically gives a new name to the skeleton model.

Pick OK and Create Options dialog box will appear. Pick Browse... tab and select the SKL_TEMPLATE.PRT as shown below.



SKL_TEMPLATE.PRT is template file that contains default datum features and accuracy settings.

Pick OK and newly created skeleton model will appear in the active assembly i.e. BLOWER.ASM in the model tree as shown below.



The system always inserts the newly created skeleton before all other components and assembly features.

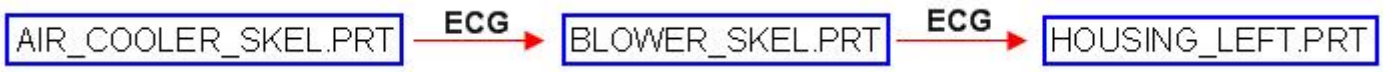
You can also create this skeleton model by opening the BLOWER.ASM in a new window and then picking Create

Communicating the Design Information From Skeleton to Skeleton

The geometry to be referenced for creating HOUSING_LEFT lies in AIR_COOLER_SKEL.PRT

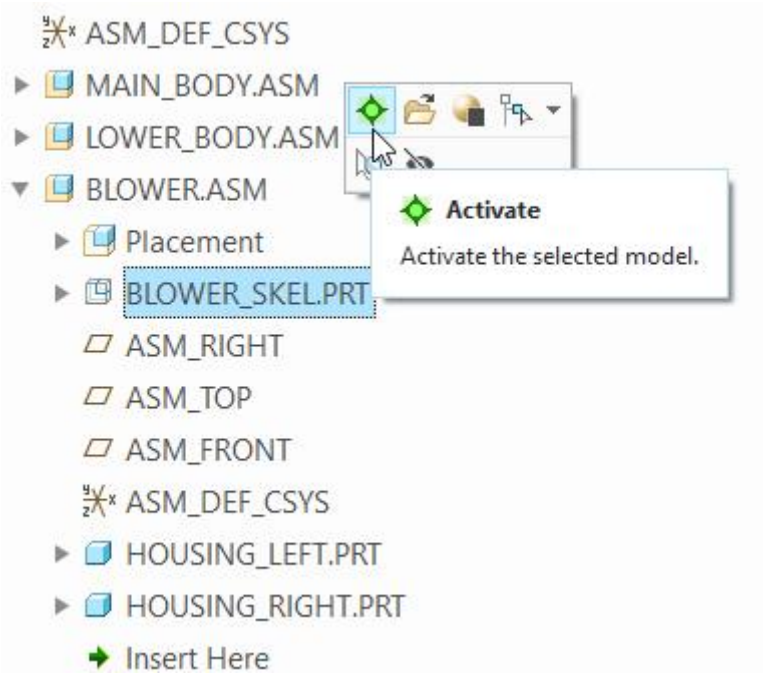
First we will use the External Copy Geometry feature to copy the references from main skeleton (AIR_COOLER_SKEL.PRT) to the skeleton in the BLOWER.ASM. Then we will use another

External Copy Geometry feature to copy references from BLOWER_SKEL.PRT to the HOUSING_LEFT.PRT. The flow of data is shown graphically in the figure below.



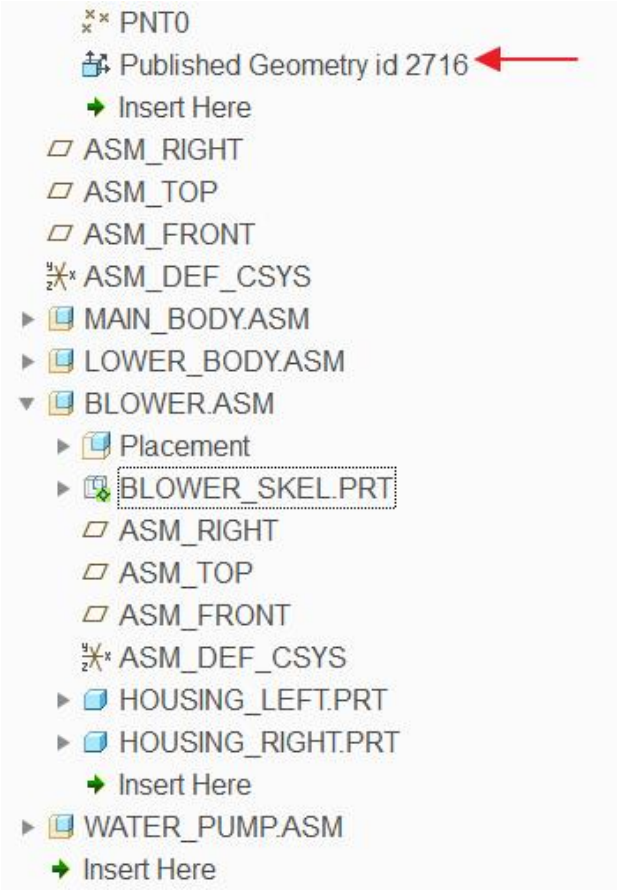
When you need to copy the geometry from the main-assembly skeleton model to a component in a sub-assembly, first copy the geometry to the skeleton model in the sub-assembly where it is needed.

In the AIR_COOLER.ASM window, pick the BLOWER_SKEL.PRT in the model tree and select **Activate**.



To create a copy geometry feature, pick Copy Geometry on the Model tab.

In the Copy Geometry dashboard Publish Geometry reference collector is active by default. So select the only publish geometry feature in the AIR_COOLER_SKEL.PRT



Pick  icon in the dashboard to make this feature External.

System will ask you to confirm the conversion process. So pick Yes to confirm.

Now system will require you to specify how the external copy geometry feature will be located relative to the source part (AIR_COOLER_SKEL.PRT).

Pick **Default** in the Placement dialog box.

The Default constraint aligns the default system-created coordinate systems of the target component to the default system-created coordinate system of the source part.

Pick OK to proceed.

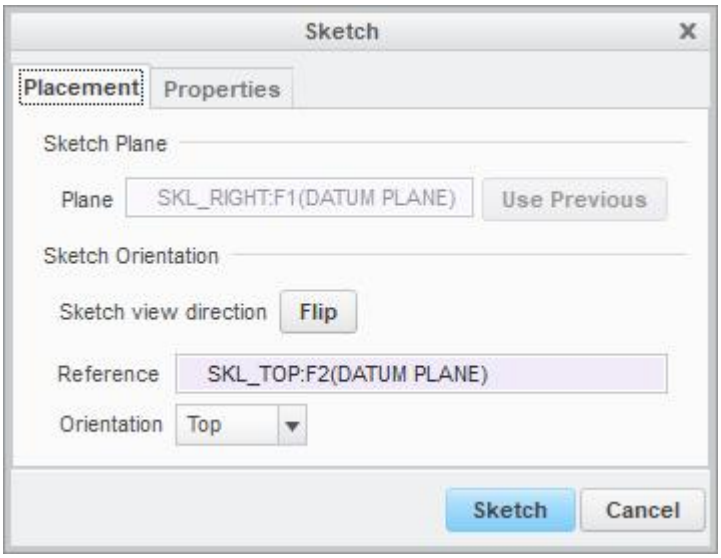
Pick  to apply the changes and exit the dashboard.

Adding Features in Skeleton

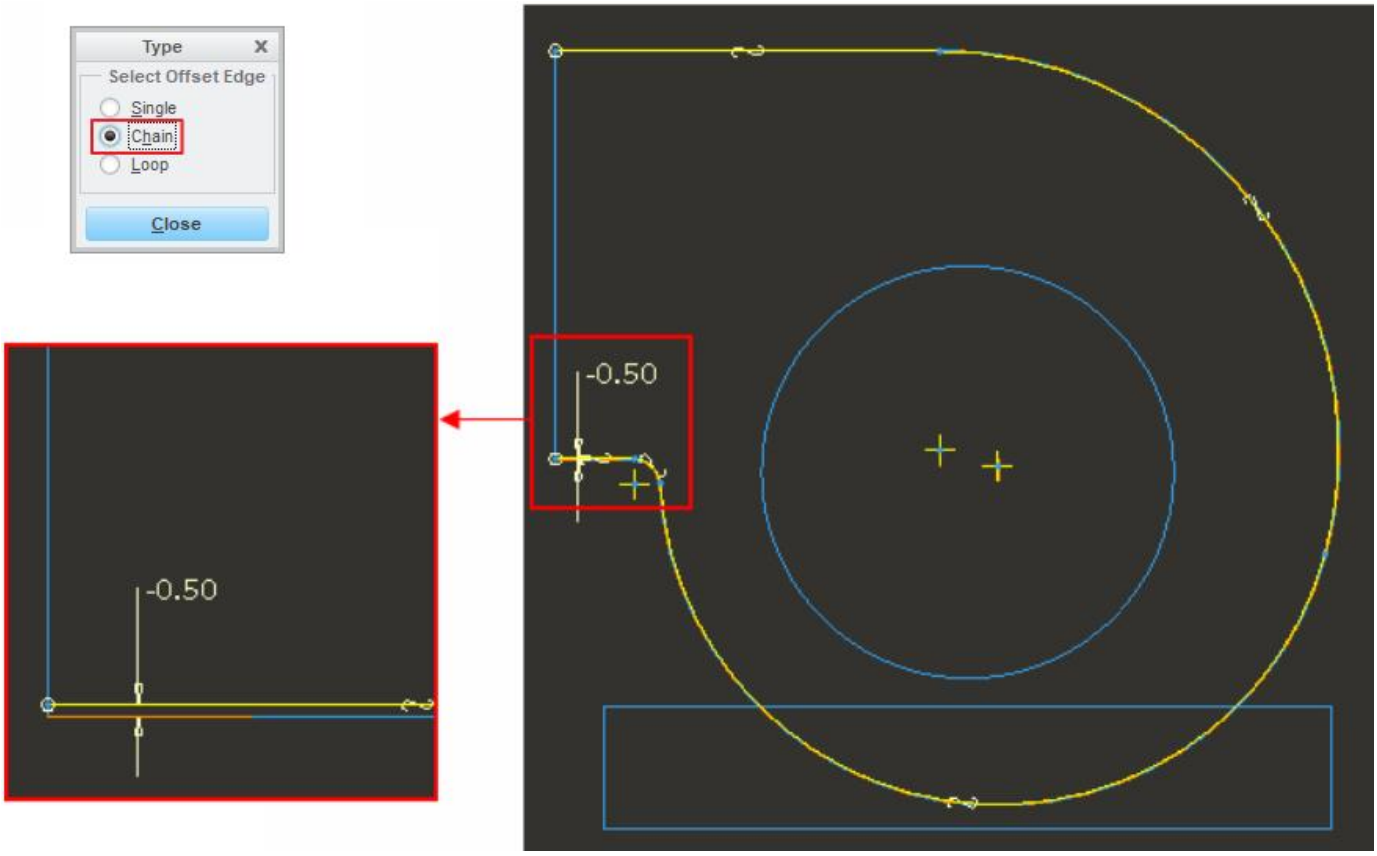
Now we will create a datum curve in the skeleton that will be used to create the interlock detail so that both parts (i.e. left and right sides of the housing) are aligned and positioned relative to each other during the assembly.

Open the BLOWER_SKEL.PRT in a separate window.

Pick and select the sketching references as shown below.



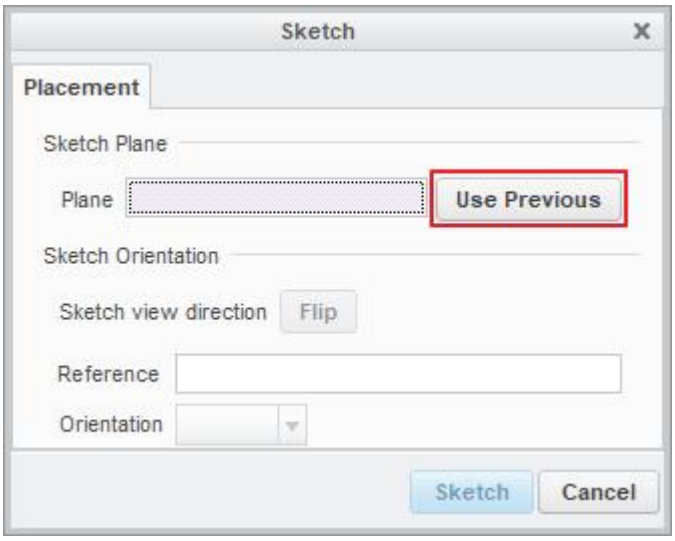
Pick Offset and offset the following chain by ***-0.5*** from the curve as shown below.



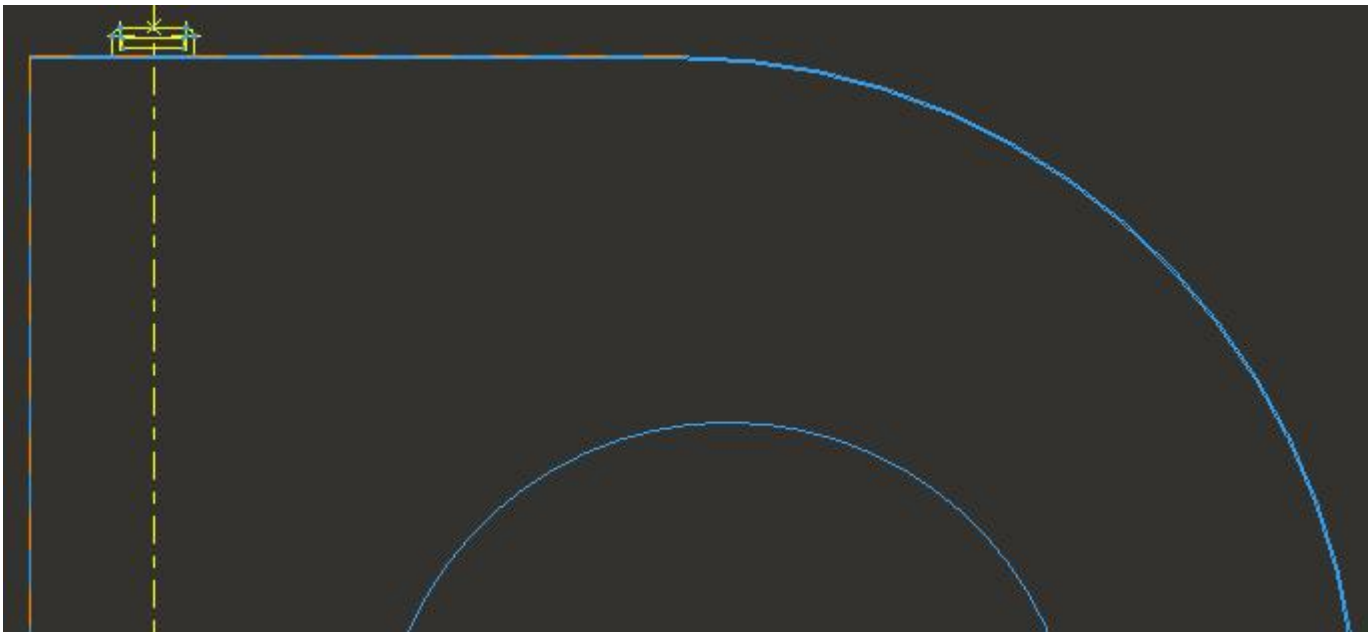
Pick to complete the section.

Now we will create another datum curve that will be used to create holding geometry for both parts (i.e. left and right sides of the housing).

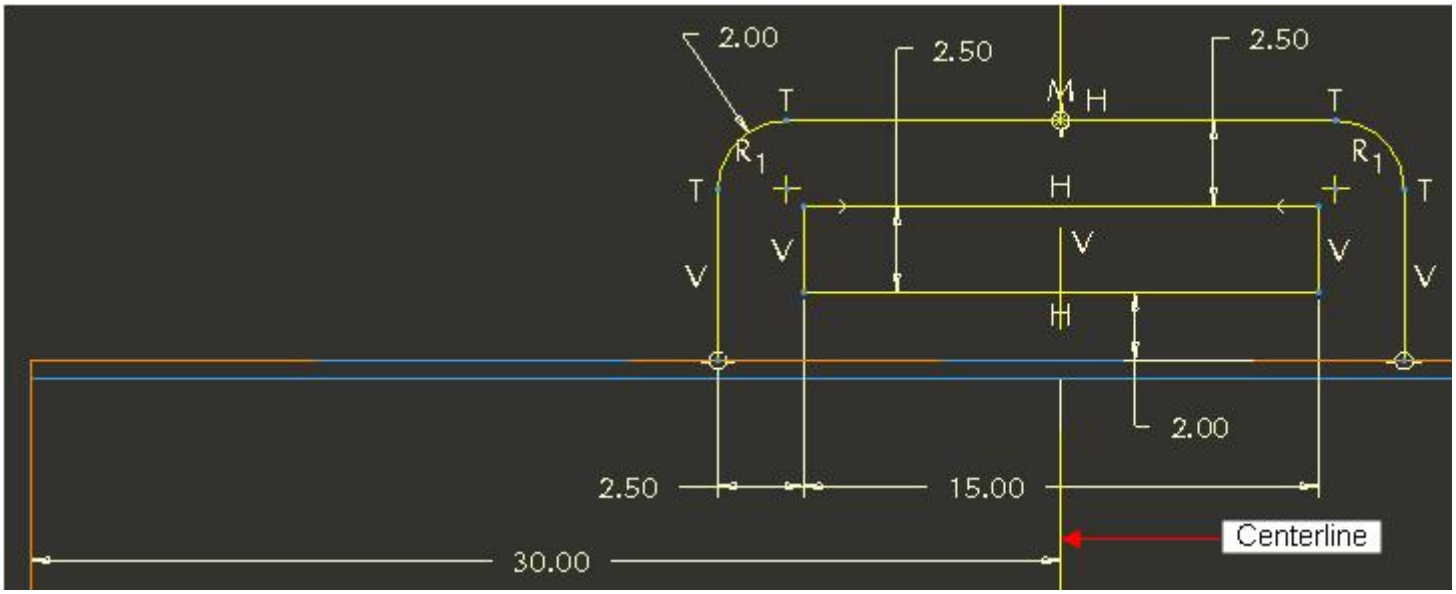
Again pick and select the same sketch placement references used for previous feature by using the **Use Previous** option in the Sketch dialog box.



Sketch the section as shown below.



The dimensioning details are given as shown below.



Pick ✔ to complete the section.

We did not create these datum curves in the AIR_COOLER_SKEL because only two parts in the project need to reference them and those parts are located in the BLOWER.ASM. Therefore we have added these datum curves in the BLOWER_SKEL.PRT so that both parts can copy the reference geometry from here without cluttering the AIR_COOLER_SKEL

Communicating the Design Information to Components

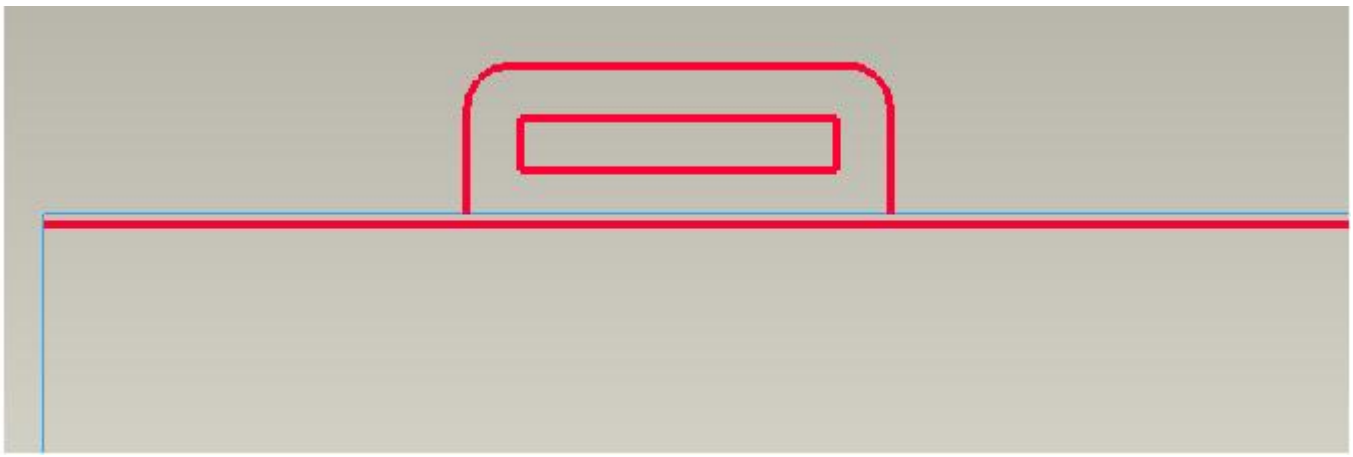
Now we will communicate the references from BLOWER_SKEL.PRT to individual parts in BLOWER.ASM

First we will create the Publish Geometry feature in the skeleton model. So make sure that skeleton model window (BLOWER_SKEL.PRT) is active.

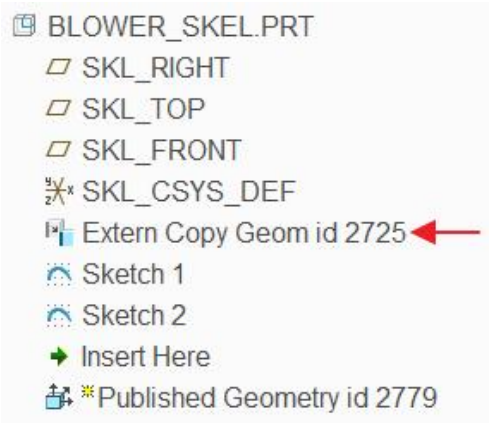
Pick on the Tools tab.

The Publish Geometry dialog box will appear. Pick in the **Chain** collector to activate it.

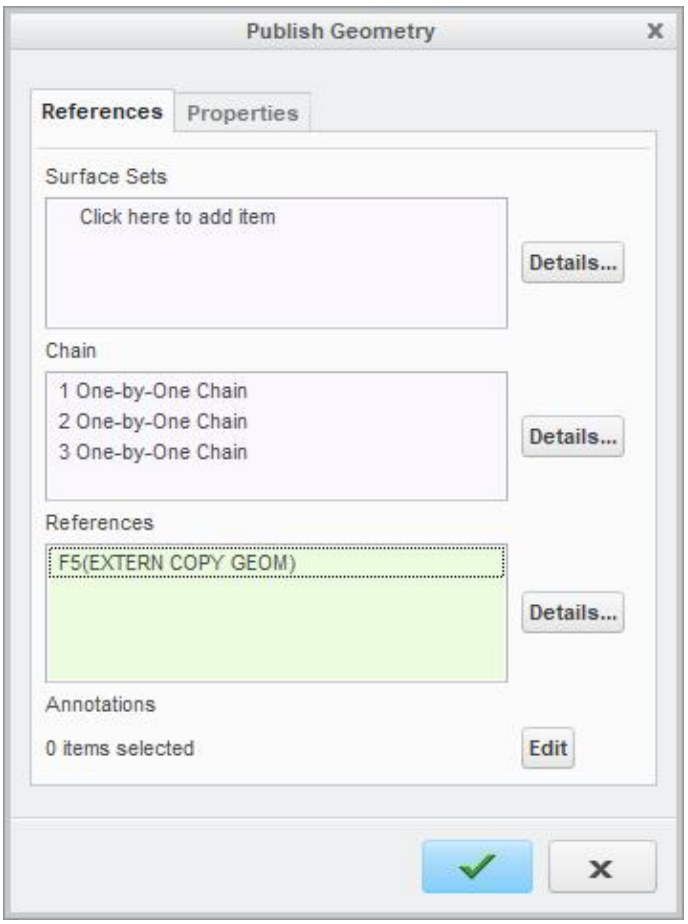
Hold down the Ctrl key and pick the datum curves in the skeleton model that we just created as shown below.



Pick in the **References** collector and select the external copy geometry feature in the model tree.



PUBLISH GEOMETRY dialog box will appear as shown below.



If complete copy geometry feature is not required, we can copy the required geometry belonging to a copy geometry feature by using the Surface and Chain collectors.

Pick  to apply the changes and exit the dialog box.

Now we will create External Copy Geometry feature in HOUSING_LEFT.PRT. This External Copy Geometry feature will reference the Publish Geometry feature created in the skeleton part.

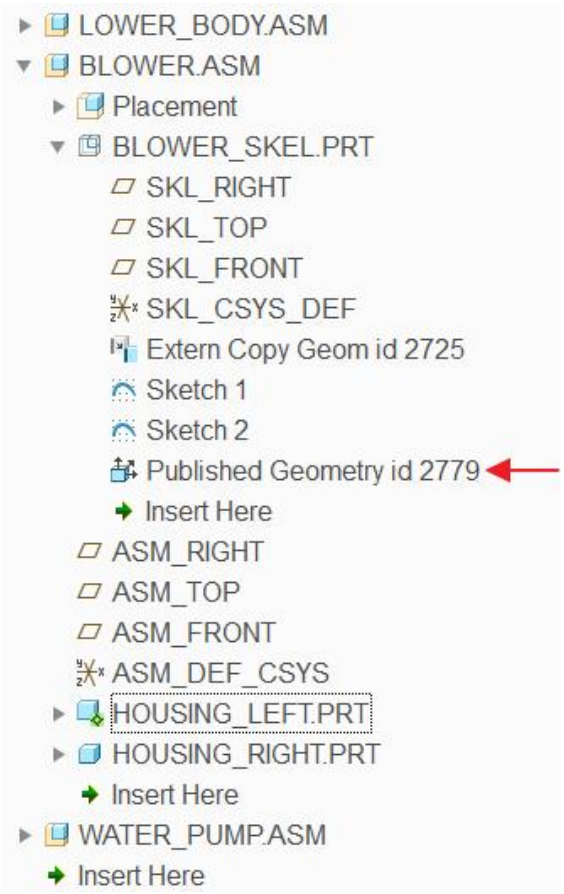
Switch to the AIR_COOLER.ASM and make it active. (You can also create the ECG by switching to BLOWER.ASM window. The end result will be same)

Select the HOUSING_LEFT.PRT in the model tree and select **Activate**.

To create a copy geometry feature, pick 

on the Model tab.

As Publish Geometry reference collector is active by default so select the publish geometry feature in the skeleton (BLOWER_SKEL) part by picking it in the model tree as shown below.



Pick icon in the dashboard to make this feature External.

System will ask you to confirm the conversion process. So pick Yes to confirm.

Pick **Default** in the Placement dialog box.

Pick OK to proceed.

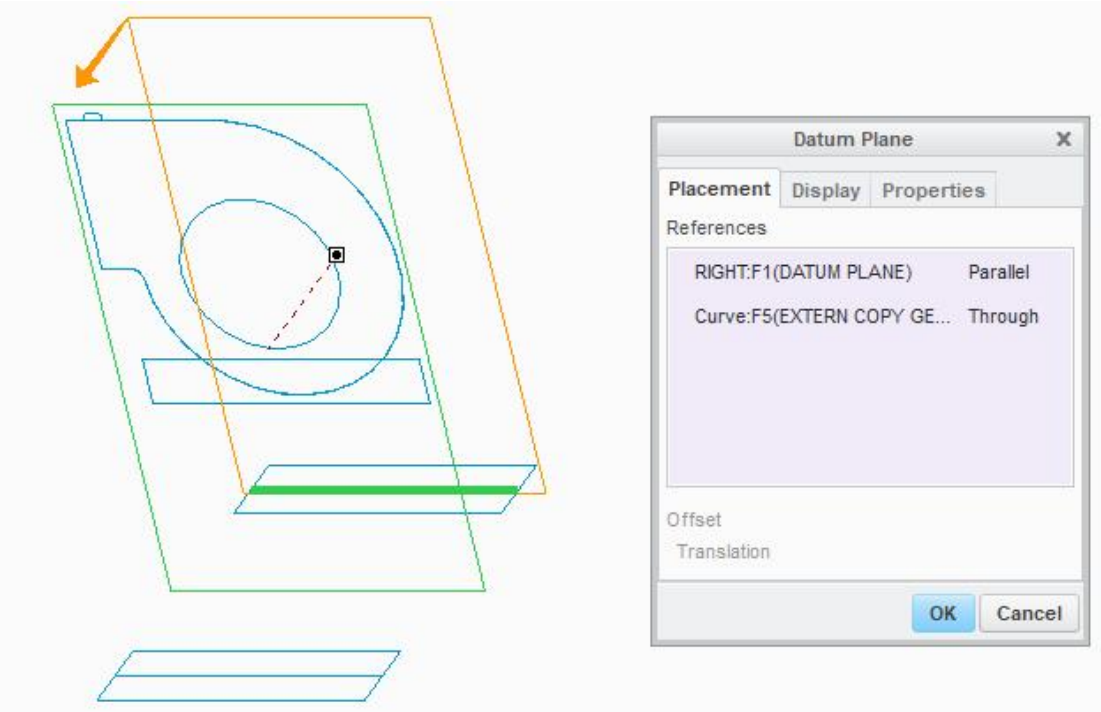
Pick to apply the changes and exit the dashboard.

Creating Geometry in Component

Now the information is captured from the skeleton model into the individual component. We will use the External Copy Geometry feature as a reference to build geometry in the part.

Open the HOUSING_LEFT.PRT in separate window

First we will create a datum plane. So pick on the Model tab and select the references as shown below. Set the view to **ISO2** to avoid any ambiguity.

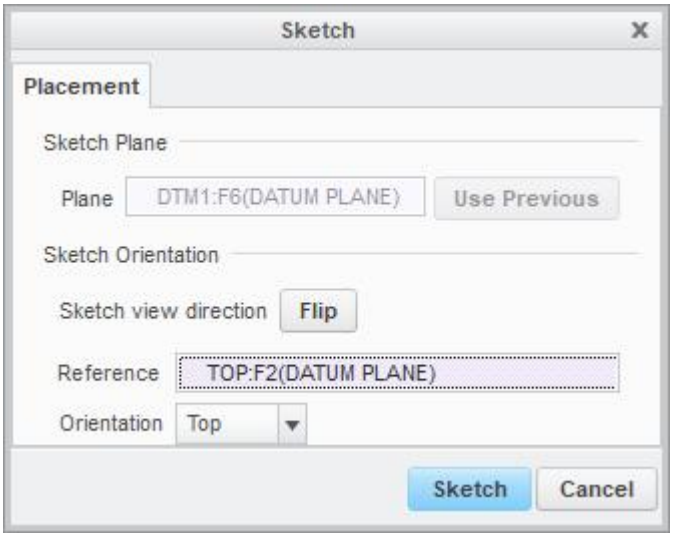


Notice that datum plane is parallel to RIGHT datum and passes through the selected curve.

Pick OK icon to complete the feature.

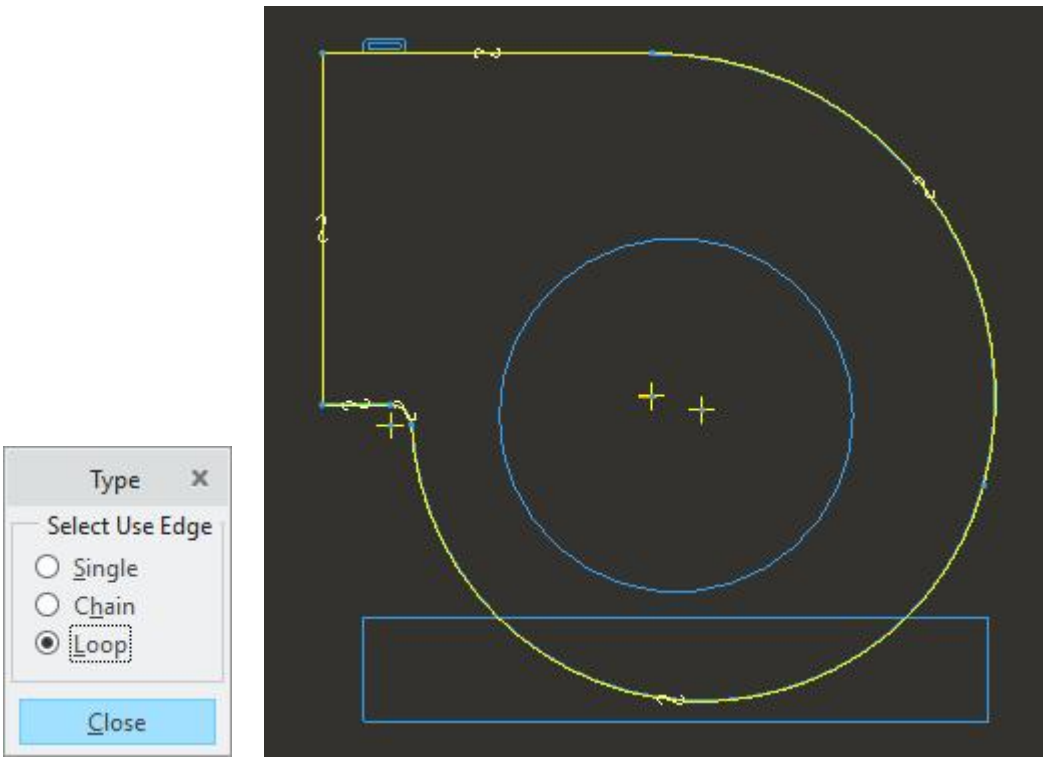
Pick to invoke Extrude tool.

Select the sketching references as shown below

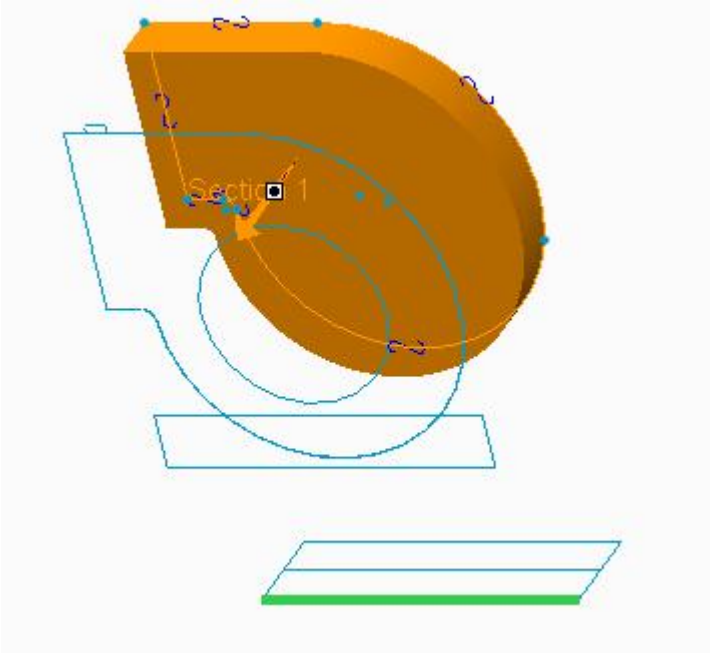


"DTM 1" is the newly created datum plane.

Pick Project icon and select the following loop.



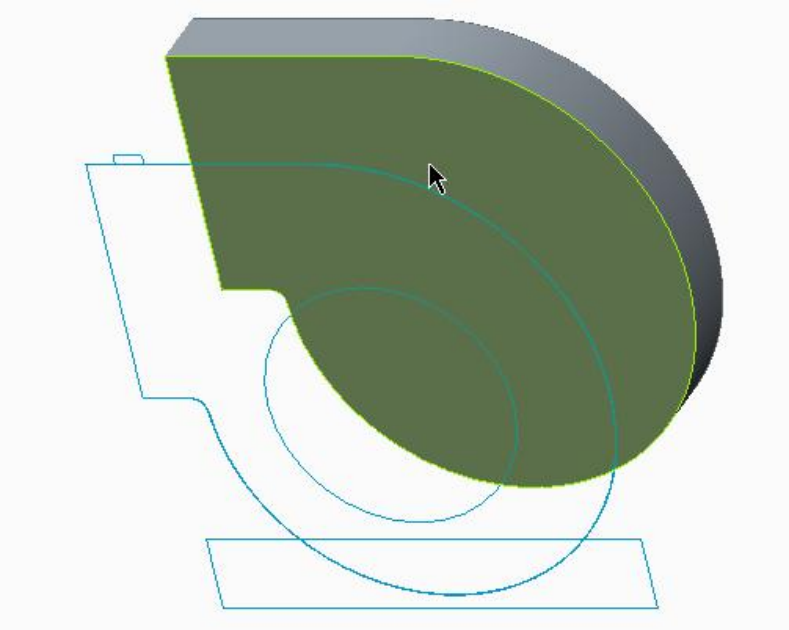
After completing the sketch, change the depth option to **To Selected** ( ) and select the highlighted curve as reference.



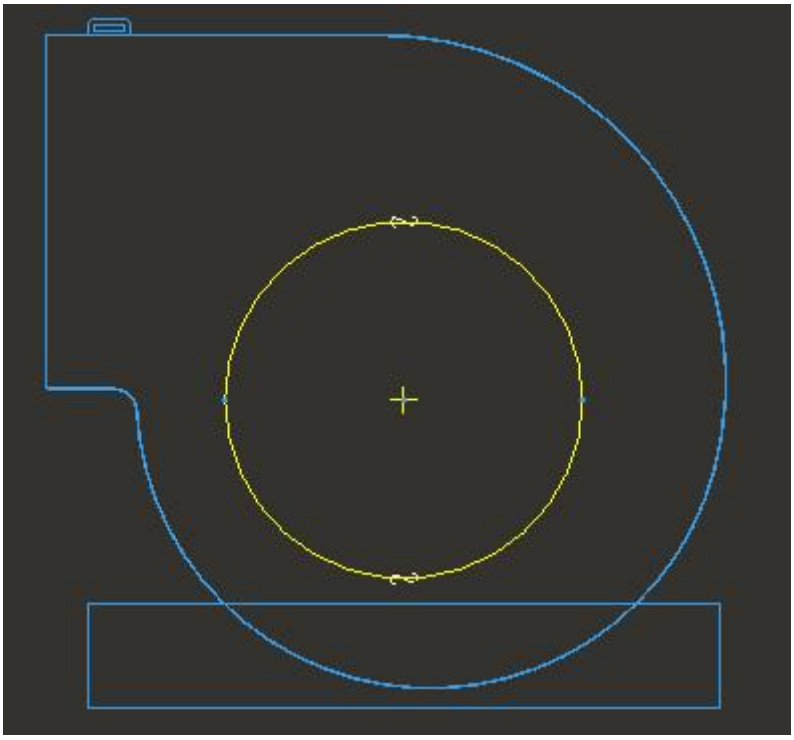
Pick icon to complete the feature.

Pick to invoke Extrude tool.

Select the highlighted surface as sketching plane.



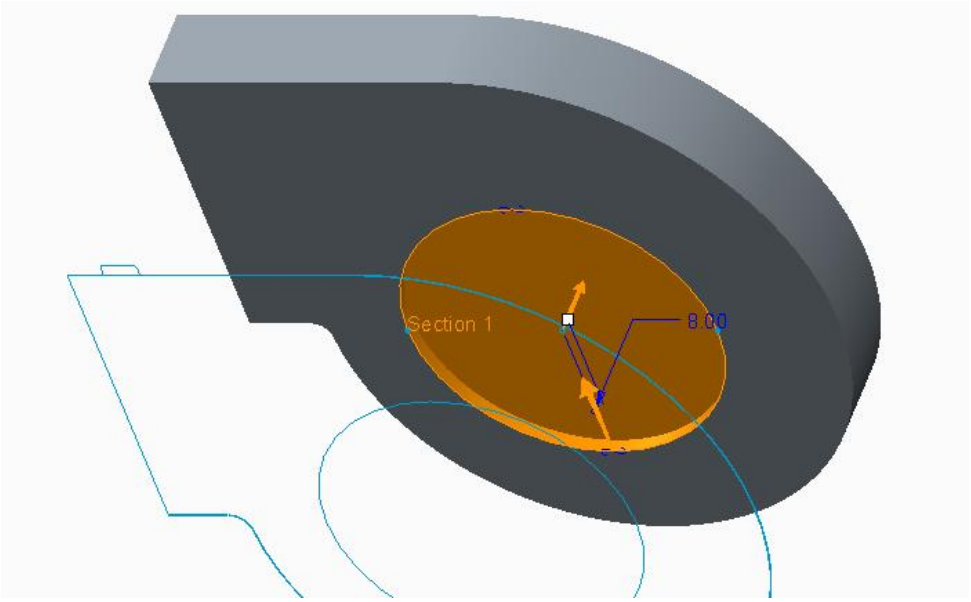
Pick Project icon and select the following loop.



After completing the sketch specify the blind depth of **8**.

Pick the icon to reverse the direction of feature creation.

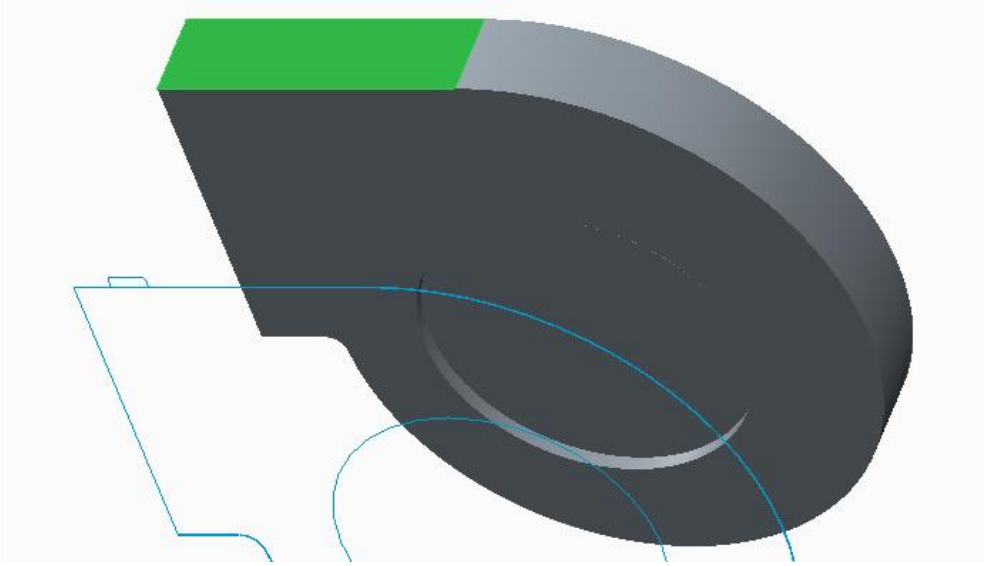
Pick icon to create the feature as cut.



Pick  icon to complete the feature.

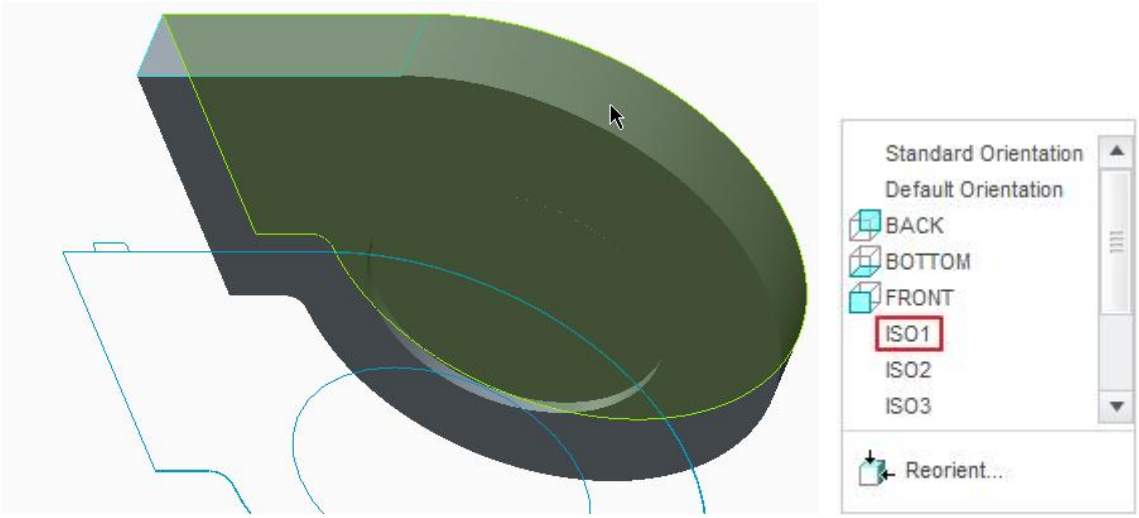
Now we will apply draft and rounds to this part then shell it.

Select the following surface.



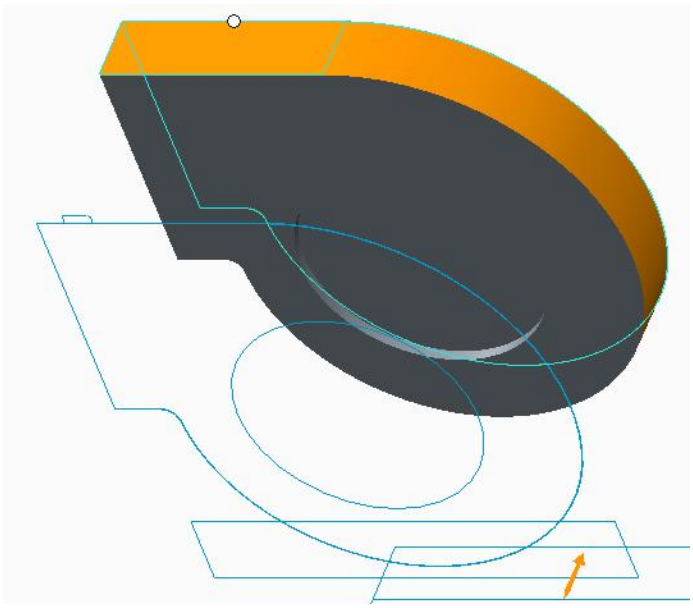
Pick  to access the Draft tool.

Notice that Draft hinges collector is active so select the following highlighted surface.



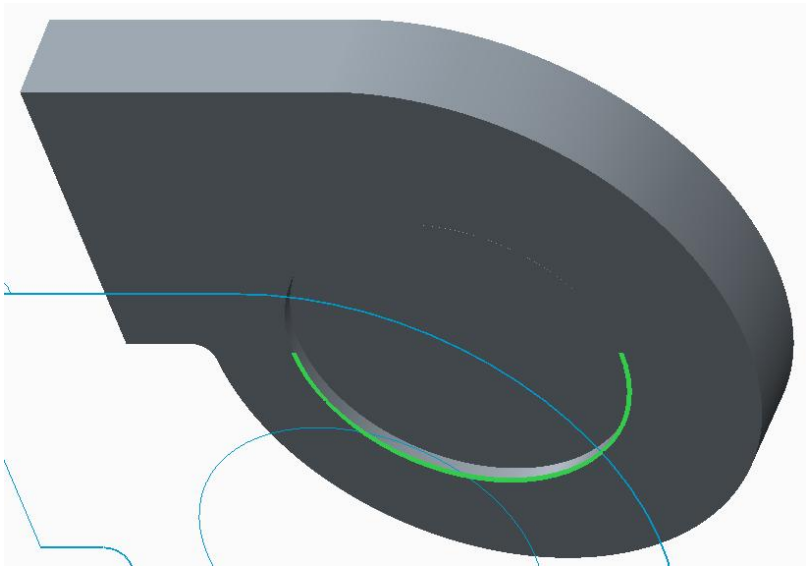
Enter ***1*** in the Draft angle field on the dashboard.

The preview of the drafted surface will appear as shown below.



Pick  icon to complete the feature.

Now select the following edge for applying round.

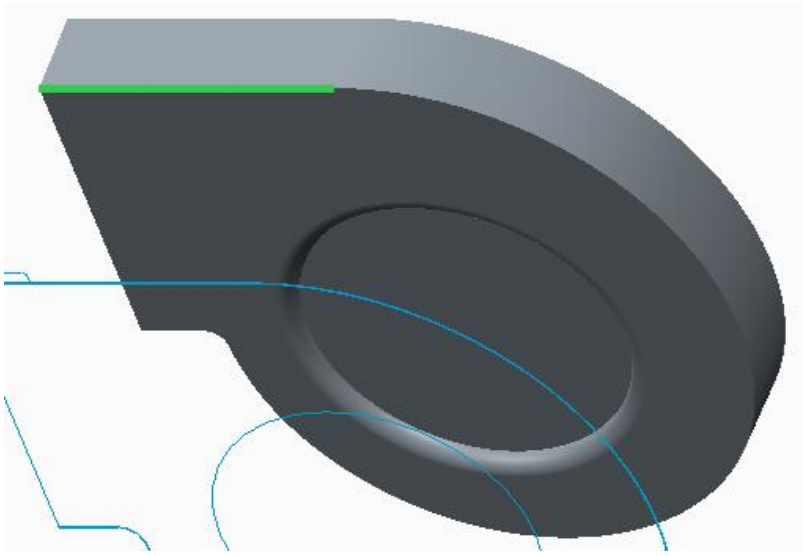


Pick Round to access the Round tool.

Enter ***10*** as the radius value

Pick icon to complete the feature.

Now select the following edge for applying round.



Pick Round to access the Round tool.

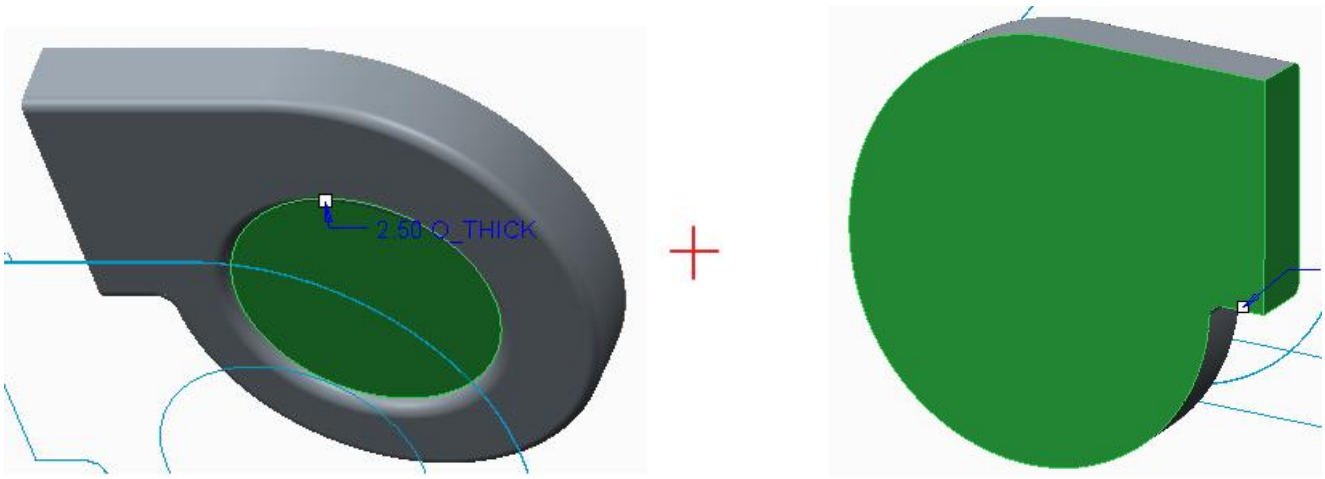
Enter ***8*** as the radius value

Pick icon to complete the feature.

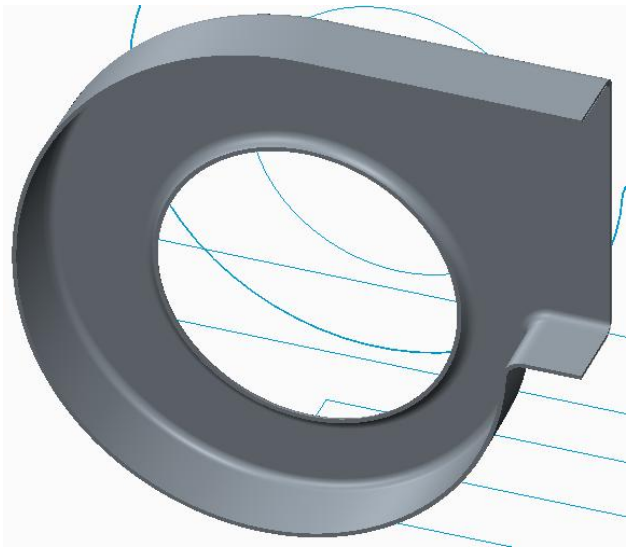
Pick Shell to access the Shell tool.

Enter ***2.5*** as the thickness value

Select the following three highlighted surfaces to add them to Removed surfaces collector.

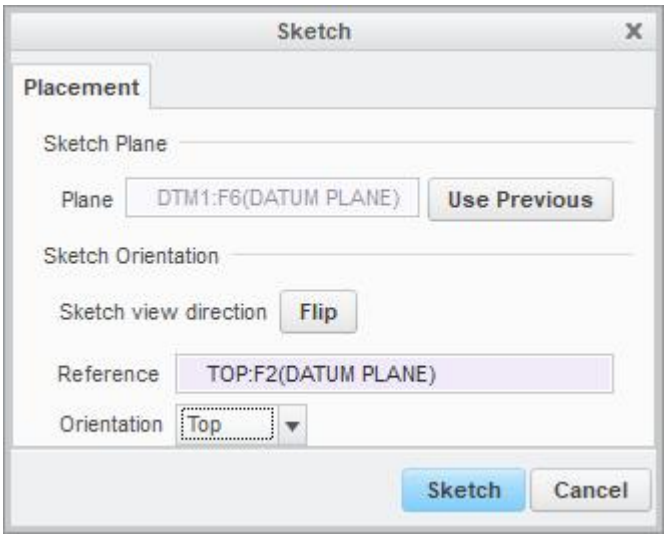


Pick icon to complete the feature. The part will appear as shown below.

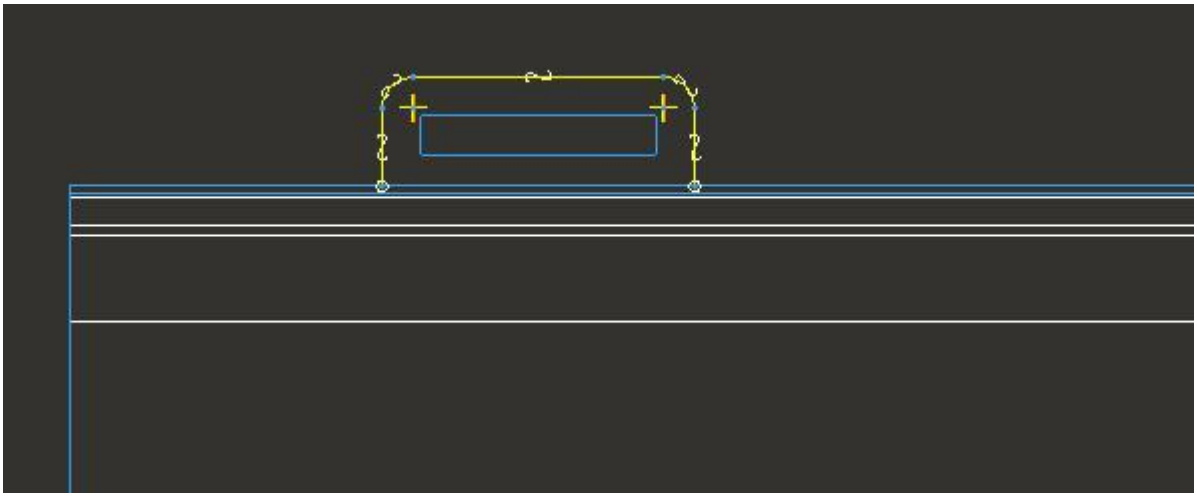


Now we will create the holding geometry.

Pick to invoke Extrude tool and select the sketching references as shown below



Pick Project icon and select the following loop.



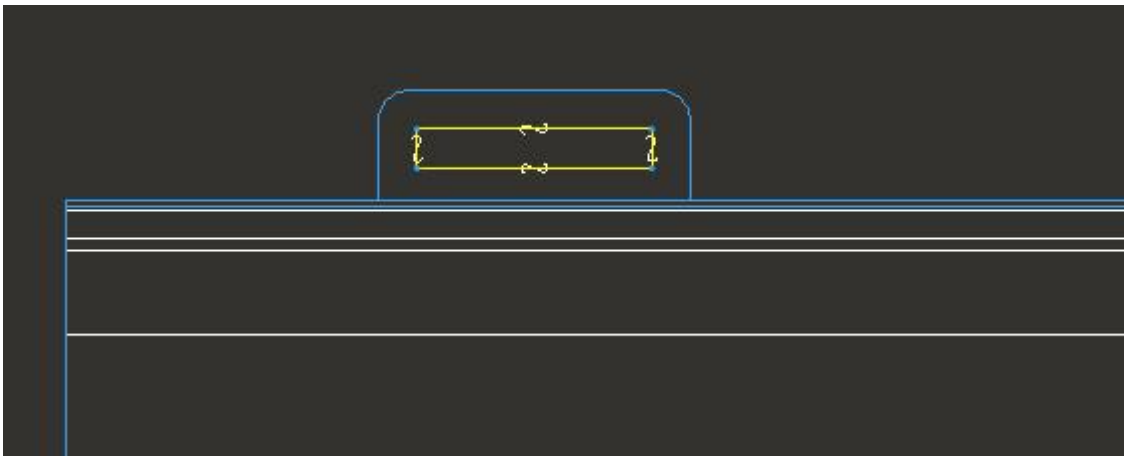
After completing the sketch, specify the blind depth of ***2.5***

Pick icon to complete the feature.

Again pick to invoke Extrude tool.

Select the same sketching references that were used for previous section by using the **Use Previous** option in the Sketch dialog box.

Pick Project icon and select the following loop.



After completing the sketch pick to create the feature as cut.

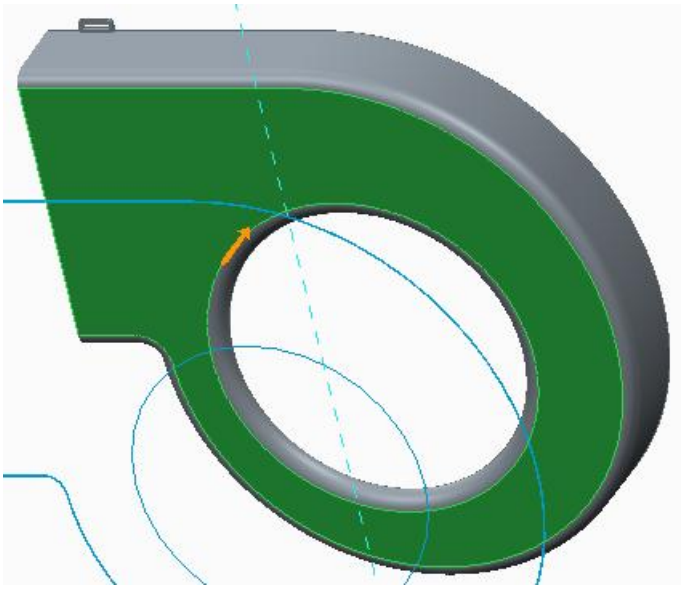
Change the depth option to **Through All** by picking the icon in the Depth options list

Pick  icon to complete the feature.

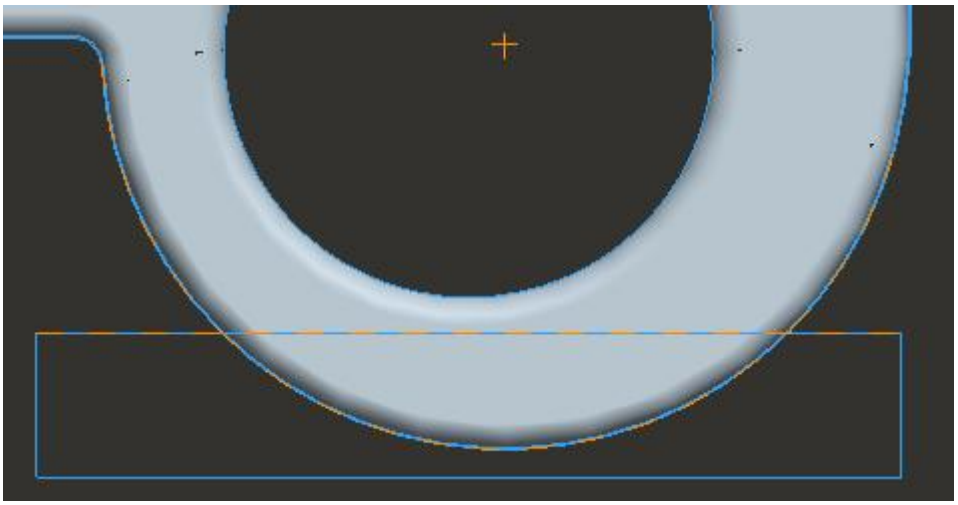
Now we will create a supporting rib that will sit against the MOTOR_BASE.PRT in the assembly.

Pick  to invoke Extrude tool.

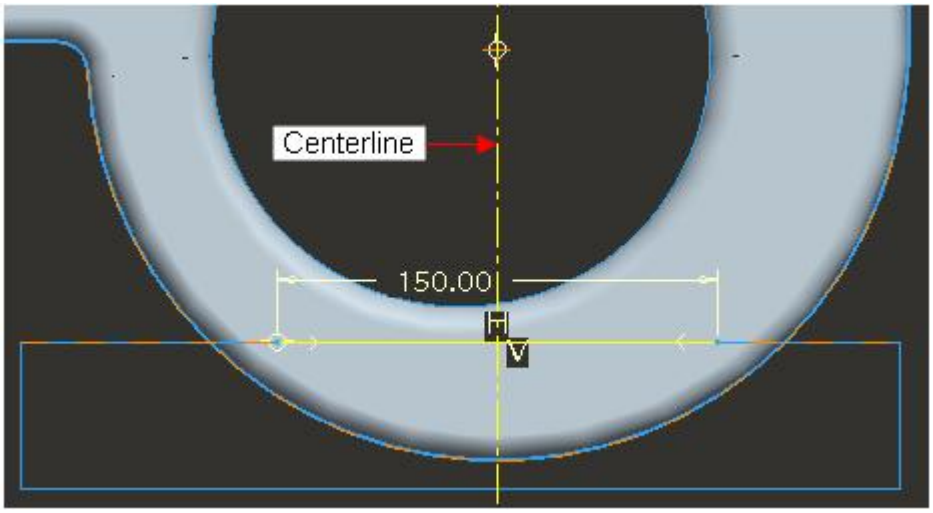
Select the highlighted surface as sketching plane.



Select the following datum curves as references.



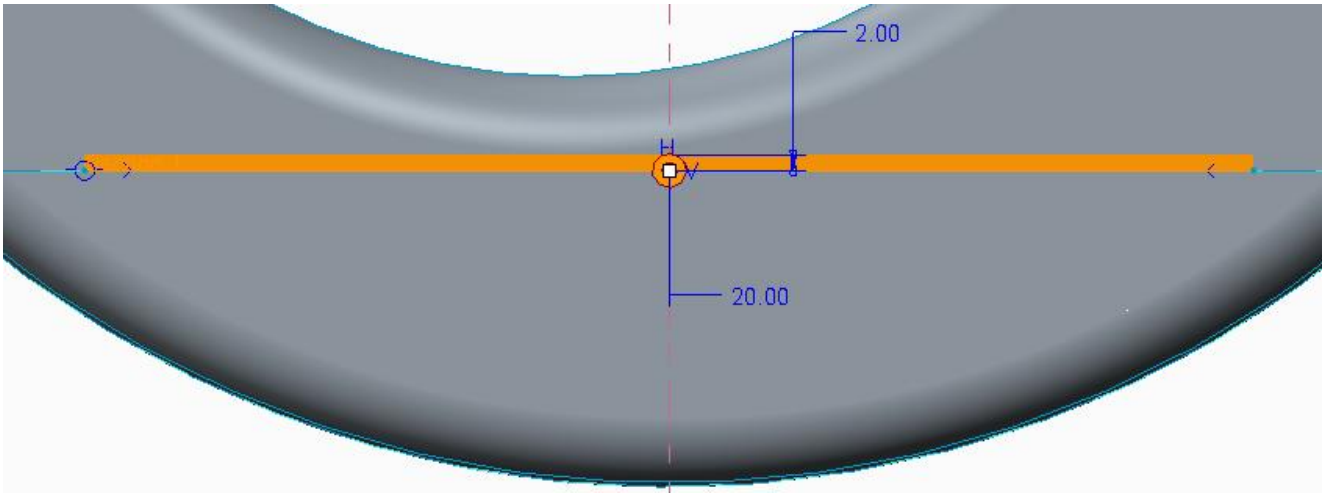
Now sketch the section as shown below.



After completing the sketch, specify the blind depth of ***20***

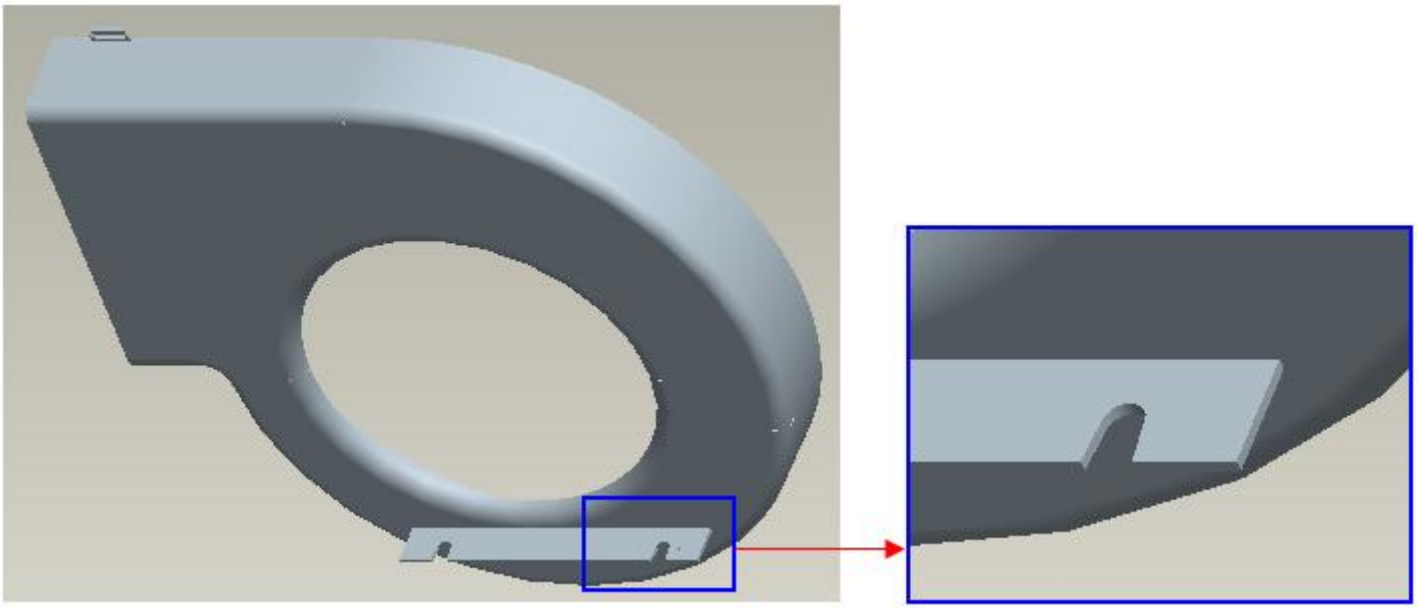
Pick  to create the feature as thin and specify the thickness of ***2.***

Pick  until the thickness is added to upper side of the sketch as shown in the figure below.



Pick  icon to complete the feature.

Now we will create cuts in the rib that will be used to screw this housing to MOTOR_BASE.PRT (that is located in the MAIN_BODY.ASM). After creating the cuts the part will appear as shown below.



The cut features in HOUSING_LEFT and bosses in MOTOR_BASE should be aligned. So we need to create the geometry in a skeleton that both parts can reference.

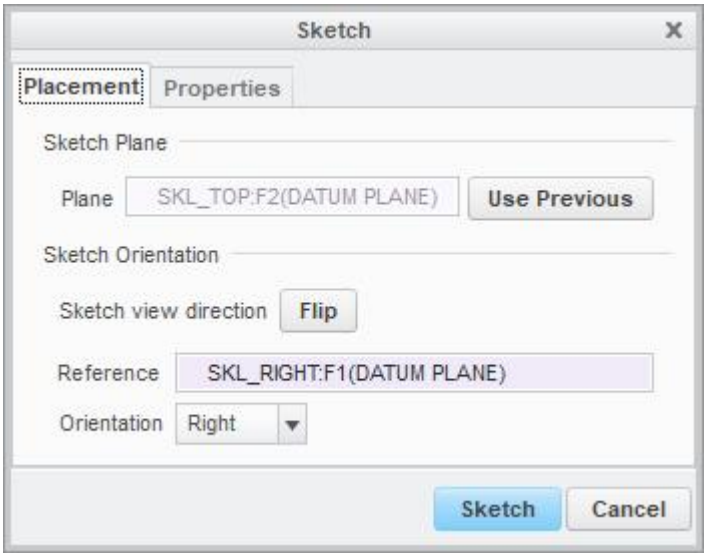
Adding Features in Main Skeleton

Now we will create datum curve in the AIR_COOLER_SKEL that will control the location of cuts in the HOUSING_LEFT and bosses in the MOTOR_BASE

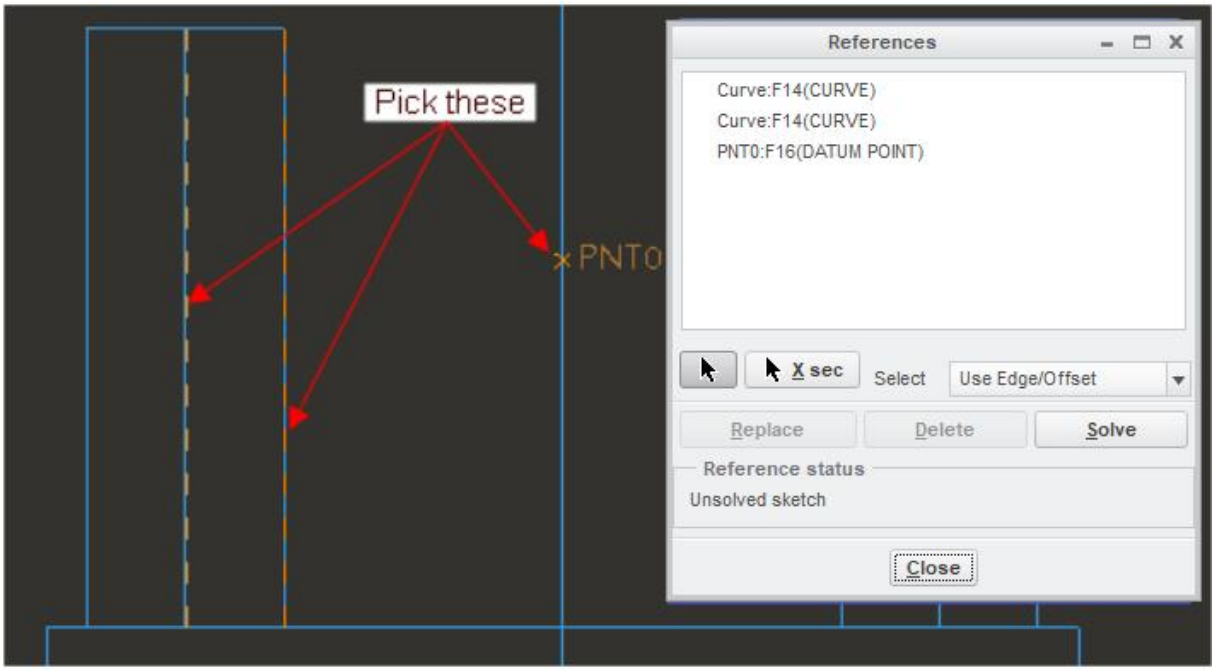
We are adding this datum curve in the AIR_COOLER_SKEL because we need this as reference in the parts that are located in different sub-assemblies

Open the AIR_COOLER_SKEL.PRT in a new window.

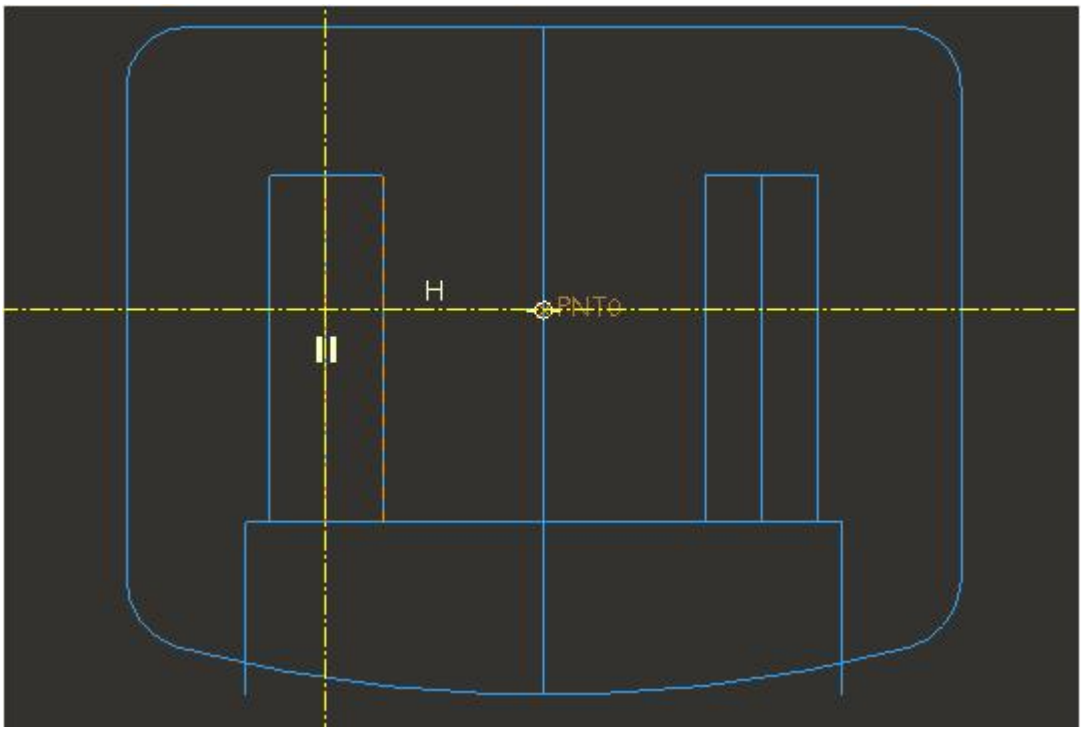
Pick and select the sketching references as shown below



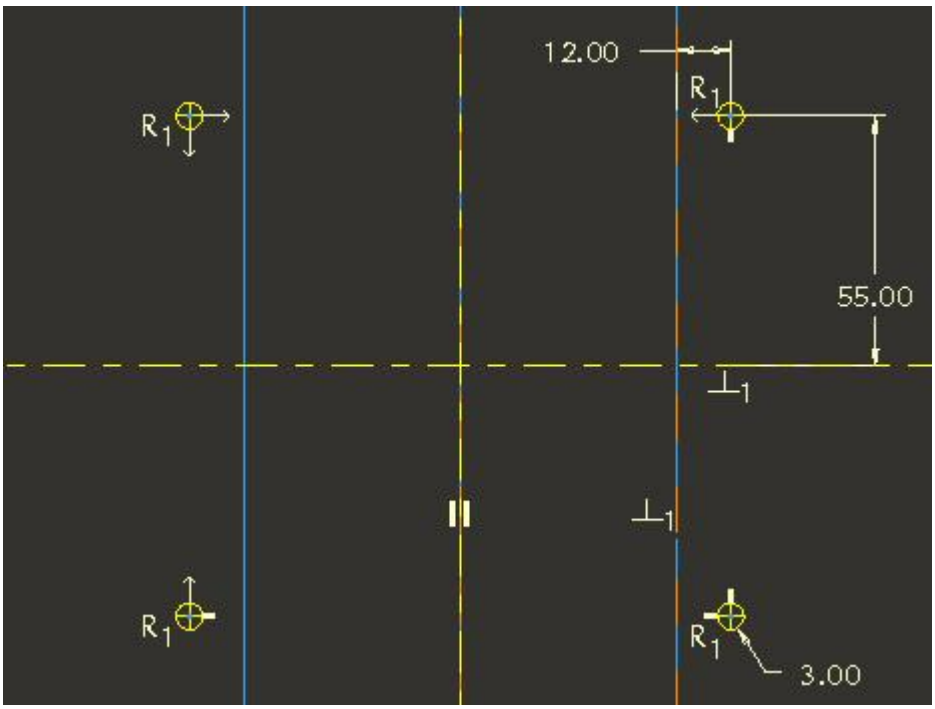
Delete the default references and select the new references as shown below



Now sketch two centerlines as shown below.



Now sketch the four circles that are symmetric about centerlines as shown below.



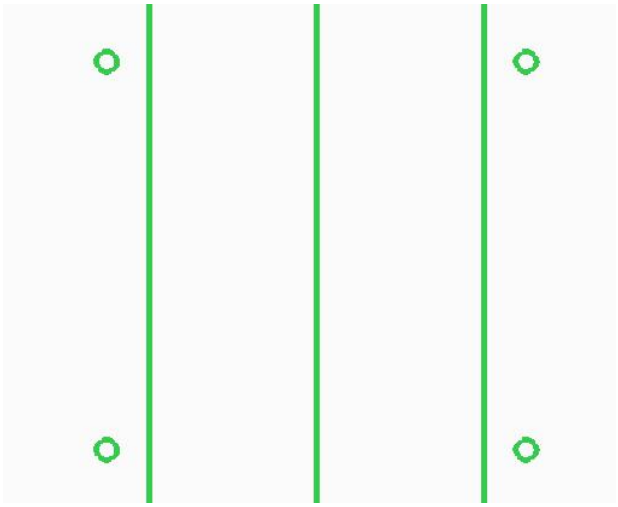
Pick ✔ to complete the section.

Now we will redefine the publish geometry feature and add this new curve. But first we should reorder this new sketched curve to appear before the publish geometry feature.

So drag the “Sketch 1” before the publish geometry feature as shown below.

Right click the publish geometry feature and pick 

Activate the Chains collector and pick the four circles while holding down Ctrl key.



Pick to apply the changes and exit the dialog box.

Creating Model Geometry

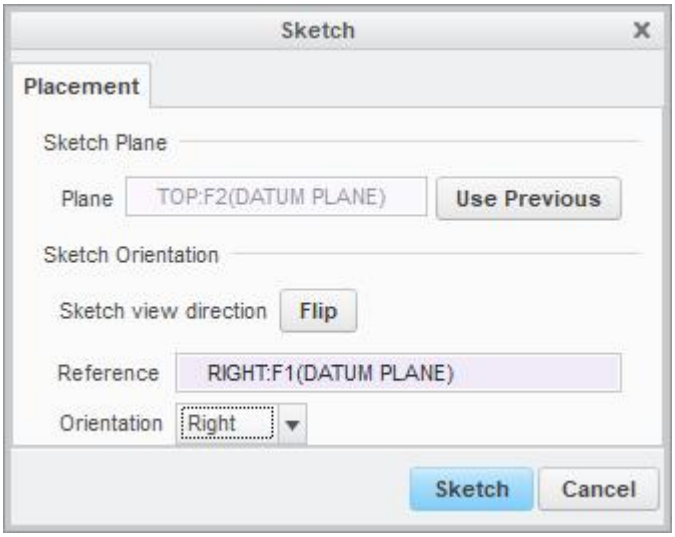
Now we will create the desired cut feature in the HOUSING_LEFT

Switch to the HOUSING_LEFT.PRT window

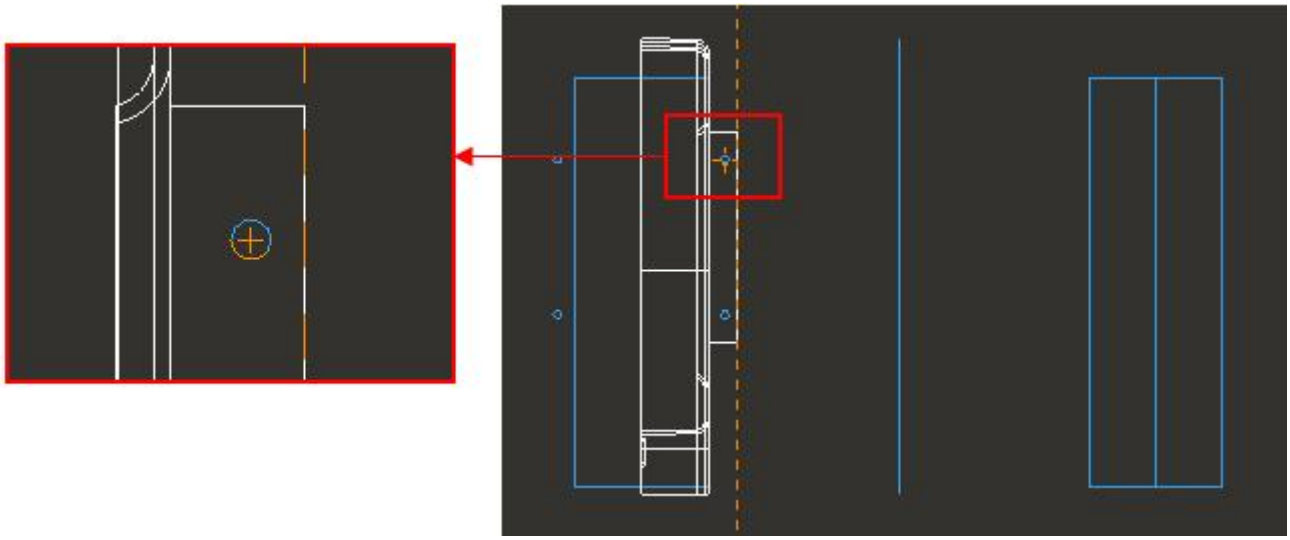
Pick to regenerate the part. As the copy geometry features are referencing the publish geometry feature in the skeleton so the newly sketched circles will appear in the window.

Pick to invoke Extrude tool.

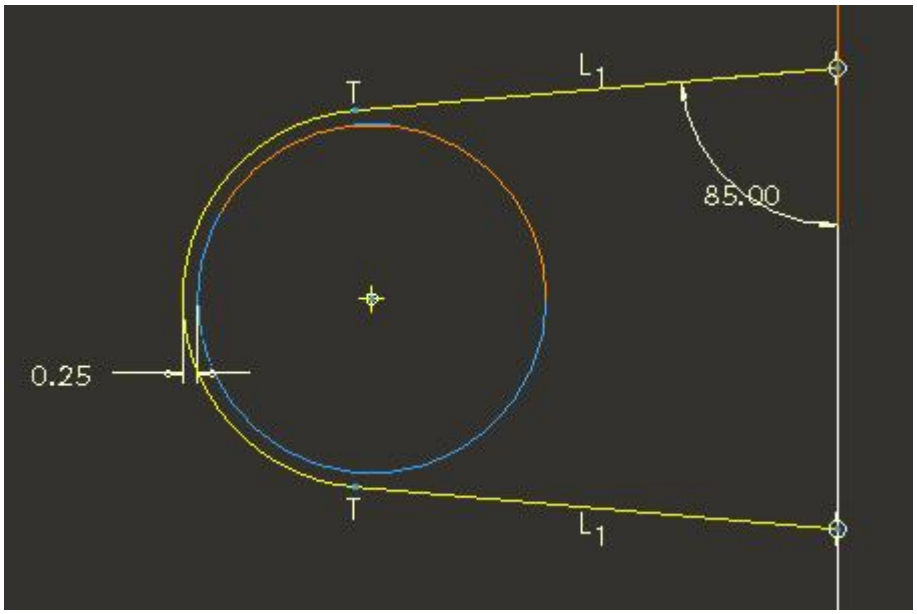
Select the sketching references as shown below



Select the references as shown below.



Sketch as shown below.

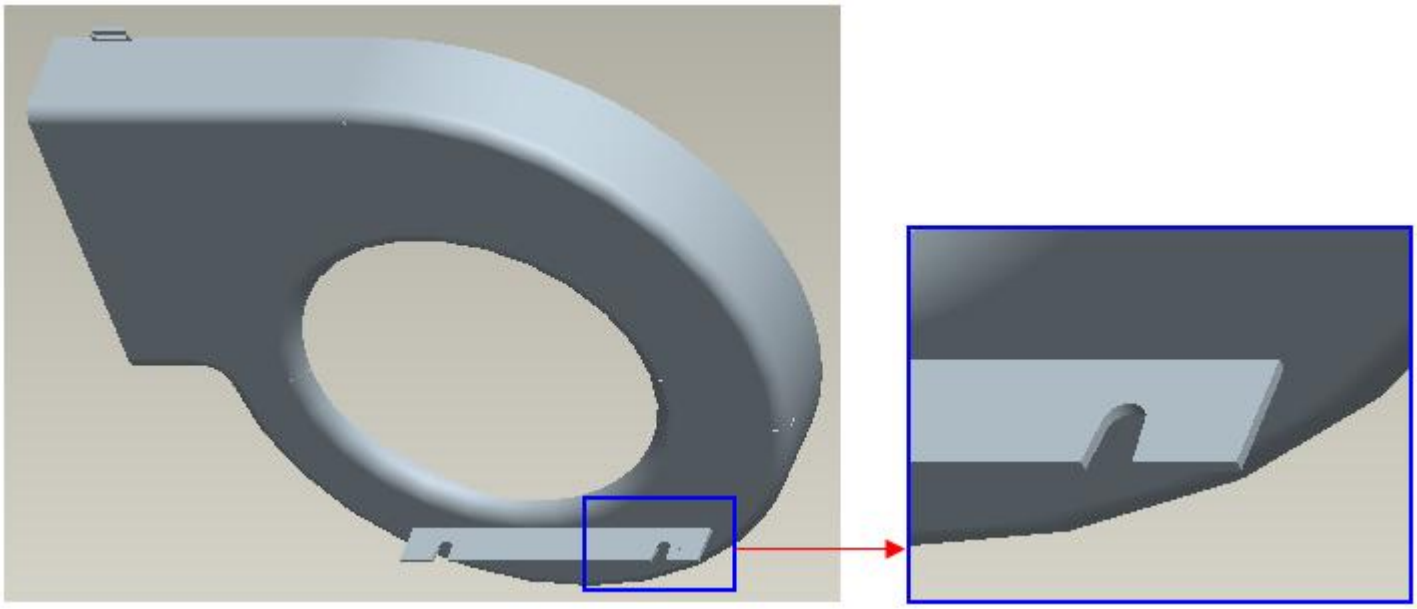


After completing the sketch pick  to create the feature as cut.

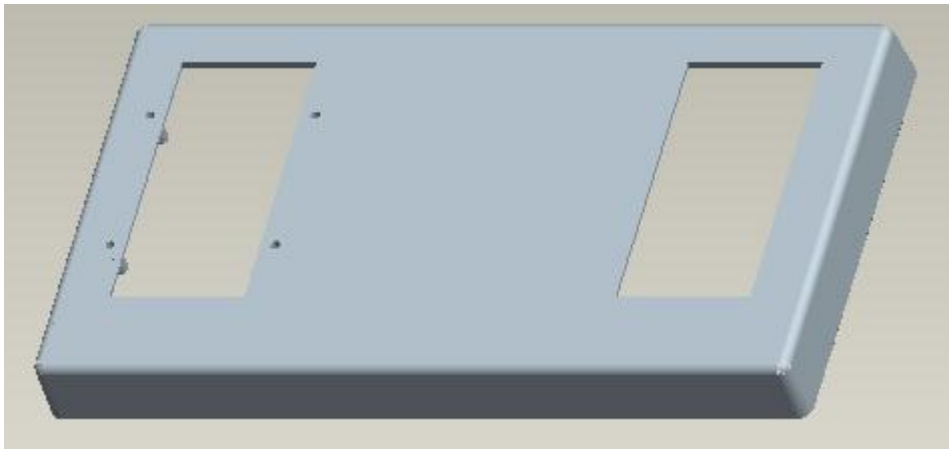
Change the depth option to **Through All** by picking the  icon in the Depth options list

Pick  icon to complete the feature.

Copy this extruded cut feature using Paste Special option so that part appears as shown below.



If you open the MOTOR_BASE.PRT in a new window and regenerate the part, you can see the new sketched circles appearing there. You can create the bosses using those circles as references on your own. After creating the bosses the part will appear as shown below.



Now you should have a clear understanding of how the multiple skeleton approach works and where you should create the necessary reference geometry.

Investigating External References

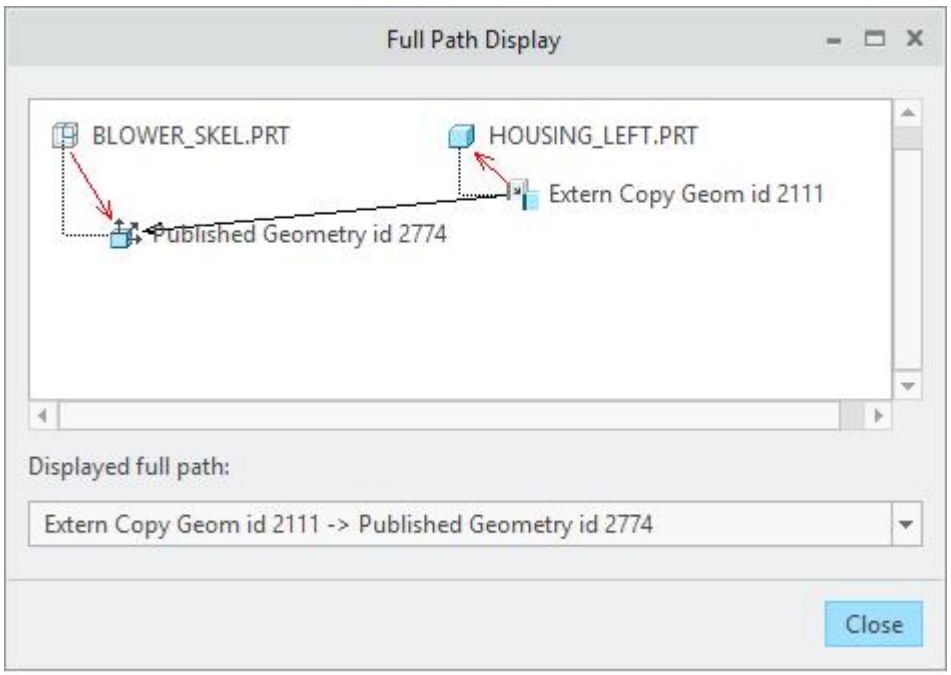
Now we will analyze the external dependencies in the parts.

Open BLOWER.ASM in a new window.

Right-click over the HOUSING_LEFT.PRT and pick **Information > Reference Viewer** to open the Reference Viewer.

Right-click the current object and pick **Display Full Path**.

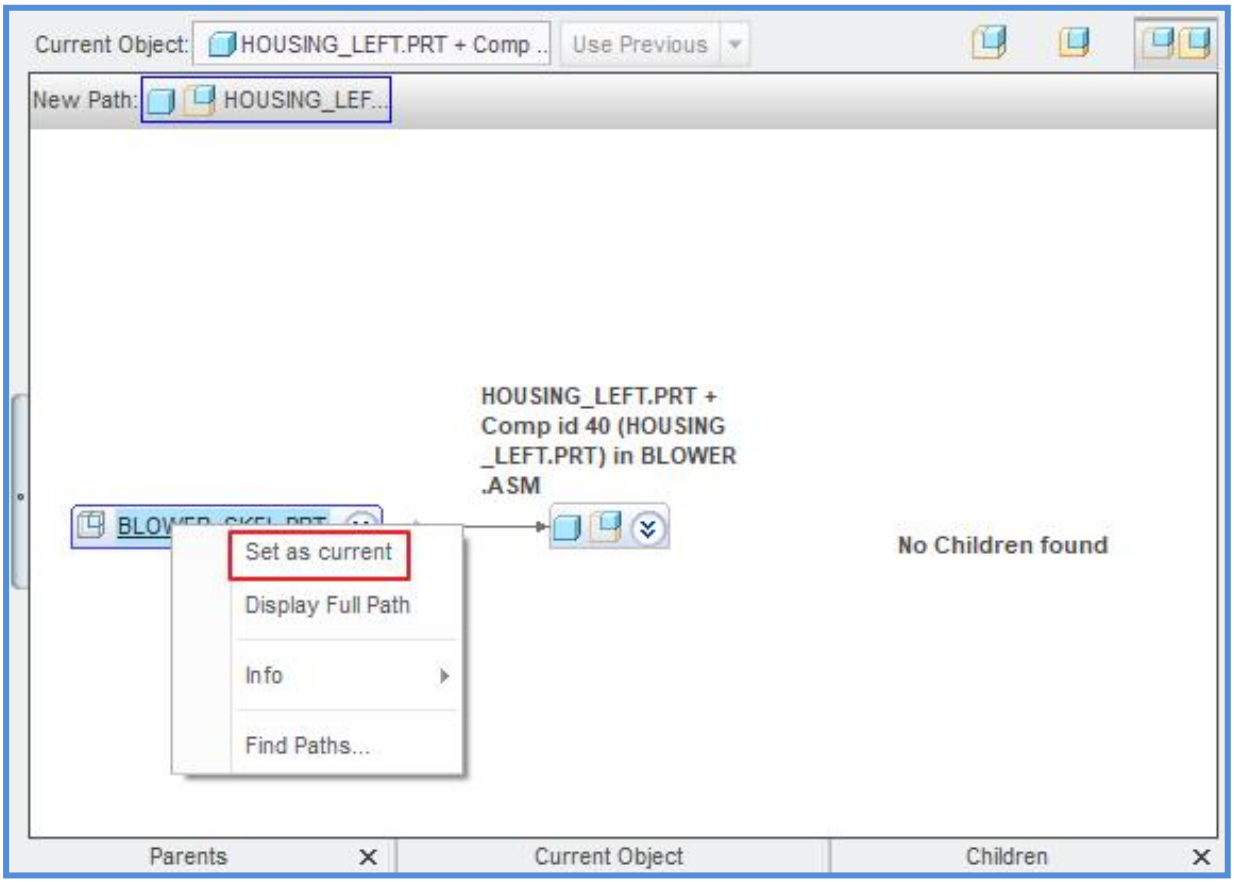
Full Path Display dialog box will appear as shown below.



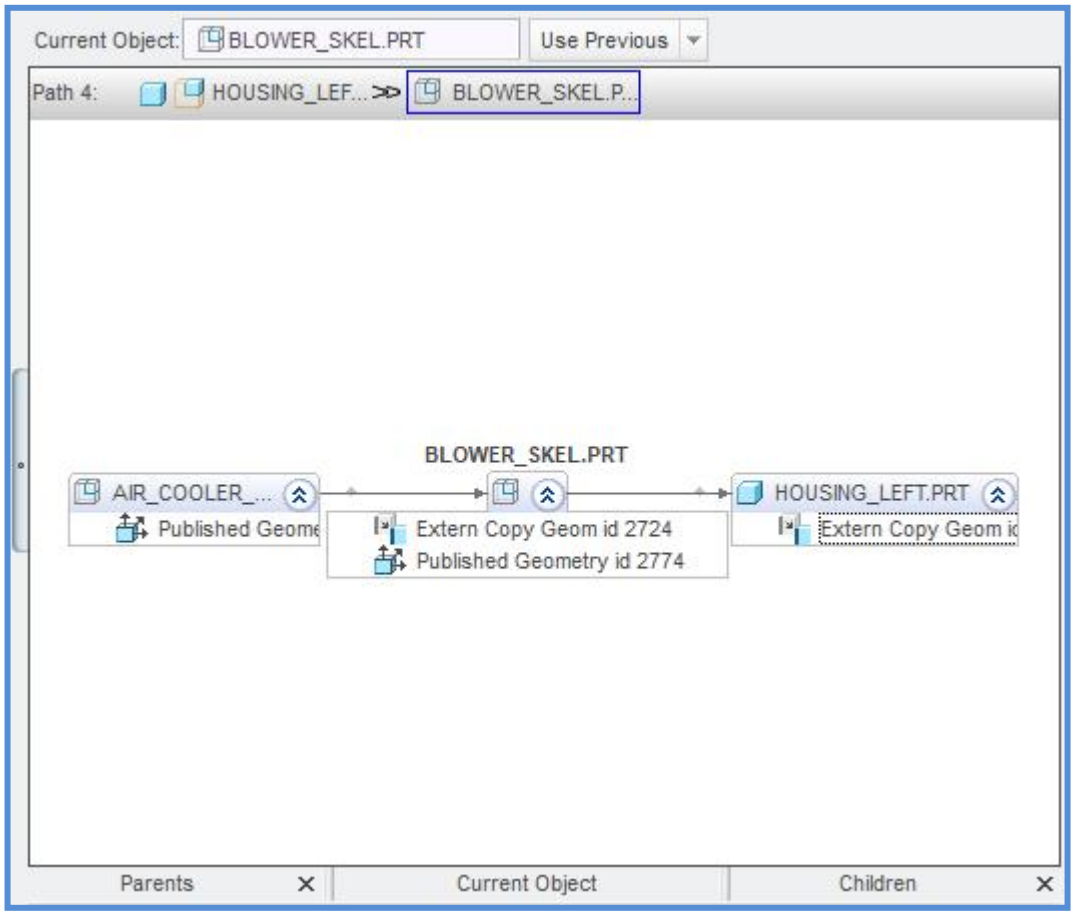
It can be seen that the parent of the external copy geometry feature in HOUSING_LEFT.PRT is the Publish Geometry feature in the BLOWER_SKEL.PRT without any dependency on the assembly.

Pick Close to close the Full Path Display dialog box.

Right-click the BLOWER_SKEL.PRT and pick **Set as current**.



Reference Viewer dialog box will update as shown below.

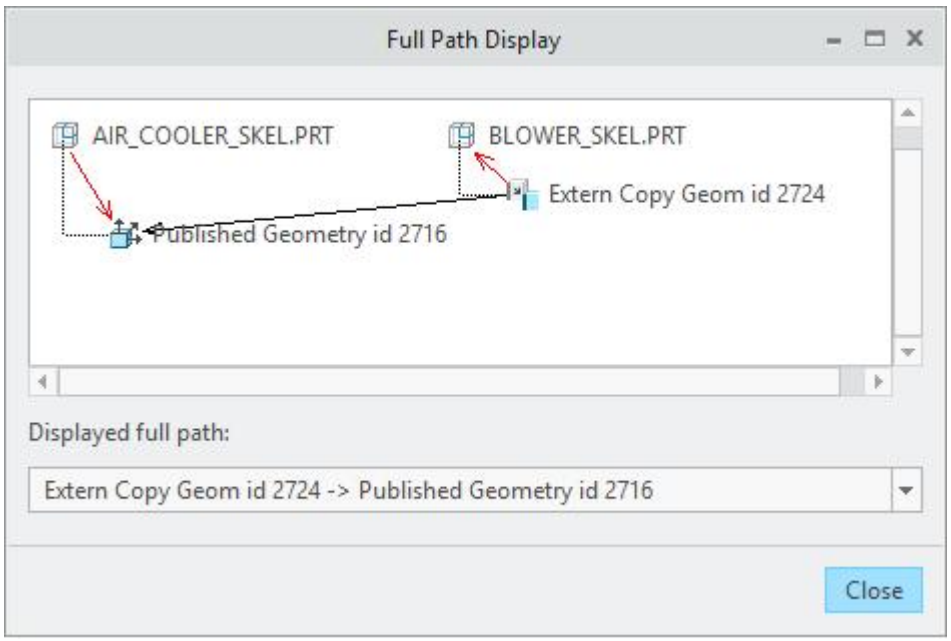


If you place mouse pointer over ECG or PG feature in BLOWER_SKEL.PRT , system will highlight the path toward their parent/child.

Notice that the parent of the BLOWER_SKEL.PRT is the AIR_COOLER_SKEL.PRT due to referencing of PG feature by ECG.

Right-click the current object (BLOWER_SKEL.PRT) and pick **Display Full Path**.

Full Path Display dialog box will appear as shown below.



Notice that parent of the external copy geometry feature in BLOWER_SKEL is the publish geometry feature in AIR_COOLER_SKEL without any dependency on the assembly. So system will only need AIR_COOLER_SKEL in session to update and regenerate BLOWER_SKEL when any change is made in AIR_COOLER_SKEL.

It can be concluded that system will only need two parent skeleton parts i.e. BLOWER_SKEL and AIR_COOLER_SKEL in session to update and regenerate HOUSING_LEFT when some change is made in AIR_COOLER_SKEL.

Pick Close to close the Full Path Display dialog box.

Pick Close to close the Reference Viewer.