AutoCAD® Self-paced eCourse

# AutoCAD 3D

## Module 3

## World Coordinate System

### Learning Outcomes

When you have completed this module, you will be able to:

1. Describe the World Coordinate System, the UCS icon and the right-hand rule.
2. Draw 3D models with the UCS located at the World Coordinate System.

### The World Coordinate System

AutoCAD has two distinct three-dimensional coordinate systems: the World Coordinate System (WCS) and the User Coordinate System (UCS). The *World Coordinate System* is permanently located at the absolute coordinates X0Y0Z0. It is a fixed coordinate system which can never be moved. The WCS is normally not used to construct models.

The *User Coordinate System* (UCS) is the coordinate system that is used to construct 3D models. The UCS can be placed exactly at the WCS or at any location in 3D space. In this module, model will be constructed with the UCS located at the WCS. It is essential to be able to locate and orientate the UCS to construct most models. This is taught in Module 4 and 5.

### The UCS Icon

Figure 3-1 shows the UCS icon and the positive X, Y and Z directions indicated by the UCS icon. When constructing models, it is very important to know which direction is positive and negative on all three axis.

When the UCS is located at the World Coordinate System, it will display a small square at the origin as can be seen in Figure 3-2. If it is located at any other location, it will display a small plus sign as shown in Figure 3-3.

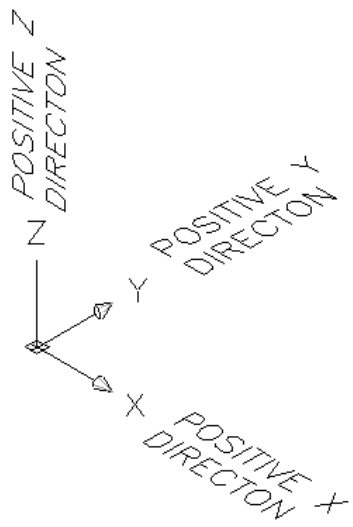



**Figure 3-1**
UCS Icon
Coordinate Directions

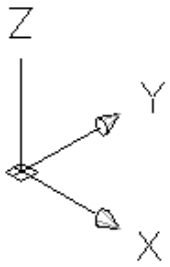



**Figure 3-2**
UCS at the World Coordinate System

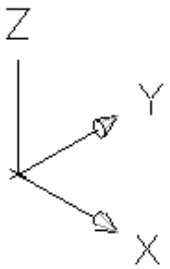



**Figure 3-3**
UCS **Not** at the World Coordinate System

## The Right-Hand Rule

Even though the 3D UCS icon indicates the positive Z direction, it is important to know how it is obtained. AutoCAD uses the *right-hand rule* to find the positive Z direction. See Figure 3-4. To use the right-hand rule, you must first know the positive X and Y directions of the current UCS. Using your right hand, point your thumb in the direction of the positive X axis. Extend your index finger in the direction of the positive Y axis. The middle finger indicates the direction of the positive Z axis. By rotating your hand, the X, Y and Z axes will rotate to change the UCS location and orientation. It is important to be able to visualize how and where to move the UCS as you construct more complicated models.

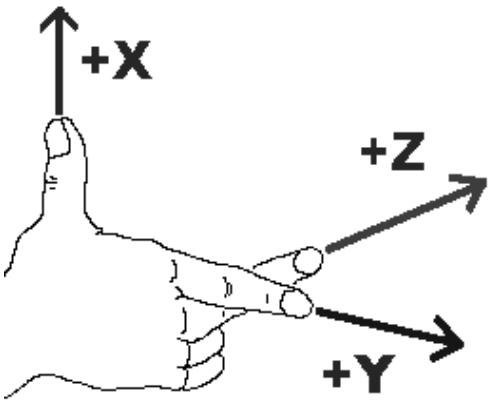



**Figure 3-4**
The Right-hand Rule

## Drawing with the Z Coordinate

While drawing in 2D, you only had to worry about entering the X and Y coordinates. Since the Z coordinate was omitted, AutoCAD used the default value of zero. When drawing in 3D, you must add the Z value in some coordinate input. For example, to enter the coordinates X2Y3Z4, enter 2,3,4 if it is an absolute coordinate and @2,3,4 if it is a relative coordinate.

## Absolute X0Y0Z0

The absolute coordinate 0,0,0 is the origin of the world coordinate system. This is the same location used in 2D when only 0,0 was entered. This is an important coordinate location as everything drawn in model space relates back to this location. Keep this in mind when drawing all future models. It is especially important when constructing models that relate to real world locations. For example, when drawing a map, X0Y0Z0 is located at the equator and your model must be drawn in relation to that location.

USER TIP

Similar to working in 2D, it is important to save the objects drawn for construction purposes. In all lab exercises, daw all construction objects on layer Construction and do not delete them when the drawing is complete. After completing the model, freeze layer Construction. When required, simply thaw the construction layer to display the construction objects.

WORK ALONG

## Drawing 3D Wireframe Models with the UCS Located at the WCS

**Step 1** Using the NEW command, start a new drawing using the template 3D Layout English.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 03-1. (Figure Step 2)

**Author's Comments:** Constructing models with the UCS located at the WCS is not the best method of constructing models. As a learning tool for this module, it simplifies model construction. This will help you when you draw your first few models.

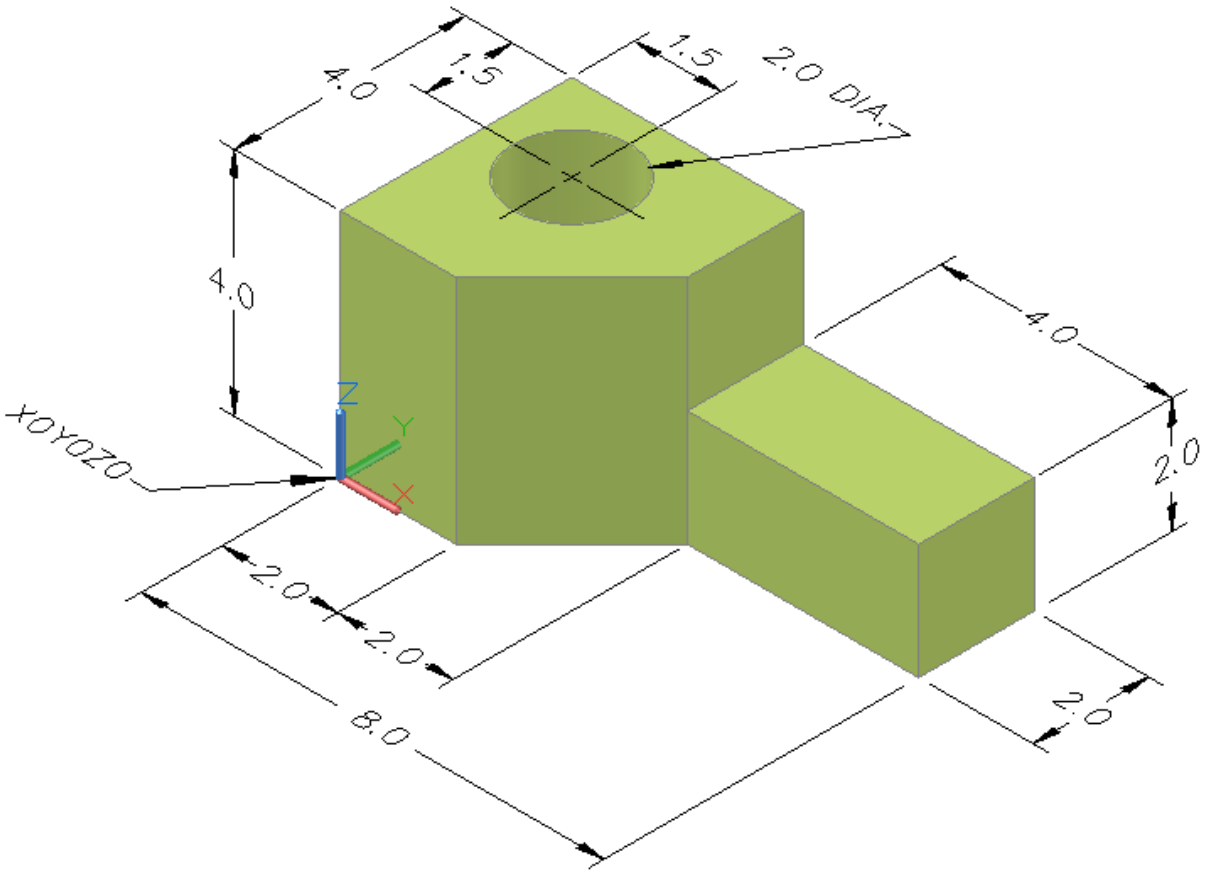



**Figure Step 2**
Dimensioned Solid Model

**Step 3** Set the current view to SE Isometric. (Figure Step 3)

**Step 4** Ensure that the UCS Icon is enabled (On) and the Origin is enabled as shown in Module 1 page 1-4.

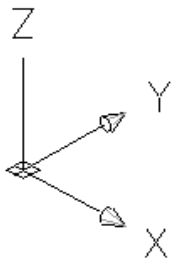



**Figure Step 3**

**Step 5** Set layer Model as the current layer. Enter the LINE command, as shown below, to draw the lines to start the construction of the model. (Figure Step 5)

Command: **LINE**
Specify first point: **0,0,0**
Specify next point or [Undo]: **@2,0**
*(Since you are working at Z zero, you can omit the Z value.)*
Specify next point or [Undo]: **@2,2**
Specify next point or [Close/Undo]: **@4,0**
Specify next point or [Close/Undo]: **@0,2**
Specify next point or [Close/Undo]: **@-8,0**
Specify next point or [Close/Undo]: **C**
Command:
*(Draw the object that is located on the XY axis as you did in 2D.)*

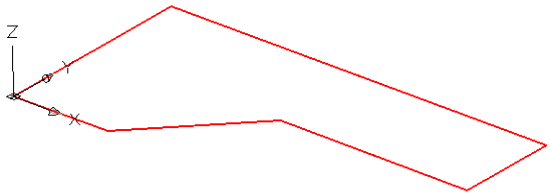



**Figure Step 5**

**Step 6** Using the OFFSET command, offset the two lines 1.5 units as shown in the figure. Change the layer properties of the two lines to layer Construction. (Figure Step 6)

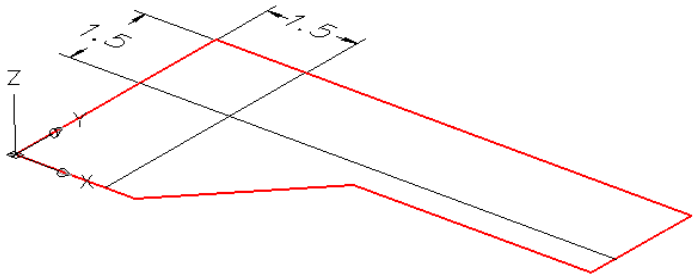



**Figure Step 6**

**Step 7** Use the CIRCLE command to draw a 2 diameter circle with its center located at the intersection of the two construction lines. (Figure Step 7)

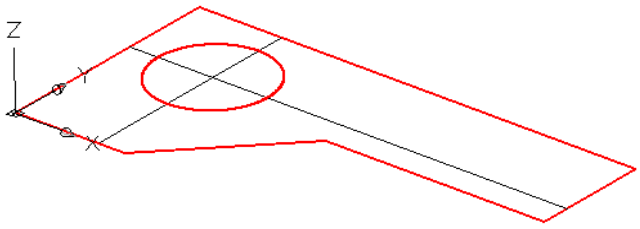



**Figure Step 7**

**Step 8** Freeze layer Construction. Enter the COPY command, as shown below, and copy the three lines and the circle 4 units in the positive Z direction. (Figure Step 8).

Command: **COPY**
Select objects:
*(Select the three lines and the circle as shown in Figure Step 8.)*
Select objects:
Specify base point or displacement, or [Multiple]: **0,0,0**
Specify second point of displacement or <use first point as displacement>: **@0,0,4**
(Copy the 4 objects 4 units in the positive Z direction. Looking at the UCS or using the right-hand rule will indicated if it is a positive or negative direction.)
Command:

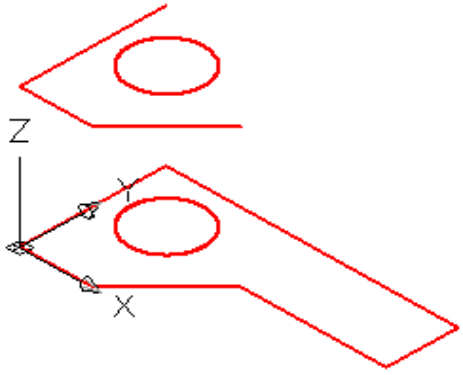



**Figure Step 8**

**Step 9** Using the 3DORBIT command, orbit the model slightly. (Figure Step 9)

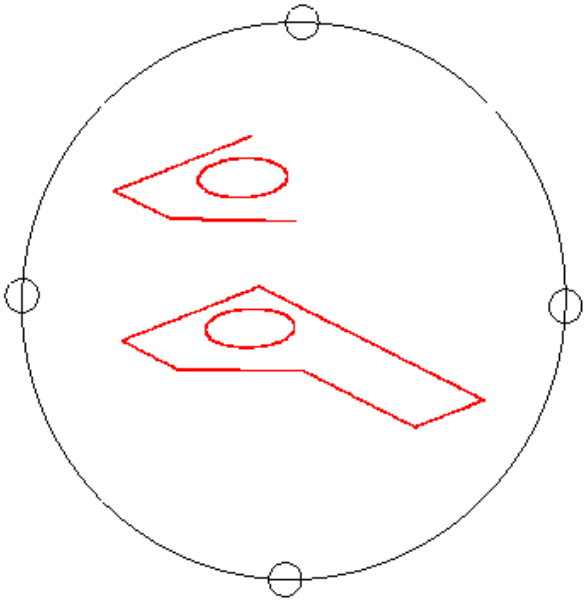


**Figure Step 9**

**Step 10** Using the COPY command, copy the 2 lines 2 units in the positive Z directions. (Figure Step 10)

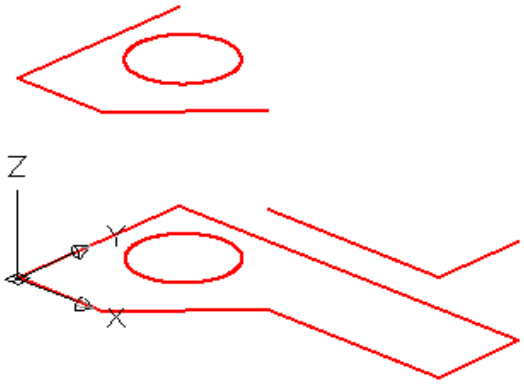



**Figure Step 10**

**Step 11** Use the LINE command to draw six lines between the ends of the existing lines. Ensure that you snap to the ends of the lines. (Figure Step 11)

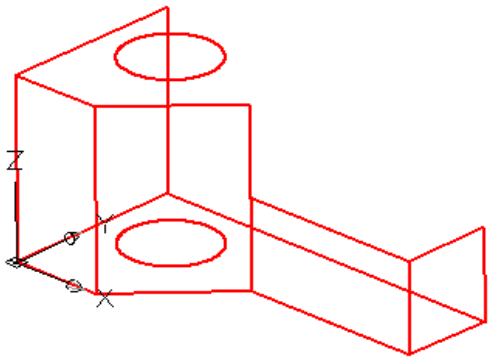



**Figure Step 11**

**Step 12** Using the COPY command, copy the short line located at the right end of the model two times. Ensure that you use snap mode to locate the lines exactly. (Figure Step 12)

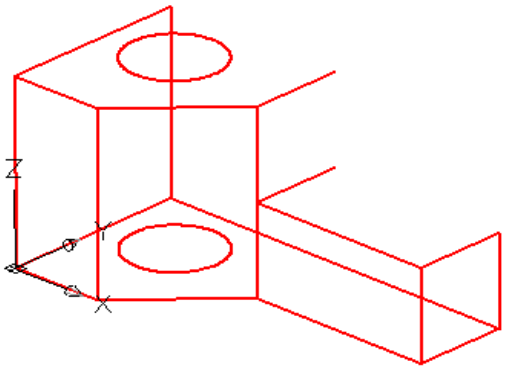



**Figure Step 12**

**Step 13** Draw three lines between the ends of the existing lines. Ensure to snap to the ends of the existing lines. (Figure Step 13)

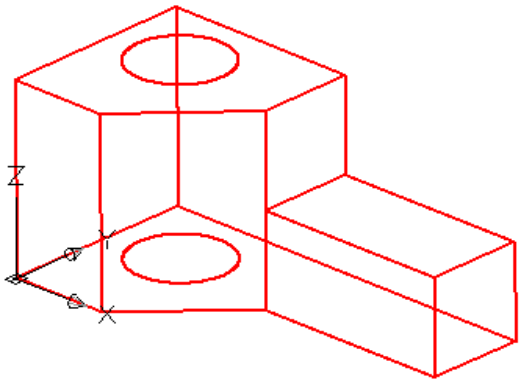



**Figure Step 13**

**Step 14** Using the VIEW command, save the current view with the name Working Isometric. (Figure Step 14)

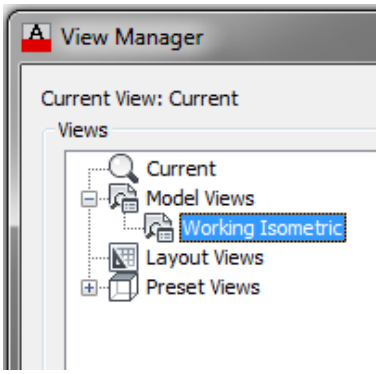



**Figure Step 14**

**Author's Comments:** If you have trouble doing this, see Module 1 page 1-9 and 1-10.

**Step 15** Change the view to SE Isometric. (Figure Step 15A and 15B)


**Figure Step 15A**

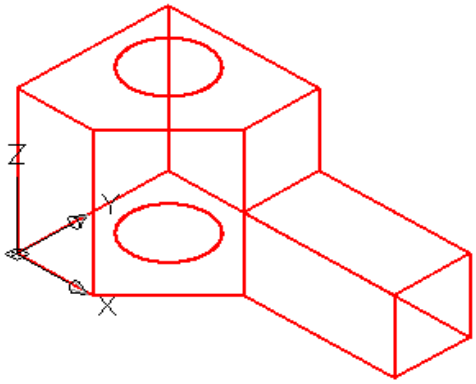



**Figure Step 15B**

**Step 16** Enter the UNITS command. In the Units dialogue box, set the Insertion Units to Inches. Insert the key AutoCAD 3D Workalong 03-1. It will overlay the model with a magenta model. (Figure Step 16)

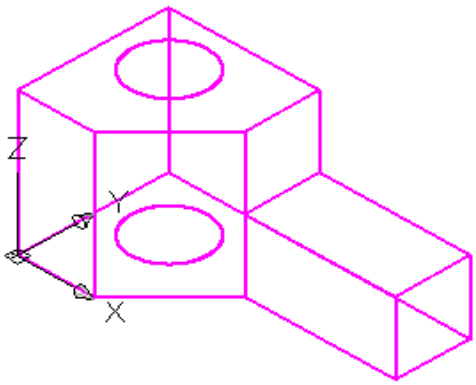



**Figure Step 16**

**Author's Comments:** If you require help doing this, redo Module 2.

**Step 17** Save and close the drawing.

WORK ALONG

## Drawing 3D Wireframe Models With the UCS Located at the WCS

**Step 1** Using the NEW command, start a new drawing using the template 3D Layout Metric.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 03-2. (Figure Step 2)

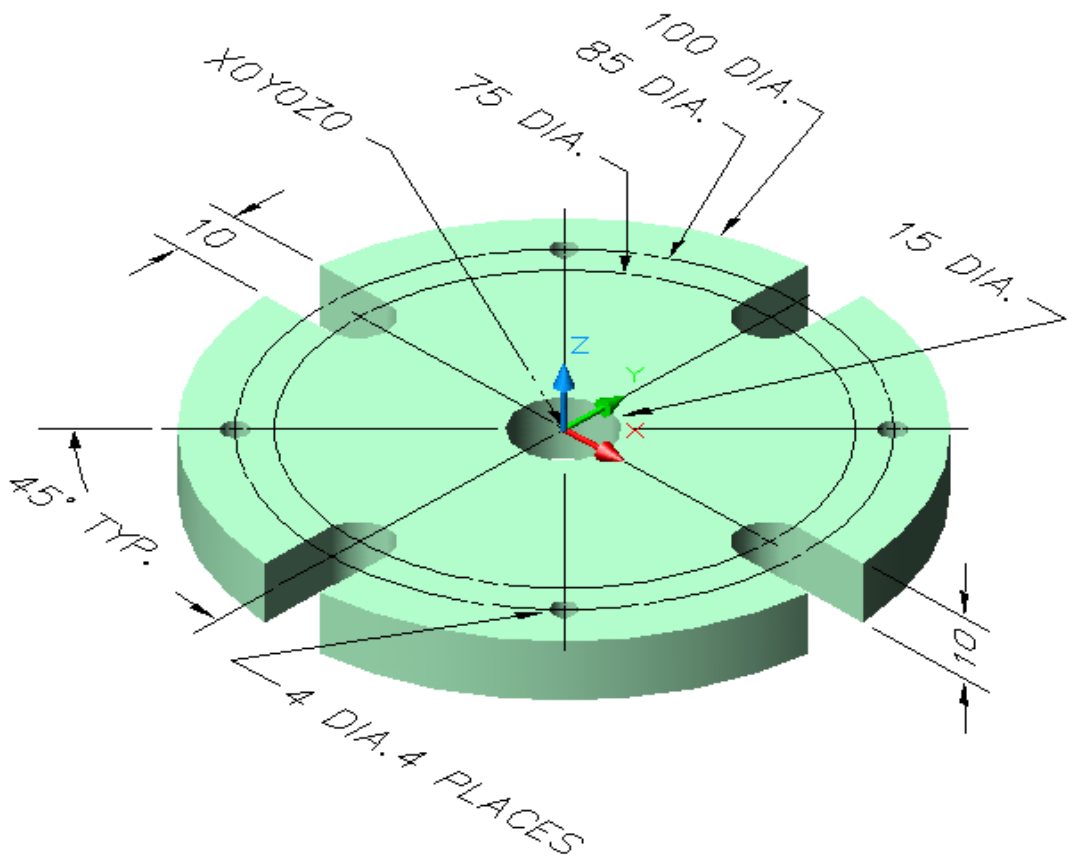



**Figure Step 2**
Dimensioned Solid Model

MUST KNOW

AutoCAD has two distinct three-dimensional coordinate systems. The World Coordinate System (WCS) and the User Coordinate System (UCS). The World Coordinate System is located at the absolute coordinates X0Y0Z0. It is a fixed coordinate system and cannot be moved. The WCS is normally not used to construct models. The UCS the coordinate system that is used to construct 3D models. The UCS can be placed exactly at the WCS or at any location in 3D space.

**Step 3** Set the current view to SE Isometric. (Figure Step 3)

**Step 4** Ensure that the UCS Icon is enabled (On) and the Origin is enabled as shown in Module 1, page 1-4.

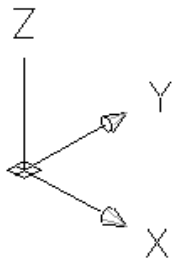



**Figure Step 3**

**Step 5** Set layer Model as the current layer. Draw the shape of the top of the object. Use the ARRAY command to speed up the construction. (Figure Step 5)

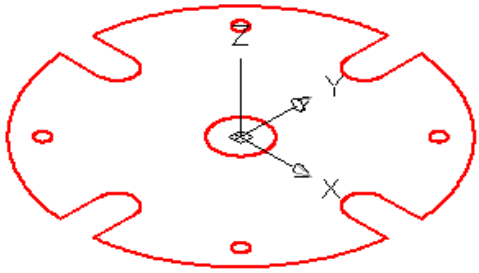



**Figure Step 5**

**Step 6** Using the COPY command, as shown below, copy all of the objects 10 units in the negative Z direction. (Figure Step 6)

Command: **COPY**
Select objects:
*(Select all objects.)*
Select objects:
Specify base point or displacement, or [Multiple]: **0,0,0**
Specify second point of displacement or <use first point as displacement>: **@0,0,-10**
Command:

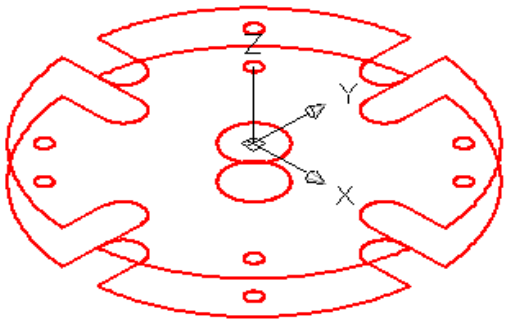



**Figure Step 6**

**Step 7** Using the 3DORBIT command, orbit the model slightly until it appears similar to the figure. (Figure Step 7)

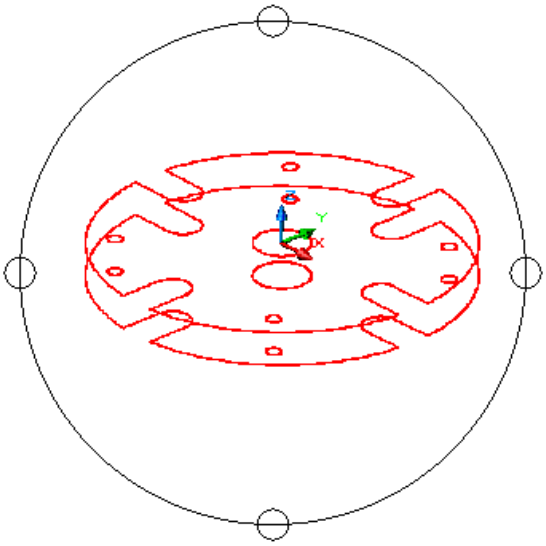


**Figure Step 7**

**Step 8** Draw the vertical lines by snapping to the endpoints to complete the wireframe model. (Figure Step 8)

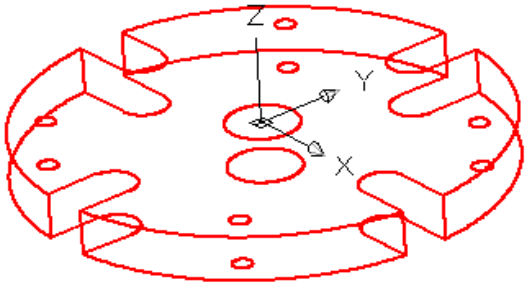



**Figure Step 8**

**Step 9** Using the VIEW command, save the current view with the name Working Isometric. (Figure Step 9)

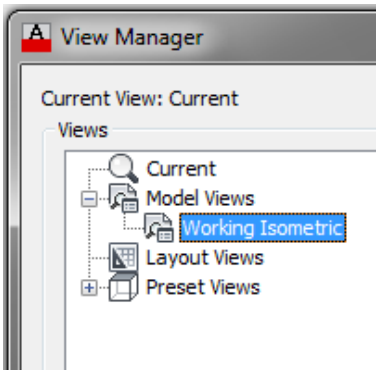



**Figure Step 9**

**Step 10** Change the view to SE Isometric. (Figure Step 10A and 10B)


**Figure Step 10A**

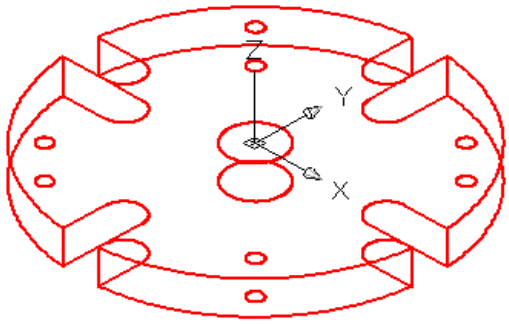



**Figure Step 10B**

**Step 11** Enter the UNITS command. In the Units dialogue box, set the Insertion Units to Millimeters. Insert the key AutoCAD 3D Workalong 03-2. It will overlay the model with a magenta model. (Figure Step 11)

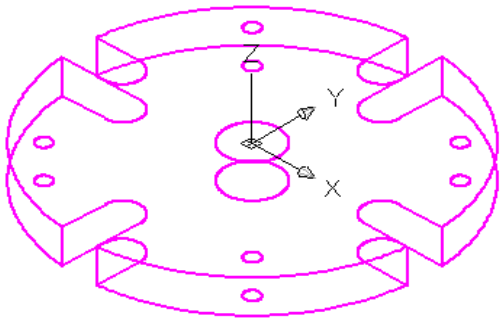



**Figure Step 11**

**Step 12** Save and close the drawing.

## The Key Principles in Module 3

**1** AutoCAD has two distinct three dimensional coordinate systems: the World Coordinate System (WCS) and the User Coordinate System (UCS).
**2** The World Coordinate System is permanently located at the absolute coordinates X0Y0Z0. It is a fixed coordinate system which can never be moved. The WCS is normally not used to construct models.
**3** The User Coordinate System is the coordinate system that is normally used to construct 3D models. The UCS can be placed exactly at the WCS or at any location in 3D space.
**4** AutoCAD uses the right-hand rule to find the positive Z direction. To use the right-hand rule, you must first know the positive X and Y directions of the current UCS. Using your right hand, point the thumb in the direction of the positive X axis. Extend your index finger in the direction of the positive Y axis. Your middle finger indicates the direction of the positive Z axis.
**5** The absolute coordinate 0,0,0 is the origin of the world coordinate system. This is the same point used when drawing in 2D when 0,0 was entered. This is an important coordinate location as everything drawn in model space relates back to this location.

| **Lab Exercise 3-1** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 03-1 | 3D Layout English | Inches |

**Step 1** Save and name the drawing AutoCAD 3D Lab 03-1.

**Step 2** Draw all construction objects on layer Construction and model objects on layer Model.

**Step 3** Draw a wireframe model of the object shown in the figure. (Figure Step 3A and 3B)

**Step 4** Start your model with the view in SE Isometric. If required, orbit it slightly with 3DORBIT to help the line of sight.

**Step 5** Save the isometric working view with the name Working Isometric.

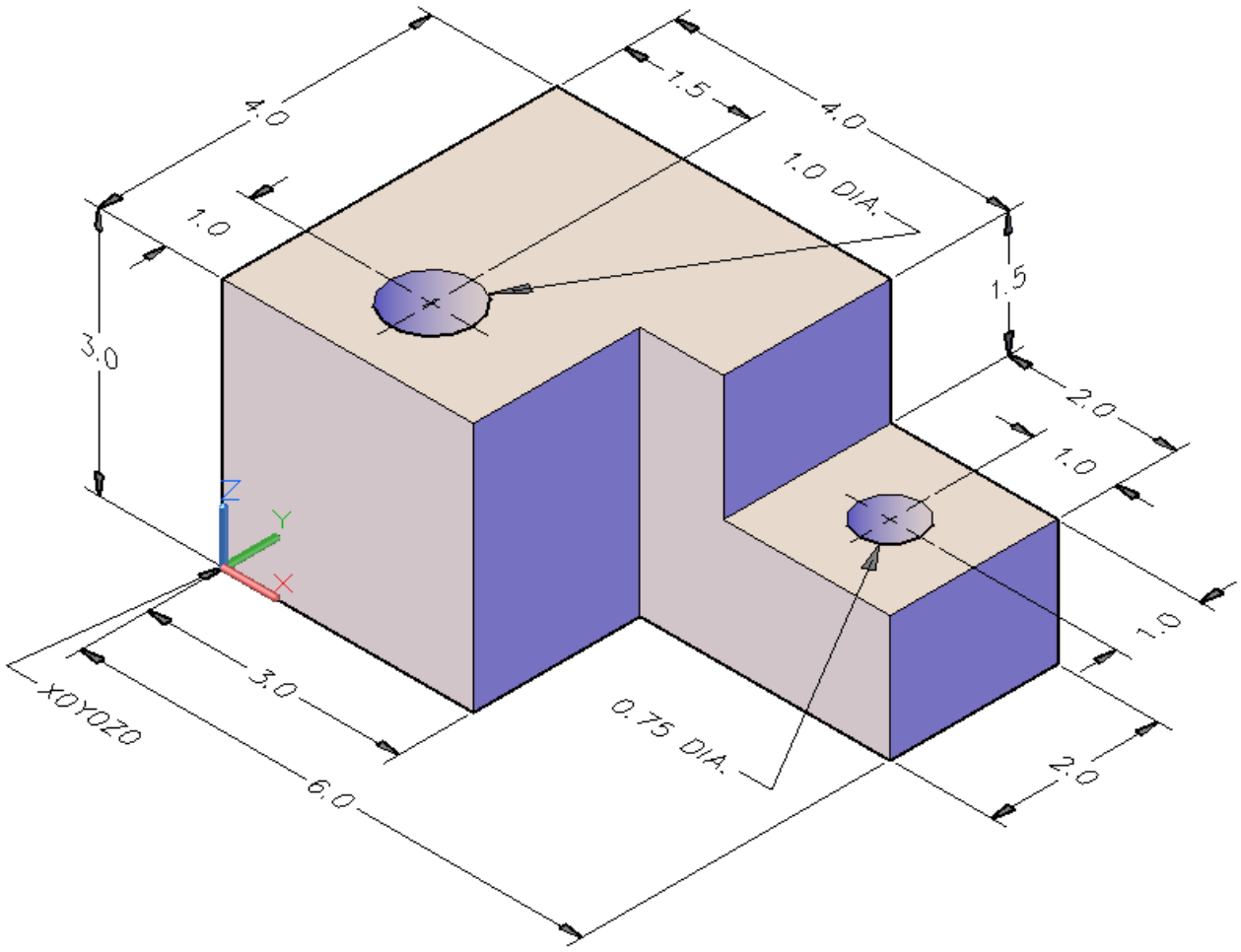



**Figure Step 3A**
Dimensioned Solid Model

**Step 6** When complete, freeze layer Construction.

**Step 7** Enter the UNITS command. In the Units dialogue box, set the Insertion Units to Inches.

**Step 8** Check your drawing with the key. The key name is the same as the drawing name.

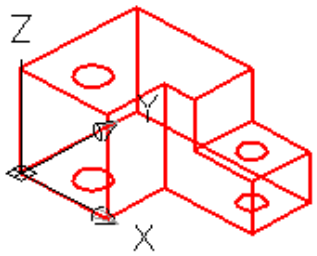



**Figure Step 3B**
Completed
Wireframe Model
SE Isometric View

**Construction Techniques:** The following steps are the construction technique suggested by the author to help you learn how to construct objects using AutoCAD. It is only the suggested method and if you can complete the drawing accurately using a different construction technique, that is what is important. You may want to compare your construction technique with the authors.

**Hint 1**

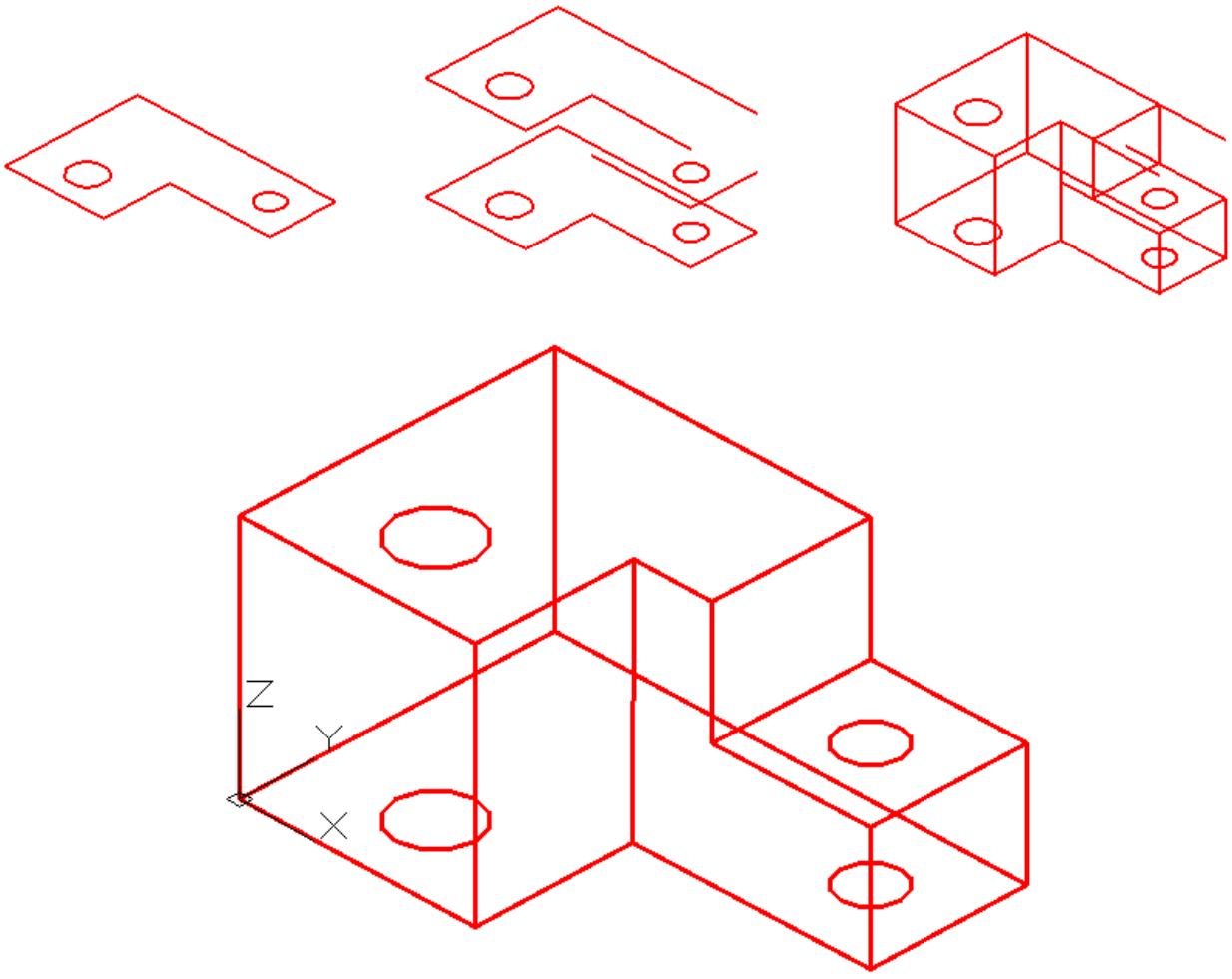



**Figure Hint 1**
Construction Steps

| **Lab Exercise 3-2** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 03-2 | 3D Layout Metric | Millimeters |

**Step 1** Save and name the drawing AutoCAD 3D Lab 03-2.

**Step 2** Draw all construction objects on layer Construction and all model objects on layer Model.

**Step 3** Draw a wireframe model of the object shown in the figure.
(Figure Step 3A, 3B, 3C, and 3D)

**Step 4** Start your model with the view in SE Isometric. If required, orbit it slightly with 3DORBIT to help the line of sight.

**Step 5** Save the isometric working view with the name Working Isometric.

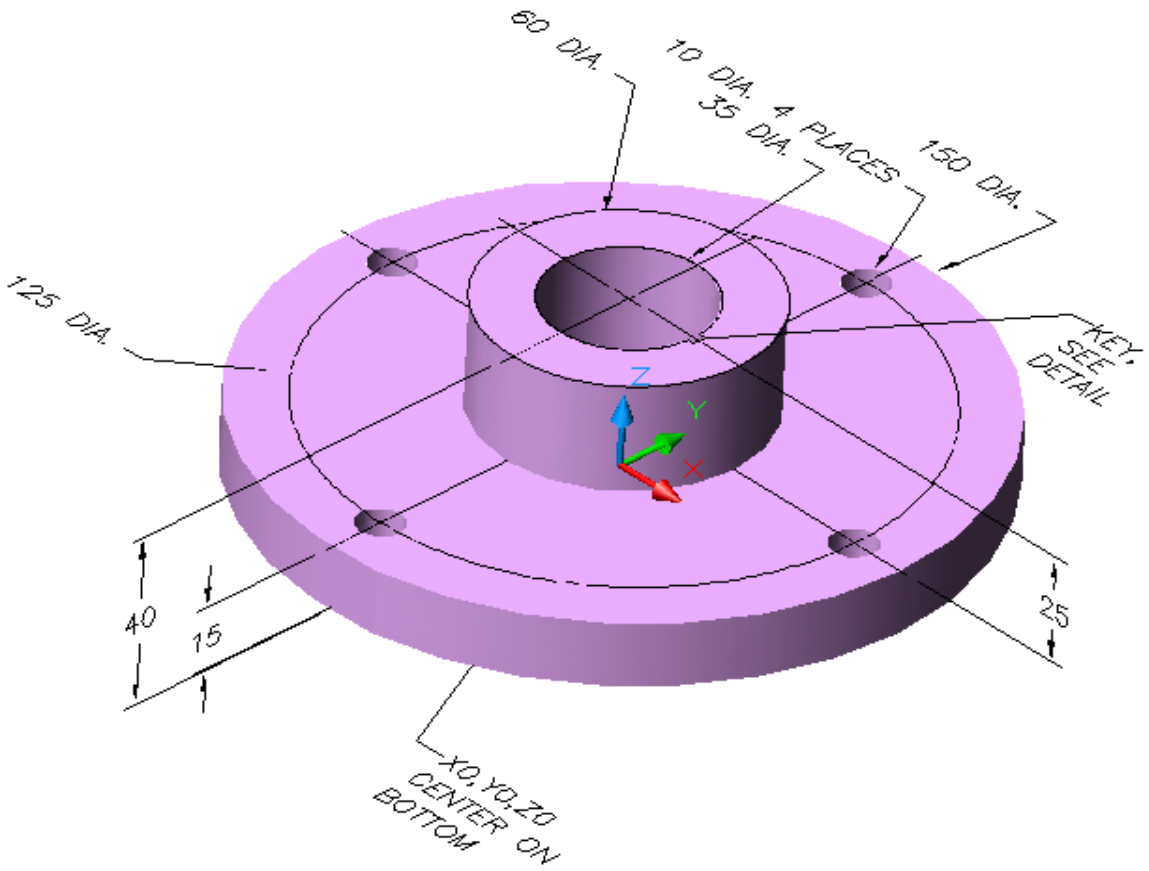



**Figure Step 3A**
Dimensioned Solid Model

**Step 6** When complete, freeze layer Construction.

**Step 7** Enter the UNITS command. In the Units dialogue box, set the Insertion Units to Millimeters.

**Step 8** Check your drawing with the key. The key name is the same as the drawing name.

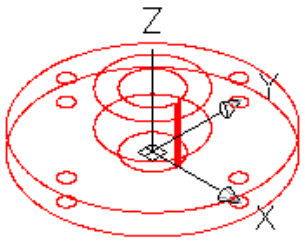



**Figure Step 3B**
Completed
Wireframe Model
SE Isometric View

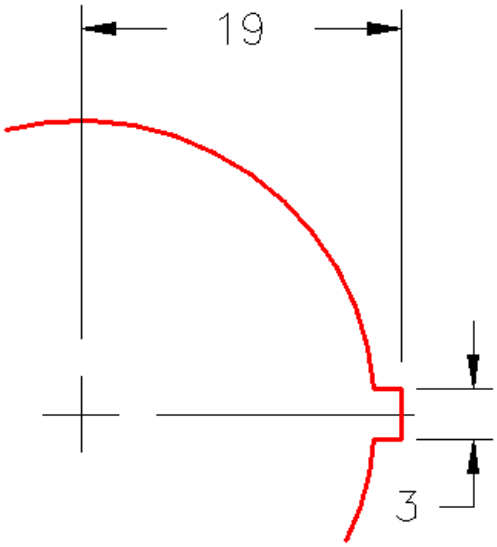



**Figure Step 3C**
Key Detail

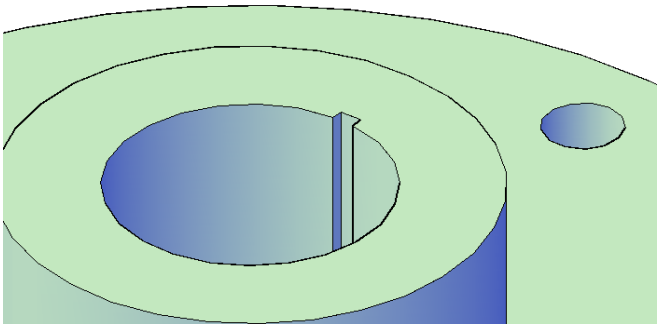


**Figure Step 3D**
View of Keyway - Orbited

**Construction Techniques:** The following steps are the construction technique suggested by the author to help you learn how to construct objects using AutoCAD. It is only the suggested method and if you can complete the drawing accurately using a different construction technique, that is what is important. You may want to compare your construction technique with the authors.

**Hint 1**

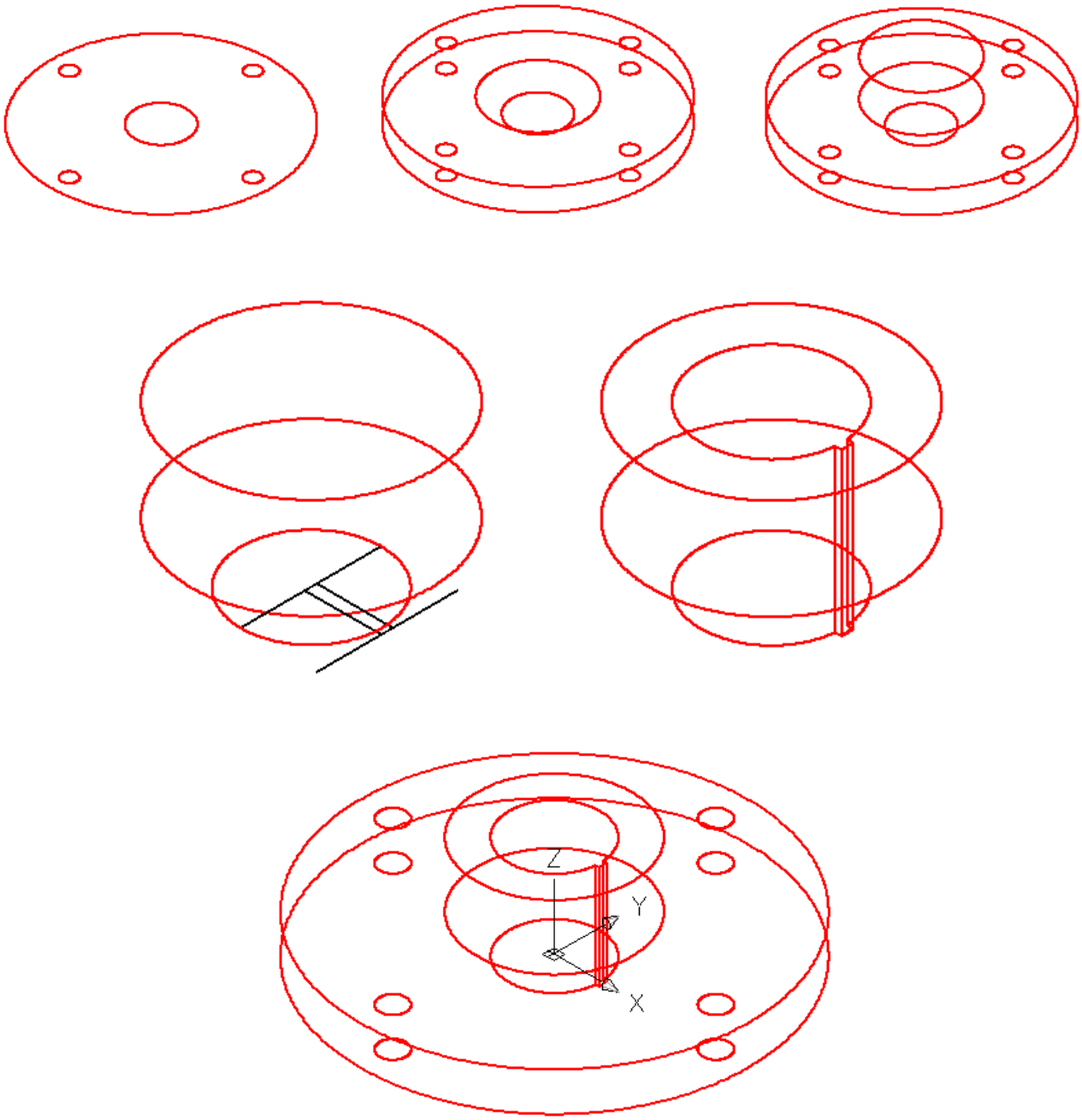



**Figure Hint 1**
Construction Steps

AutoCAD® Self-paced eCourse

# AutoCAD 3D

## Module 13

## Surface Modeling - Part 2

### Learning Outcomes

When you have completed this module, you will be able to:

1 Describe geometry defined meshes including rule surfaces, revolved surfaces and tabulated surfaces.
2 Apply the RULESURF, REVSURF, and TABSURF commands to apply mesh surfaces to 3D models.

### Geometry Defined Surface Meshes

*Geometrically defined surface meshes* use existing geometry that must be created before the surfaces. In almost all cases, the wireframe of the model is used as the existing geometry. There are four geometrically defined surface meshes that can be created in AutoCAD. They are the ruled surface, revolved surface, tabulated surface, and edge surface. The commands to create these meshes are RULESURF, REVSURF, TABSURF and EDGESURF. The EDGESURF command is taught in Module 15.

To create a geometry defined surface mesh, start with the wireframe geometry and ensure that it is on its own layer. Surface the wireframe model on all sides, making sure that all exposed sides have a surface covering them. Think of the model as an object that must be made water tight. Even the inside of a hole going through the model must have a surface applied on it. Place the surface meshes on their own layer. When the surfaced model is complete, freeze the layer containing the wireframe or the geometry leaving only the layer with the surface mesh displayed.

### Ruled Surface

A *ruled surface*, inserted with the RULESURF command, is the most commonly used method to surface a model. To place a ruled surface, simply select two lines, a line and an arc, two arcs, or two circles to place the surface between. See Figure 13-1.

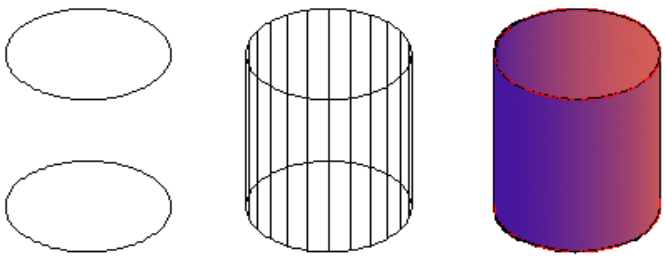
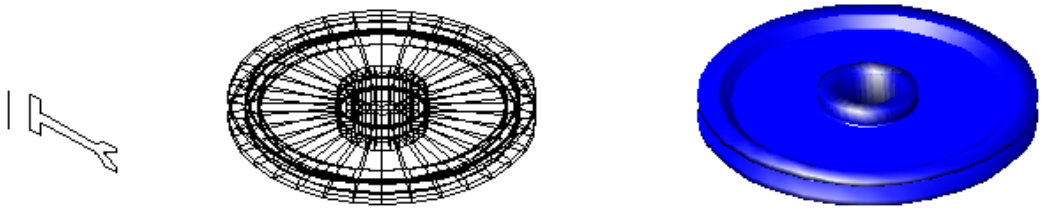



**Figure 13-1**
Ruled Surface

## Revolved Surface

A *revolved surface*, inserted with the REVSURF command, is a surface created by revolving a profile around an axis. The profile can be a line, arc, circle, or an open or closed 2D polyline or 3D polyline. See Figure 13-2. The axis must be a line or an open 2D or 3D polyline. If a polyline is used as the axis, the REVSURF command will simply use a straight line between the start point and end point of the polyline.

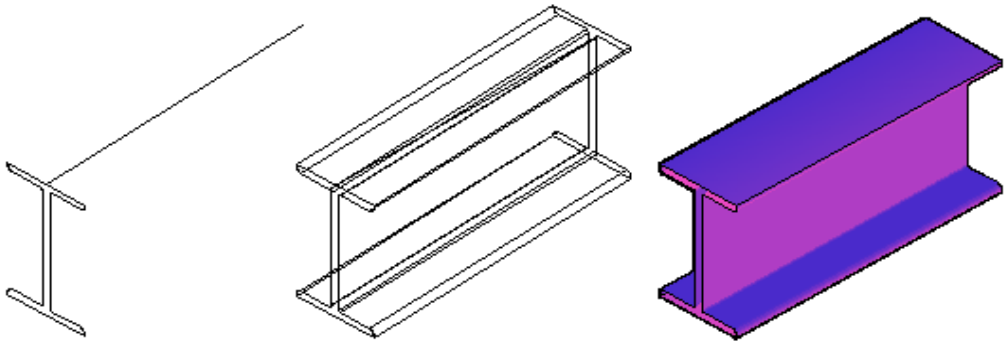


Path Curve and Axis Surfaced Shaded

**Figure 13-2**
Revolved Surface

## Tabulated Surface

A *tabulated surface,* inserted with the TABSURF command, is a surface created by projecting a profile along a path. The profile defines the surface of the mesh as it follows the path. See Figure 13-3. The profile can be a line, arc, circle, ellipse, or an open or closed 2D or 3D polyline. The path can be a line or a polyline. If a polyline is used as the axis, the TABSURF command will simply use a straight line between the start point and end point of the polyline. The surface is drawn starting at the point on the profile closest to the point selected in the command.



Path Curve and Direction Vector Surfaced Shaded

**Figure 13-3**
Tabulated Surface

## Setting the Mesh Density

The *mesh density* represented by the lines, circles, or arcs that make the rows and columns of the surface mesh are controlled with the system variables SURFTAB1 and SURFTAB2. On flat surfaces, the density of the mesh is not that important but with curved or irregular shaped surfaces, the density is very important since the higher the setting, the more segments are used when creating circles and arcs. If the mesh is not dense enough, small gaps will be left where a curved surface meets a flat surface. See Figure 13-4.

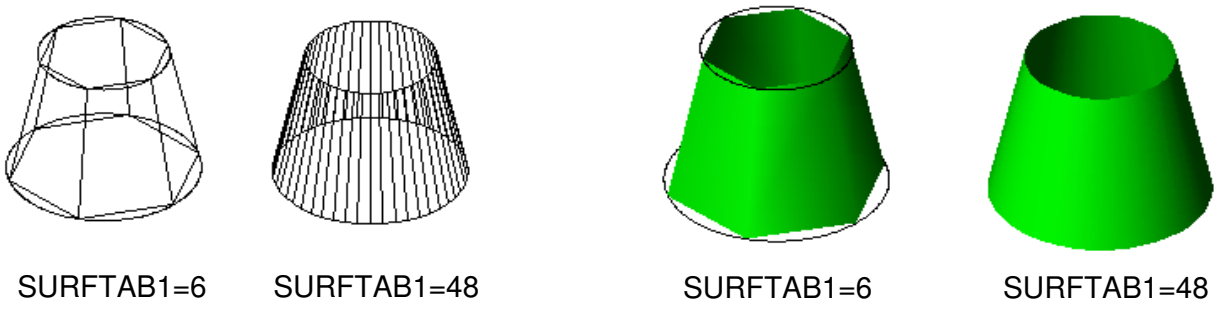


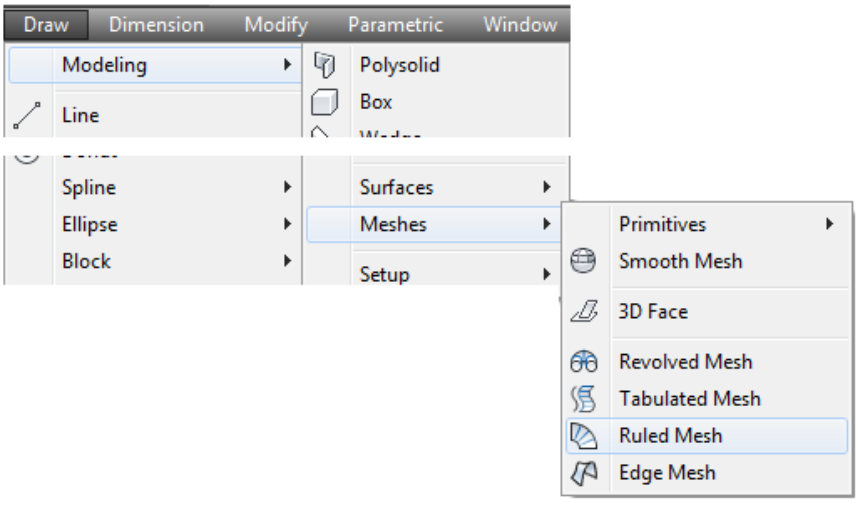

**Figure 13-4**
SURFTAB Settings

## AutoCAD Command: RULESURF

The RULESURF command is used to create a rule surface between two existing edges.

Shortcut: none

SURFTAB1 = YES
SURFTAB2 = No Effect



WORK ALONG

## Inserting Ruled Surfaces

**Step 1** Using the NEW command, start a new drawing using template 3D Layout Metric.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 13-1.

**Step 3** Set the current layer to Model and the current visual style to 2D Wireframe.

**Step 4** Draw a wireframe model of the multiview drawing. (Figure Step 4A and 4B)

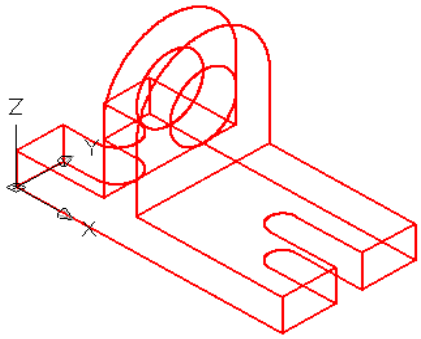



**Figure Step 4A**
Wireframe Model

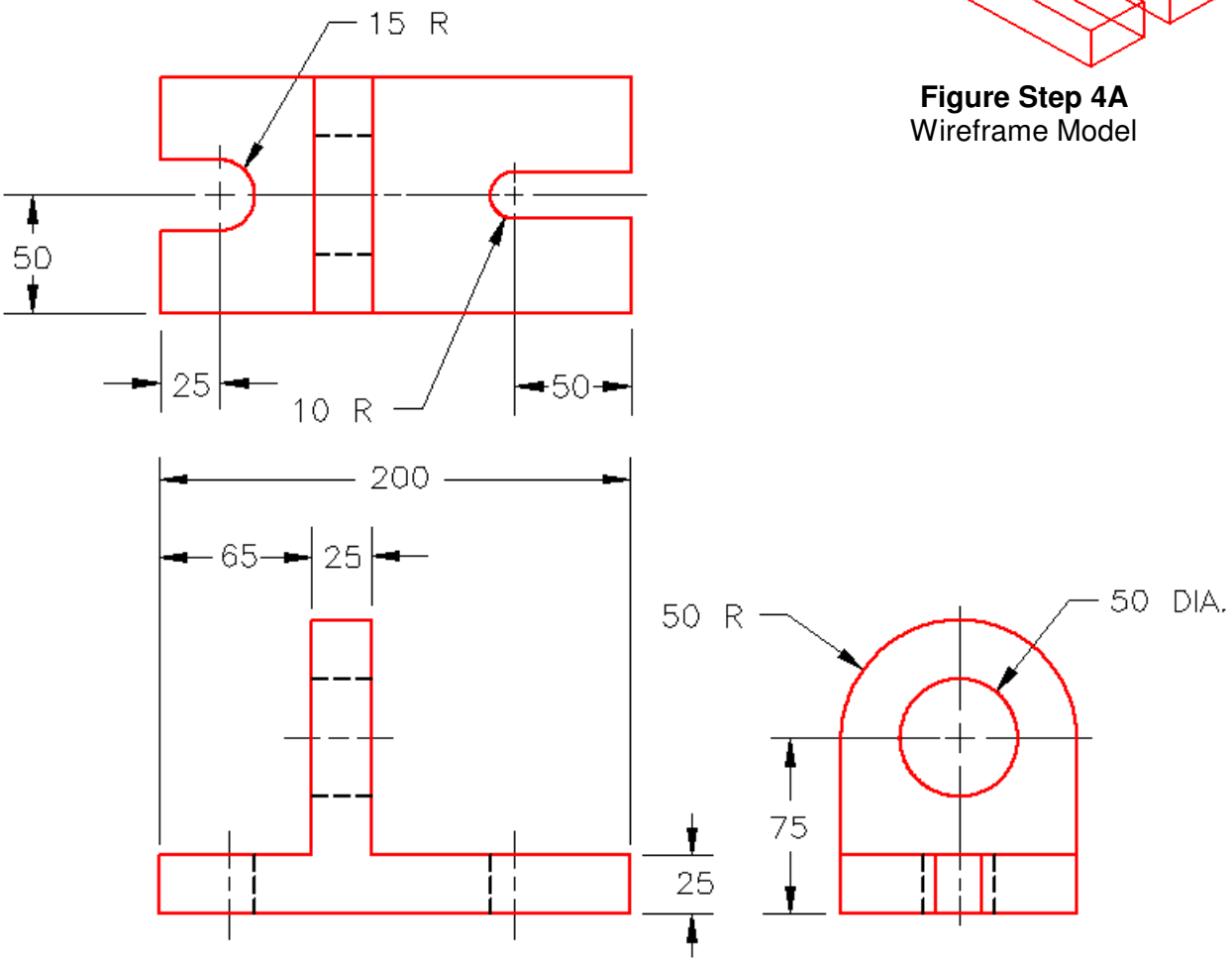



**Figure Step 4B**
Dimensioned Multiview Drawing

**Step 5** Set the system variable SURFTAB1 to 24 as shown below:

Command: **SURFTAB1**
Enter new value for SURFTAB1 <8>: **24**
Command:

**Author's Comments:** Setting SURFTAB1 to 24 sets the mesh density to 24 for the ruled surfaced inserted.

**Step 6** On layer Construction, draw a line along the top edge of each side of the model. (Figure Step 6)

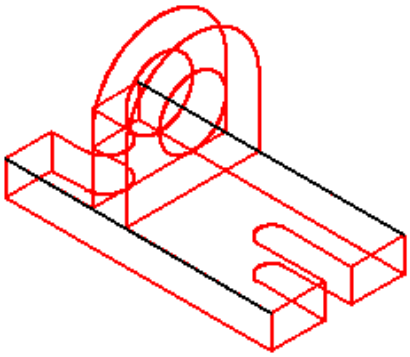


**Figure Step 6**

**Author's Comments:** On some models, construction lines must be drawn on the wireframe to make it easier to insert surfaces.

**Step 7** Set layer Surface 1 as the current layer. Enter the RULESURF command, as shown below, to insert a ruled surface. (Figure Step 7A and 7B)

Command: **RULESURF**
Current wire frame density: SURFTAB1=24
Select first defining curve: **P1**
Select second defining curve: **P2**
Command

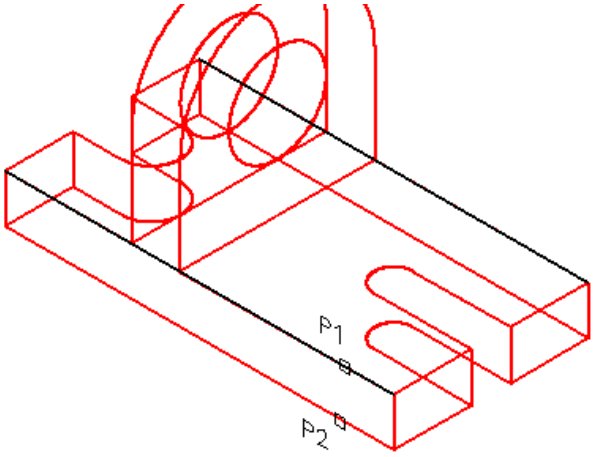



**Figure Step 7A**

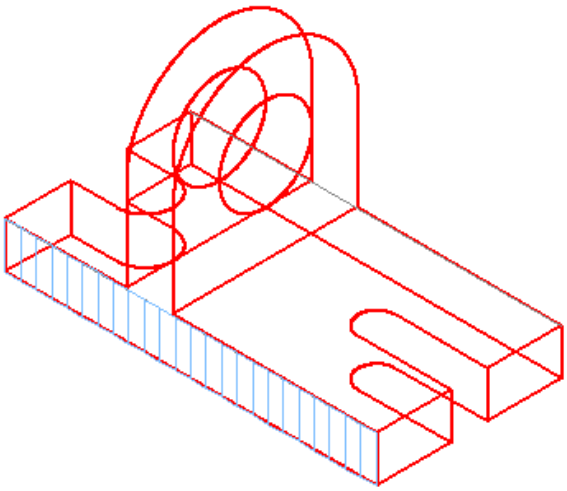


**Figure Step 7B**

**Step 8** Repeat the RULESURF command and insert surfaces all around the edge of the model. (Figure Step 8)

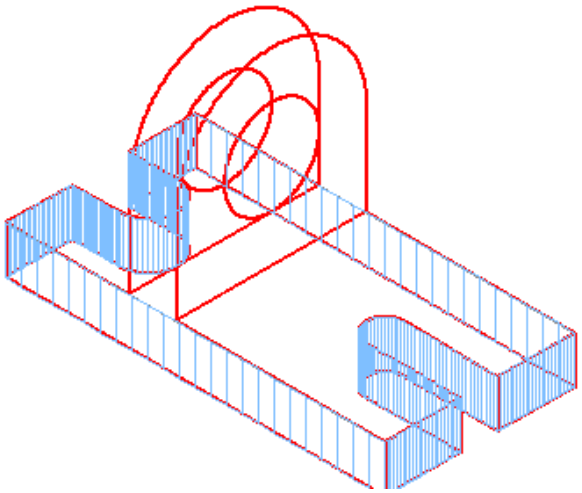


**Figure Step 8**

**Step 9** Turn layer Surface Off off and lock layers Model and Construction. Select all of the surfaces inserted in Steps 7 and 8 and change their layer to Surface Off. (Figure Step 9)

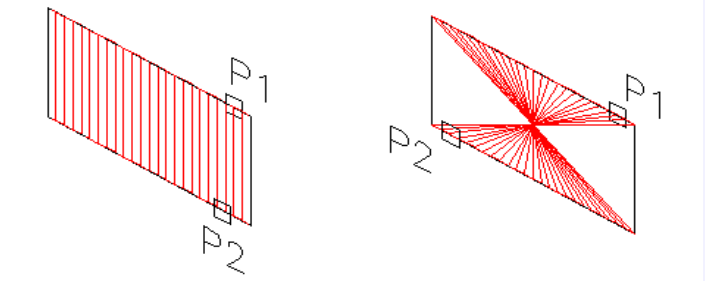
| Stat | Name | On | Freeze | Lock | Color | Linetype |
|---|---|---|---|---|---|---|
| | 0 | | | | white | Continuous |
| | Construction | | | | 253 | Continuous |
| | Defpoints | | | | white | Continuous |
| | Key | | | | magenta | Continuous |
| | Layout Titleblock | | | | white | Continuous |
| | Model | | | | red | Continuous |
| ✓ | Surface | | | | 151 | Continuous |
| | Surface Off | | | | 71 | Continuous |

**Figure Step 9**

**Author's Comments:** Here I use a little trick to help you when surfacing the model. Temporarily change the layers of newly created surfaces to a layer that is turned off. That way, the surfaces do not display and get in the way while you are inserted additional surfaces on the model. When all of the surfaces are inserted to complete the model, turn layer Surface Off on and change the layer of all surfaces back to layer Surface 1. The reason layer Model and Construction are locked is to make is easier to select the surfaces using windows when changing their layer property.

MUST KNOW

When using the RULESURF command, ensure that you select the objects closest to matching ends. If opposite ends are selected, the mesh will twist as shown in the figure.



**Step 10** Using what was just taught, insert ruled surfaces around the top of the object and inside of the hole as shown in the figure. (Figure Step 10).

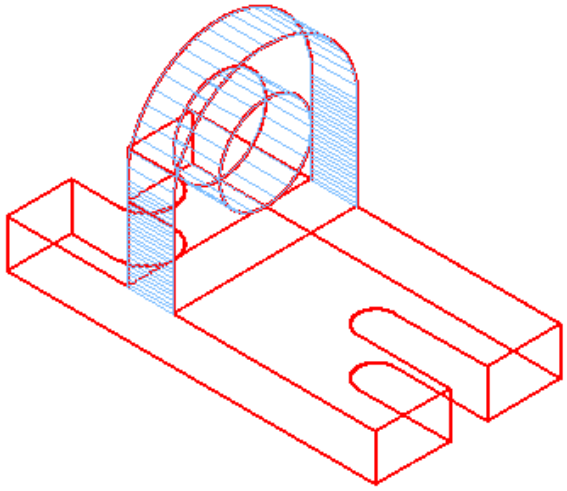


**Figure Step 10**

**Step 11** Change the layer of the surfaces inserted in Step 10 to layer Surface Off.

**Step 12** On layer Construction, draw the construction lines on the top surface as shown in the figure. Ensure to snap to the endpoints of the lines and arcs. (Figure Step 12)

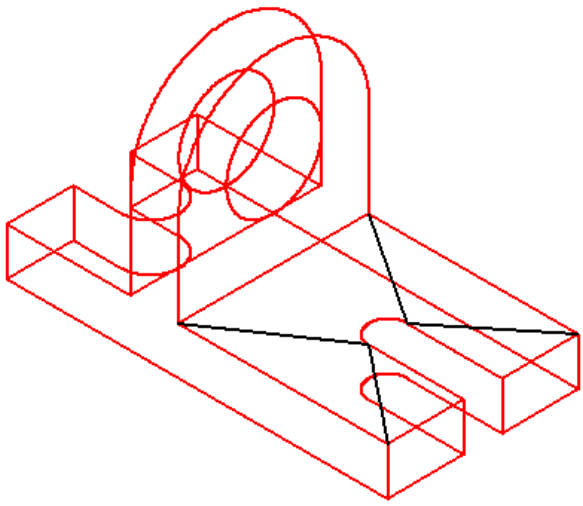


**Figure Step 12**

**Step 13** On layer Surface 1, use the RULESURF command to insert the surfaces as shown in the figure. Change the surfaces the layer Surface off. (Figure Step 13)

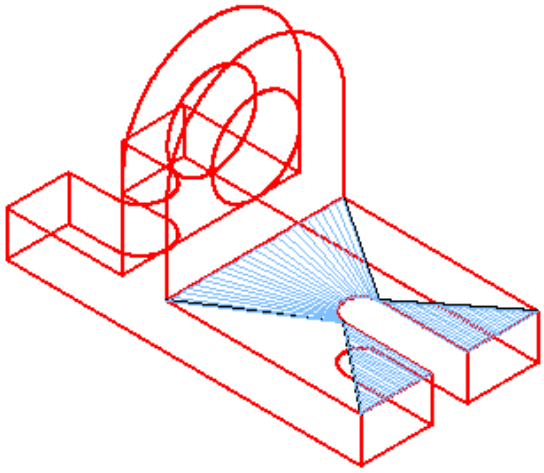


**Figure Step 13**

**Step 14** On layer Surface 1, use the RULESURF command to draw surfaces as shown in the figure. Change the layer of the surfaces to layer Surface off. (Figure Step 14)

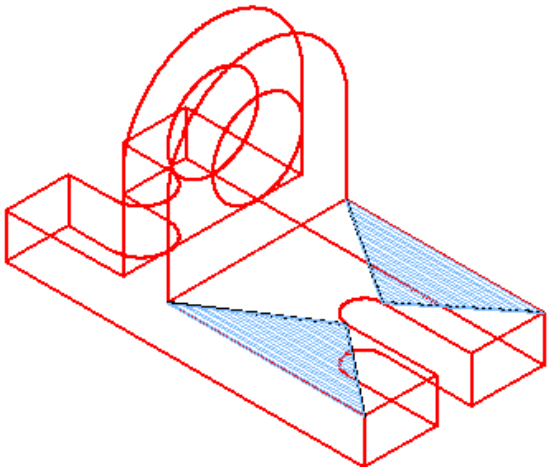


**Figure Step 14**

**Step 15** On layer Construction, draw a 180 degree arc on the top half of the circle. Ensure that you snap to the quads of the circle. To do that, ensure to locate the UCS on the same plane as the circle. (Figure Step 15)

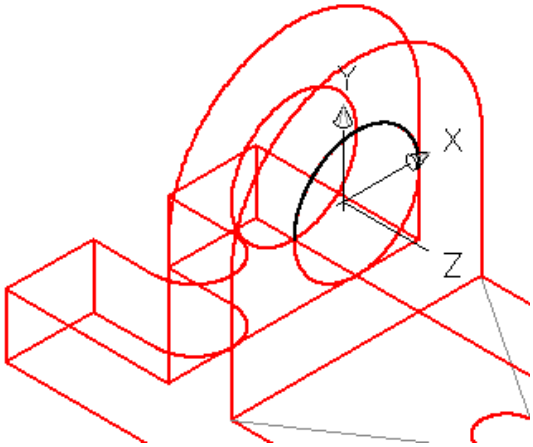



**Figure Step 15**

**Step 16** On layer Surface 1, insert a ruled surface between the arcs. (Figure Step 16)

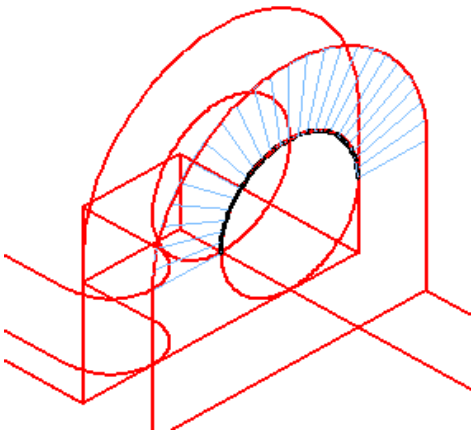


**Figure Step 16**

**Author's Comments:** Ensure that you select the arc instead of the circle under it. Sometimes, this can be tricky.

**Step 17** Change the layer of the surface that you just drew to layer Surface Off.

**Step 18** Draw two construction lines and a construction arc on the bottom half of the circle. (Figure Step 18)

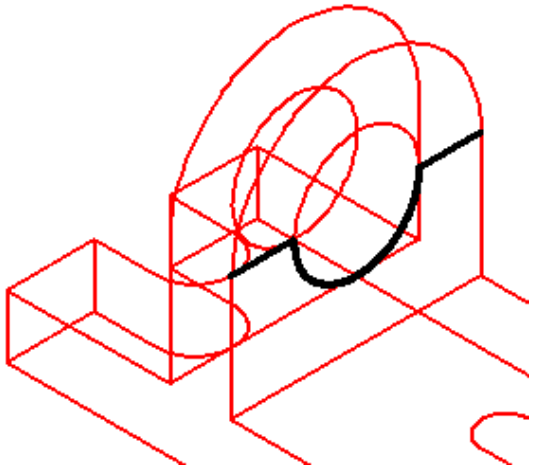


**Figure Step 18**

**Step 19** On layer Surface 1, insert a ruled surface. (Figure Step 19)

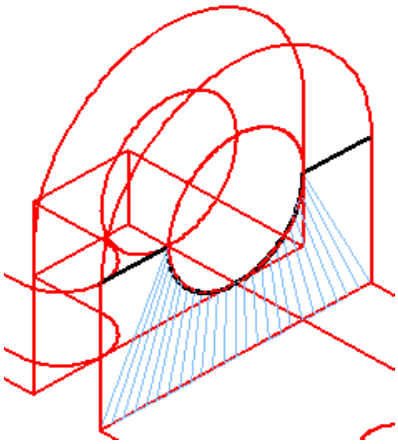


**Figure Step 19**

**Step 20** On layer Surface 1, insert the ruled surfaces as shown in the figure. (Figure Step 20)

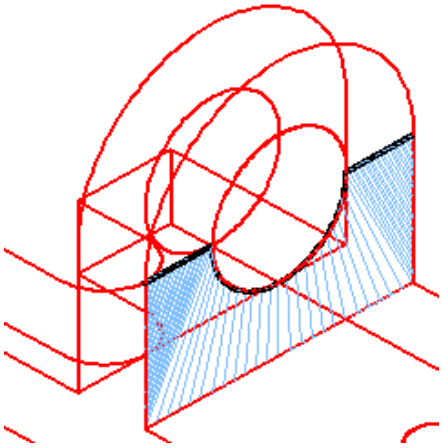


**Figure Step 20**

**Step 21** Change the layer of the existing surfaces to layer Surface 1 until your model matches the figure. (Figure Step 21)

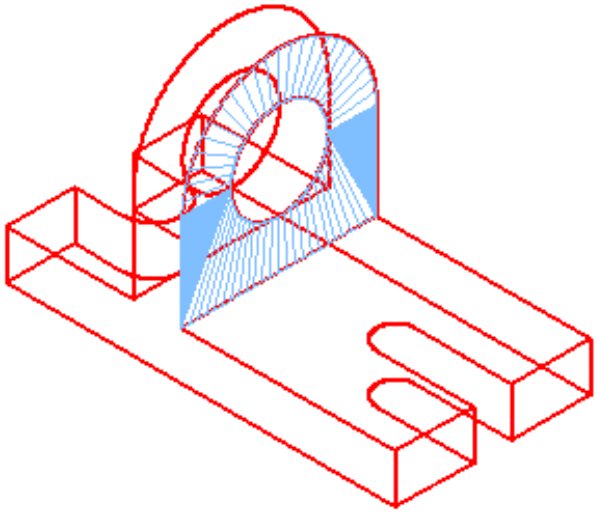


**Figure Step 21**

**Step 22** Copy the surfaces from the front side of the model to back side. (Figure Step 22)

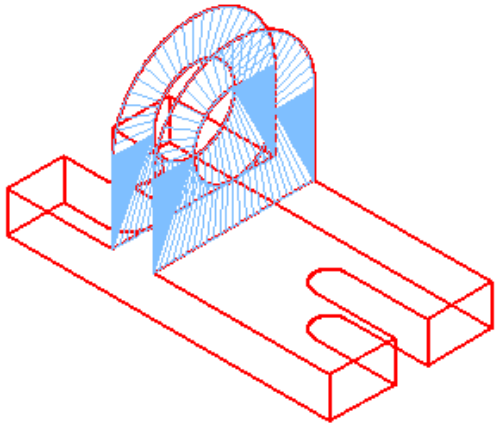


**Figure Step 22**

**Author's Comments:** To help you surface a model faster, you can copy surfaces from one side of a model to another, if they are identical.

**Step 23** Using what was just taught, complete surfacing the model. Ensure to surface the bottom of the model. When complete, change all the surfaces from Surface off to Surface 1.

**Step 24** Turn off all the layers except layer Surface 1 and the model should appear as shown in the figure. (Figure Step 24)

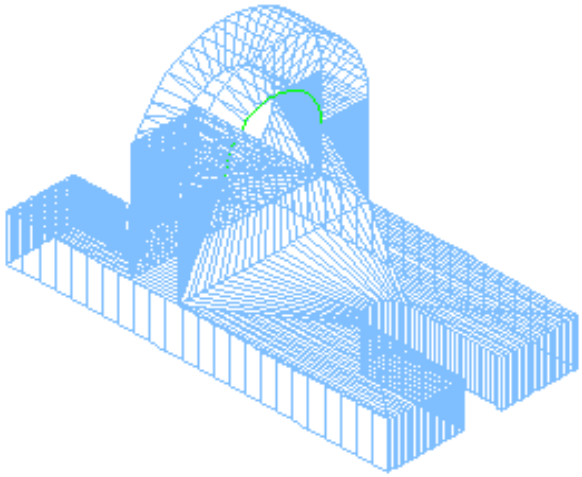


**Figure Step 24**

**Step 25** Set the current visual style to Realistic. (Figure Step 25)

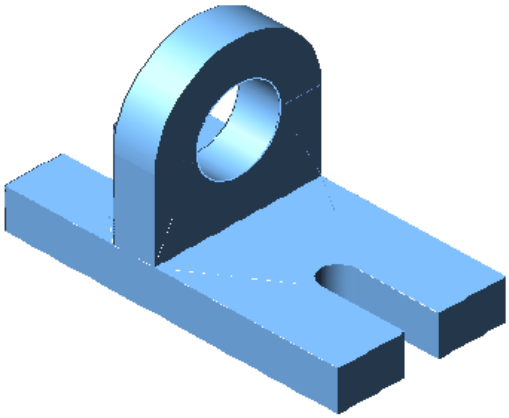


**Figure Step 25**

**Step 26** Save and close the drawing.

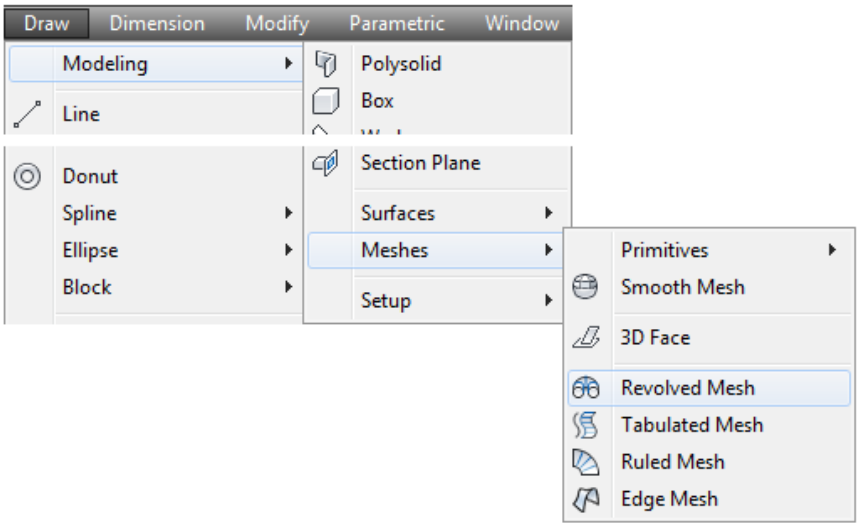
**Author's Comments:** Do not be concerned if your shaded model does not match the figures in the module exactly. There are many visual style settings that can be set to change the look of the shaded model. For now, all you should be concerned about is being able to surface the model. The advanced features of customizing visual styles are taught in the AutoCAD 3D Advanced eCourse.

## AutoCAD Command: REVSURF

The REVSURF command is used to create a surface of revolution by revolving an existing profile around an axis.

Shortcut: none

SURFTAB1 = YES
SURFTAB2 = YES



WORK ALONG

## Inserting Revolved Surfaces

**Step 1** Using the NEW command, start a new drawing using template 3D Layout English.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 13-2. (Figure Step 2)

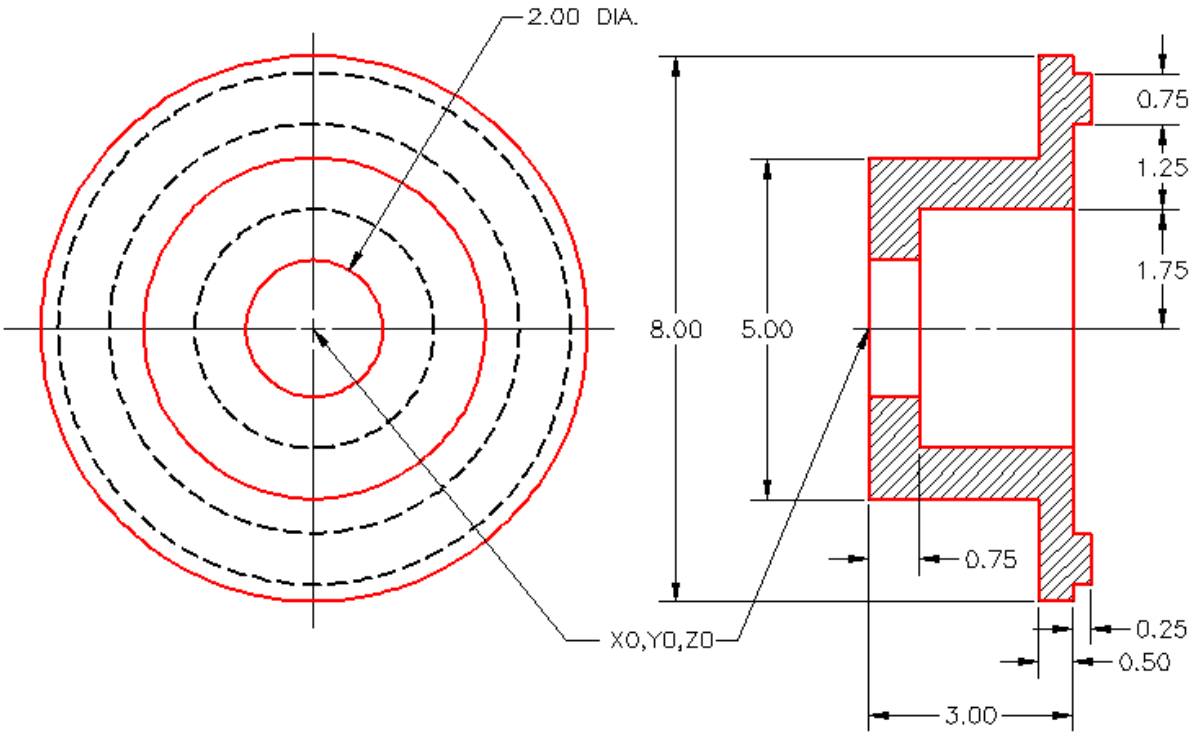



**Figure Step 2**
Dimensioned Multiview Drawing

**Step 3** Set the current layer to Pline and the current visual style to 2D Wireframe.

**Step 4** Change the view to SE Isometric and the UCS to Right. (Figure Step 4)

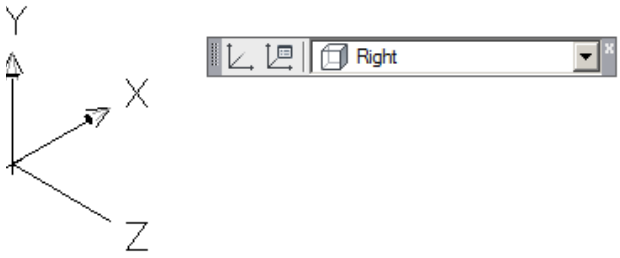



**Figure Step 4**

**Step 5** Using the multiview drawing as a reference, draw the right side cross section of the solid part of the object. (Figure Step 5)

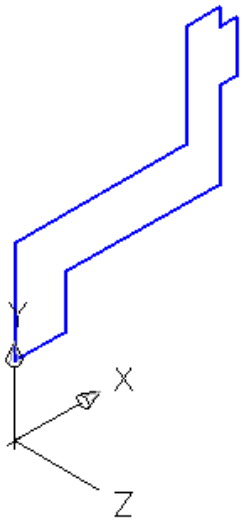



**Figure Step 5**

**Author's Comments:** You will be revolving this cross section 360 degrees to create a surface as it revolves. Therefore, only one-half of the section view is drawn.

**Step 6** On layer Construction, draw a line, of any length, from 0,0,0 along the X axis. Enable ortho mode to draw it faster. This is the center of the model and will be used as the axis for the revolution. (Figure Step 6)

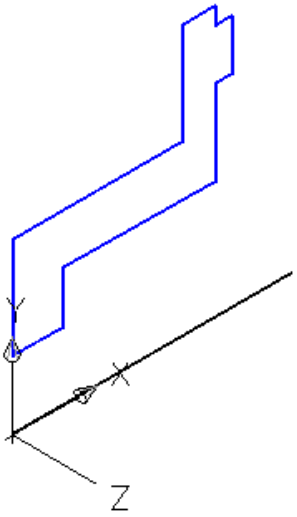



**Figure Step 6**

**Author's Comments:** To convert the model objects to a closed polyline using the PEDIT command, the drawing must be perfectly drawn with the endpoints joining exactly. There cannot be any overlapping or gaps. If you have problems using the PEDIT command to create a closed polygon, correct the drawing or redraw the objects from scratch.

**Step 7** Using the PEDIT command, as shown below, convert the lines of the model to a closed polyline.

Command: **PE**
Select polyline or [Multiple]:
*(Select one line of the model.)*
Object selected is not a polyline
Do you want to turn it into one? <Y>
*(Press Enter to accept the default.)*
Enter an option [Close/Join/Width/Edit vertex/Fit/Spline/Decurve/Ltype gen/Undo]: **J**
*(J for Join.)*
Select objects: **ALL**
13 found
Select objects:
11 segments added to polyline
Enter an option [Open/Join/Width/Edit vertex/Fit/Spline/Decurve/Ltype gen/Undo]:
Command:

**Step 8** To ensure that you have successfully created a closed polyline, open the Properties window and select the polyline. The object type should read Polyline, all the objects should show as part of the polyline and the Closed property should indicate Yes. (Figure Step 8)

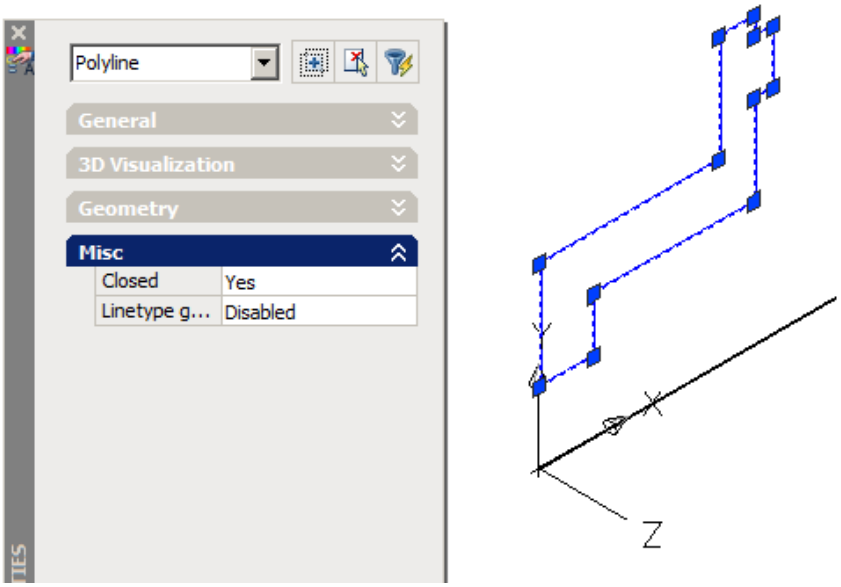



**Figure Step 8**

**Step 9** Set the system variable SURFTAB1 to 64 and SURFTAB2 to 24 as shown below.

Command: **SURFTAB1**
Enter new value for SURFTAB1 <6>: **64**
Command: **SURFTAB2**
Enter new value for SURFTAB2 <6>: **24**
Command:

**Step 10** Change the current layer to Surface 1 and enter the REVSURF command as shown below. After you complete the command, your model should appear as shown in the figure. (Figure Step 10)

Command: **REVSURF**
Current wire frame density: SURFTAB1=64 SURFTAB2=24
Select object to revolve
*(Select the closed polyline.)*
Select object that defines the axis of revolution:
*(Select the axis line.)*
Specify start angle <0>:
*(Accept the default of 0.)*
Specify included angle (+=ccw, -=cw) <360>:
*(Accept the default of 360.)*
Command:

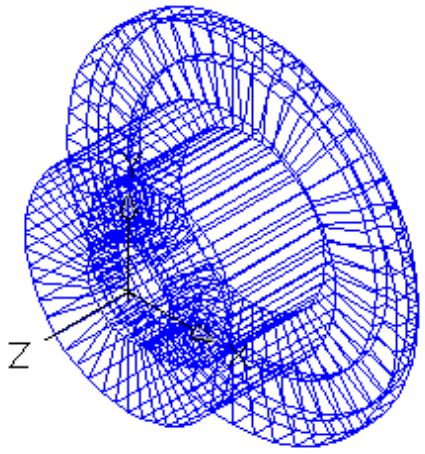



**Figure Step 10**

**Step 11** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 12** Using the 3DORBIT command, rotate the model and look at all sides. (Figure 12A and 12B)

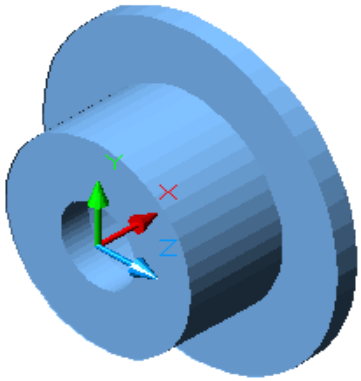


**Figure Step 12A**
SE Isometric View

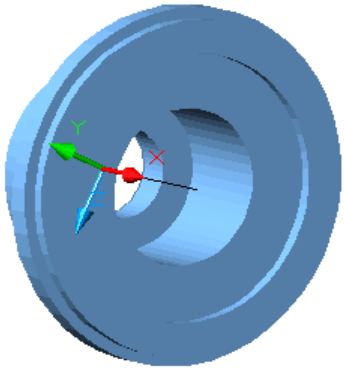


**Figure Step 12B**
Rotated View

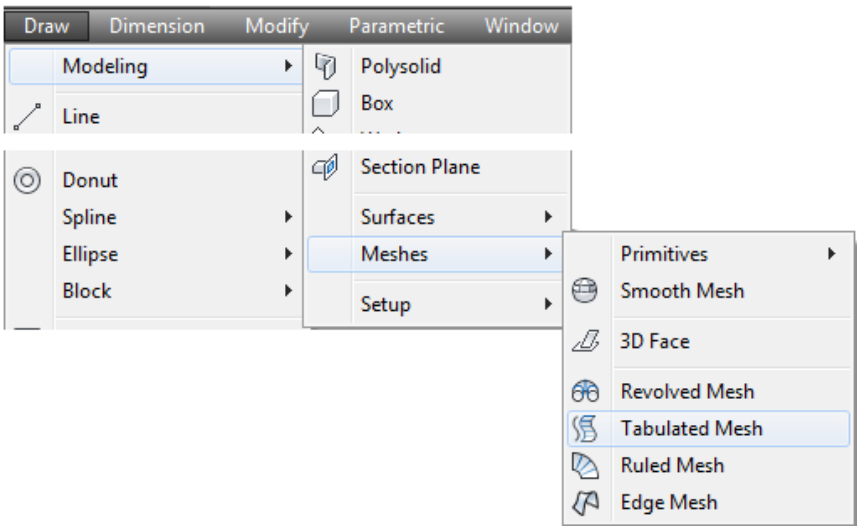
**Step 13** Save and close the drawing.

## AutoCAD Command: TABSURF

The TABSURF command is used to create a surface mesh moving a profile along a path.

Shortcut: none

SURFTAB1 = YES
SURFTAB2 = No Effect



WORK ALONG

## Inserting Tabulated Surfaces

**Step 1** Using the NEW command, start a new drawing using template 3D Layout English.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 13-3.

**Step 3** Set the current visual style to 2D Wireframe, the current view to SE Isometric and the current UCS to World. (Figure Step 3)

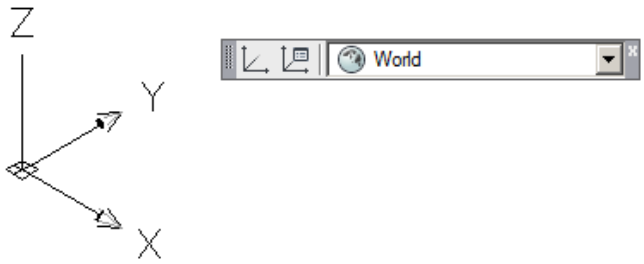



**Figure Step 3**

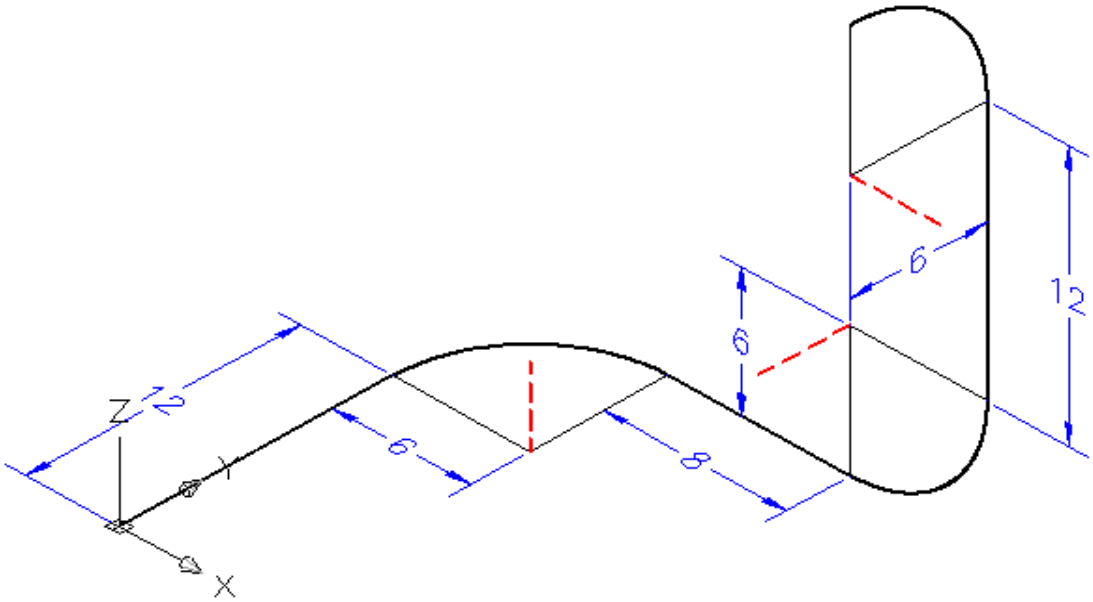



**Figure Step 4A**
Dimensioned Model
SE Isometric View

**Step 4** Set layer Construction as the current layer. Draw the model shown in the dimensioned model. These are the construction lines and arcs to be used to construct the model. When complete, your model will appear as shown in the figure. The length of the lines that appear dashed in the dimensioned model are not important since they are axis lines only. They are always drawn in the Z direction of the current UCS. They can be drawn any length as continuous linetype. (Figure Step 4A, 4B, and 4C)

**Author's Comments:** You will have to change the current UCS as you draw the construction lines to ensure that you are drawing on the correct plane.

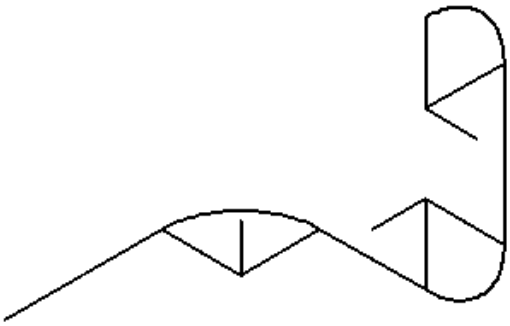


**Figure Step 4B**
SE Isometric View

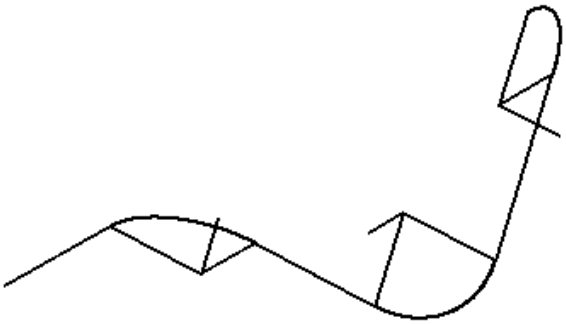


**Figure Step 4C**
Rotated View

**Step 5** With the UCS set to Front, draw a model of the object shown in the dimensioned drawing. The drawing should appear as shown in the figure. Draw the model anywhere in model space. Its location is not important. (Figure Step 5A and 5B)

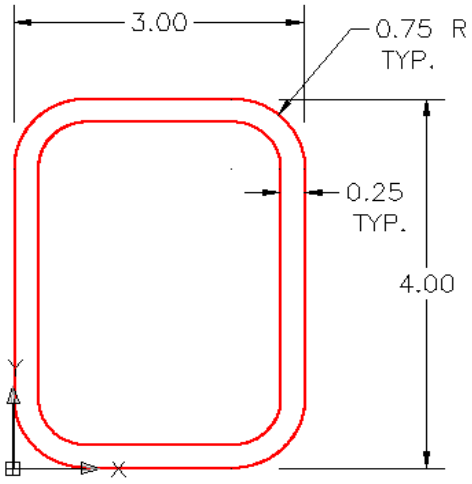



**Figure Step 5A**

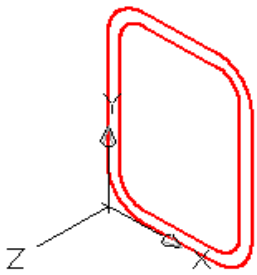



**Figure Step 5B**

**Step 6** Change the lines and arcs into two closed polylines using the PEDIT command. Check them using the Properties window. (Figure Step 6)

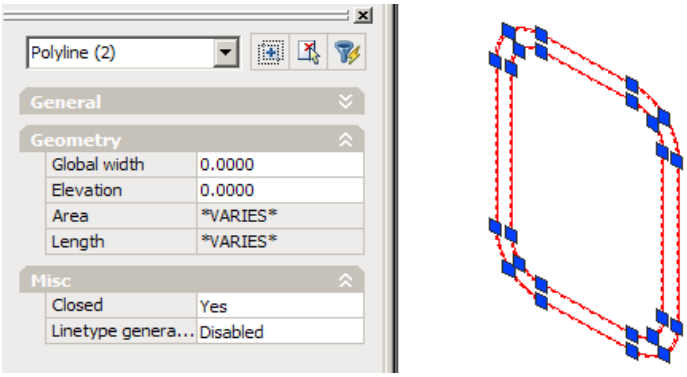



**Figure Step 6**

**Step 7** On layer Construction, draw in two construction lines from midpoint of the lines to find the exact center of the object. (Figure Step 7)

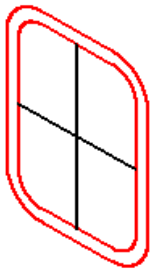


**Figure Step 7**

**Step 8** Make three additional copies of the model and rotate them to lay on different UCS planes. Their location in 3D space is not important. (Figure Step 8)

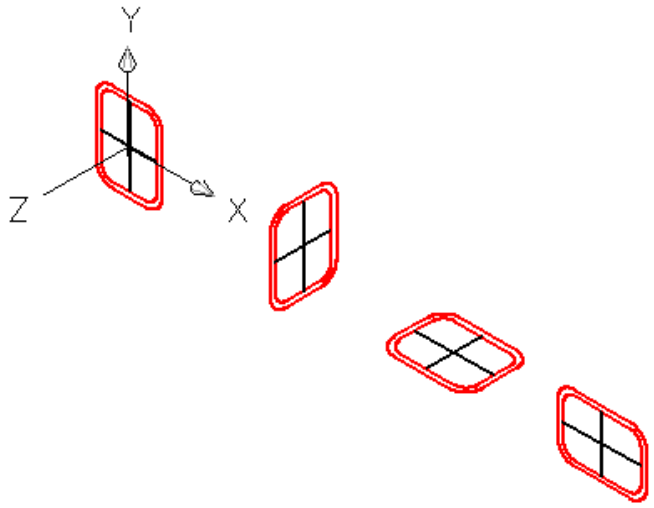



**Figure Step 8**

**Step 9** Your drawing should appear similar to the figure. (Figure Step 9)

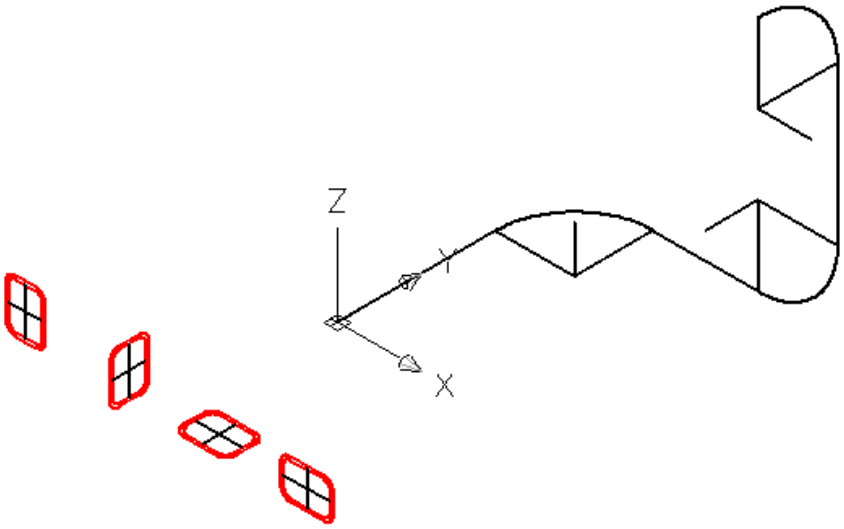



**Figure Step 9**

**Step 10** Copy the objects onto the construction lines. Ensure that the midpoint of the object (the intersections of the construction lines) aligns to the endpoints of the lines and arcs. (Figure Step 10)

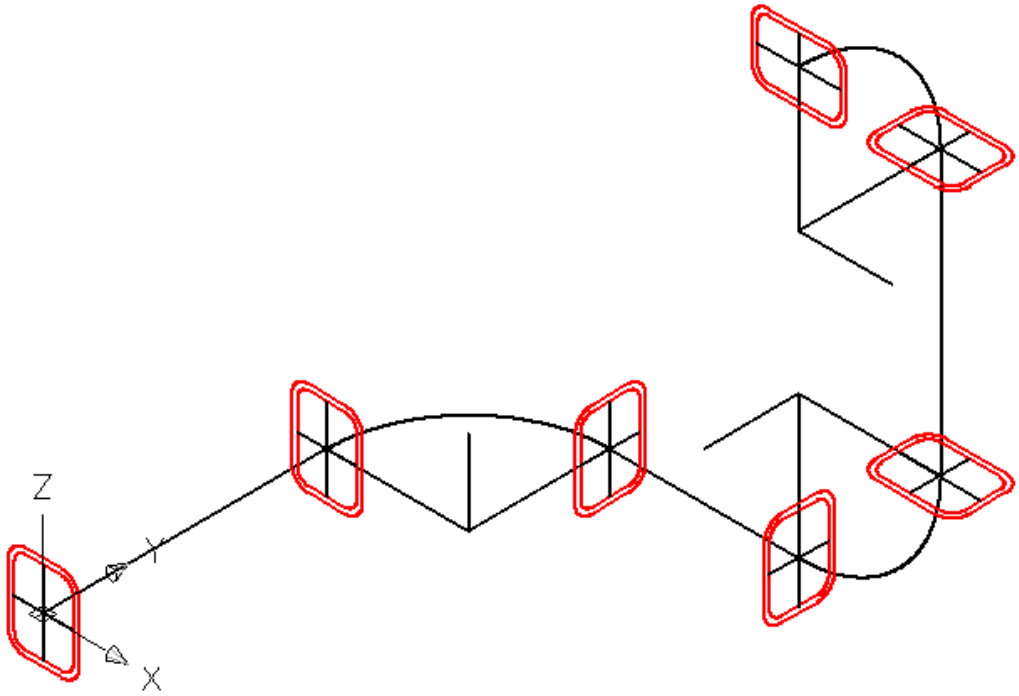



**Figure Step 10**

**Step 11** With the UCS located on the Front, SURFTAB1 set to 48 and layer Surface 1 as the current layer, enter the TABSURF command, as shown below, to create the surface for the inside of the tube. (Figure Step 11)

Command: **TABSURF**
Current wire frame density: SURFTAB1=48
Select object for path curve:
*(Select the inside polyline.)*
Select object for direction vector:
*(Select the construction axis line. Ensure you select it closer to the end where the object your are tabulating is located.)*
Command:

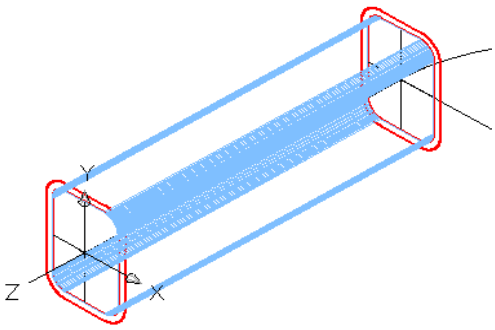



**Figure Step 11**

**Step 12** Set the current visual style to Realistic. (Figure Step 12)

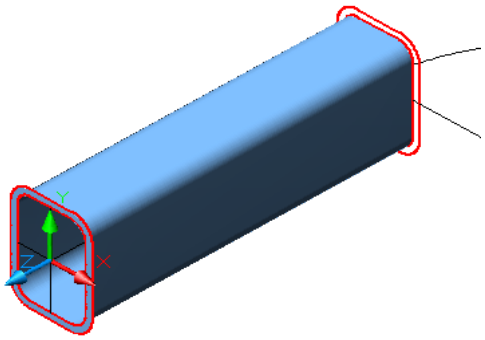


**Figure Step 12**

**Step 13** Using the TABSURF command, create the surface for the outside of the tube. (Figure Step 13)

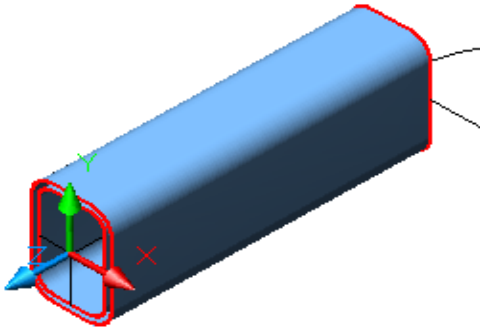


**Figure Step 13**

**Step 14** Enter the REVSURF command, as shown below, to construct the inside of the tube around the first corner. First change the layer of the straight tube surfaces constructed in Steps 11 to 13 to Surface Off. (Figure Step 14)

Command: **REVSURF**
Current wire frame density: SURFTAB1=48 SURFTAB2=6
Select object to revolve:
*(Select the inside polyline.)*
Select object that defines the axis of revolution
*(Select the axis line.)*
Specify start angle <0>:
*(Accept the default.)*
Specify included angle (+=ccw, -=cw) <360>: **-90**
Command:

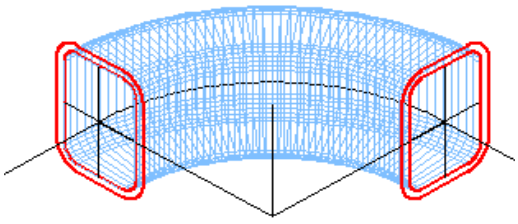


**Figure Step 14**

**Step 15** Using what was just taught, construct the outside of the tube and change the layers of the surfaces until the model appear as shown in the figure. (Figure Step 15)

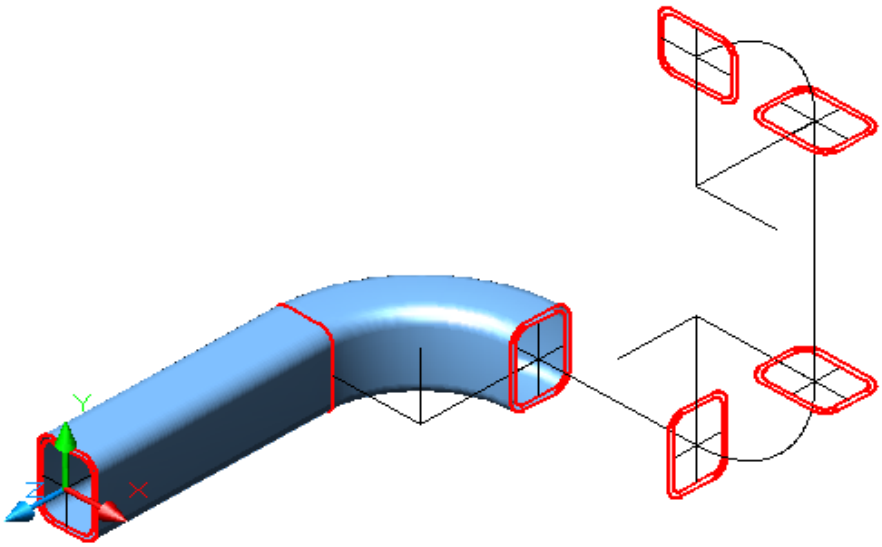



**Figure Step 15**

**Step 16** Using what was just taught, complete the model. (Figure Step 16)

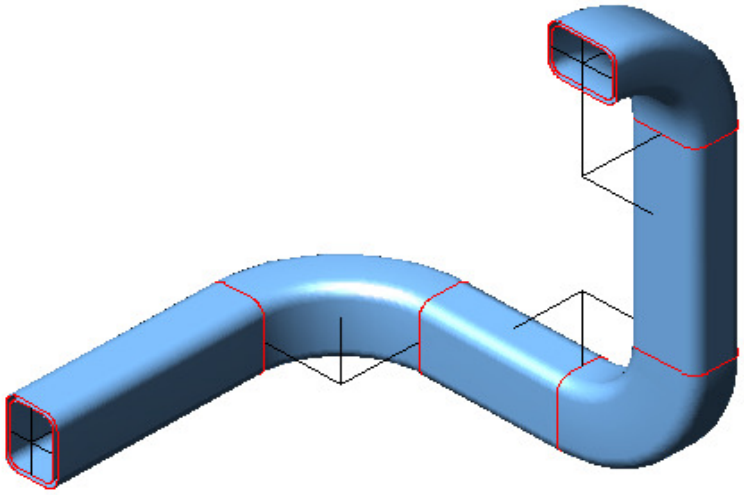


**Figure Step 16**

**Step 17** Turn off layer Model and Construction and your completed model will appear as shown in the figure. (Figure Step 17)

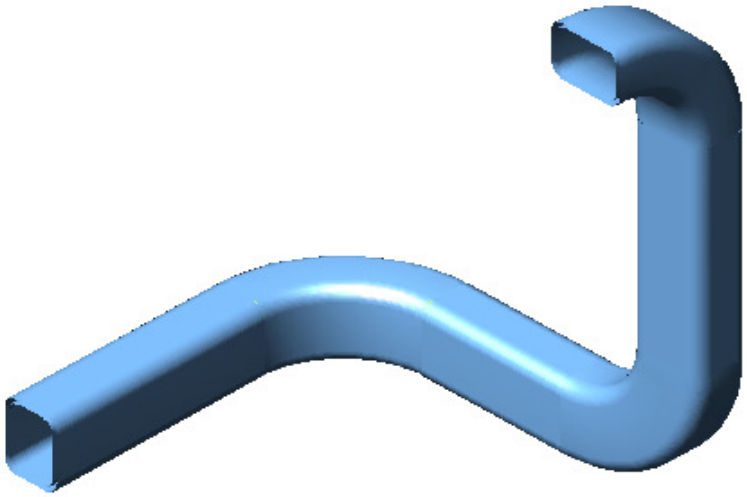


**Figure Step 17**

**Step 18** Save and close the drawing.

**Author's Comments:** Do not be concerned if your shaded model does not match the figures in the module exactly. There are many visual style settings that can be set to change the look of the shaded model. For now, all you should be concerned about is being able to surface the model. The advanced features of customizing visual styles are taught in the AutoCAD 3D Advanced eCourse.

USER TIP

Although any surfacing command can be used to create the surfaces, the RULESURF command is the easiest and fastest to use for most surfaces. To shorten the modeling time, use it whenever possible.

## The Key Principles in Module 13

**1** Geometrically defined surface meshes use existing geometry that must be created before the surfaces. In almost all cases, you will use the wireframe of the model as the existing geometry.
**2** Although any surfacing command can be used to create a surface, the RULESURF command is the easiest and fastest to use for most surfaces.
**3** When using the RULESURF command, ensure that you select the objects closest to matching ends. If opposite ends are selected, the mesh will twist.
**4** The mesh density represented by the lines, circles or arcs that make the rows and columns of the surface mesh are controlled with the system variables SURFTAB1 and SURFTAB2.

| **Lab Exercise 13-1** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 13-1 | 3D Layout English | Inches |

**Step 1** Draw a wireframe of the object shown in the figure. (Figure Step 1)

**Step 2** Pick appropriate mesh densities and on layer Surface 2, create surface meshes on all surfaces including back and bottom. (Figure Step 2)

**Step 3** Freeze layer Construction and Model.

**Step 4** Set the current visual style to Realistic. Use the 3DORBIT command to check that the model is surfaced on all sides.

**Step 5** Set the Insertion Units, change the current UCS to World and check the model with the key.

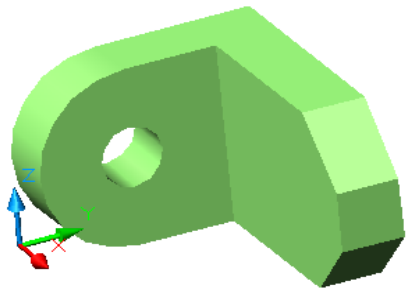


**Figure Step 2**
Completed Model
SE Isometric View

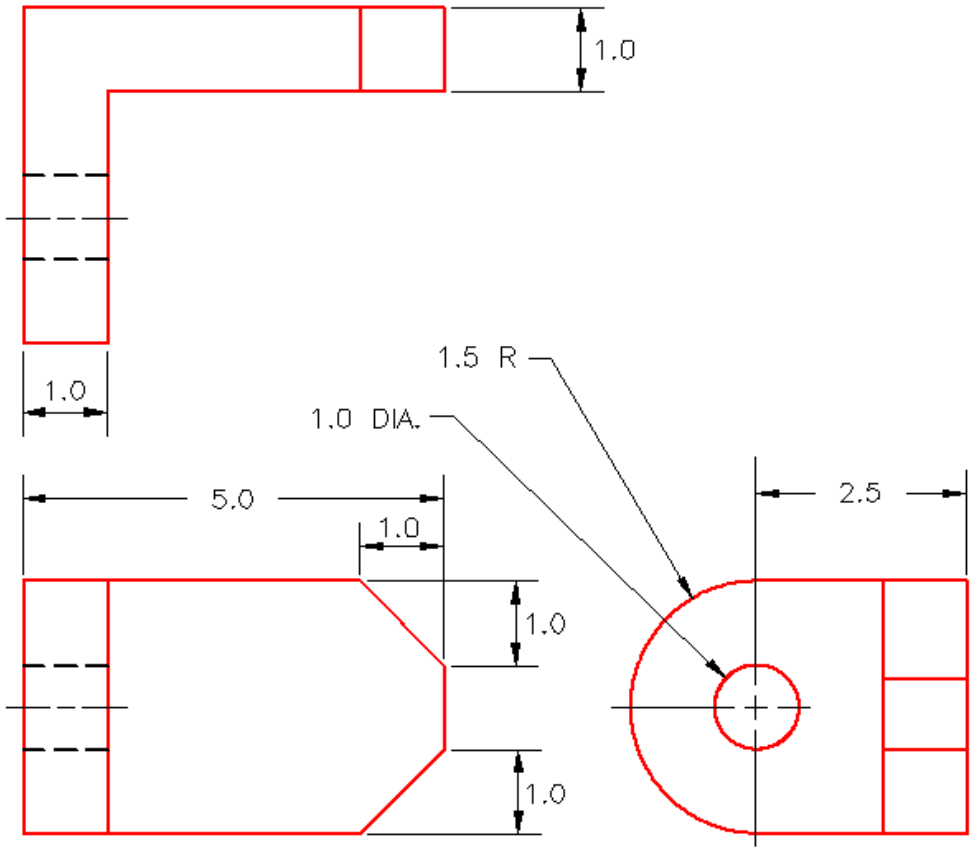



**Figure Step 1**
Dimensioned Multiview Drawing

| **Lab Exercise 13-2** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 13-2 | N/A | Inches |

**Step 1** Open the drawing AutoCAD 3D Lab 04-1.

**Step 2** Save the drawing with the name AutoCAD 3D Lab 13-2.

**Step 3** On layer Surface 5, create surface meshes on all surfaces including back and bottom. (Figure Step 3)

**Step 4** Freeze layer Construction and Model.

**Step 5** Set the current visual style to Realistic. Use the 3DORBIT command to check that the model is surfaced on all sides.

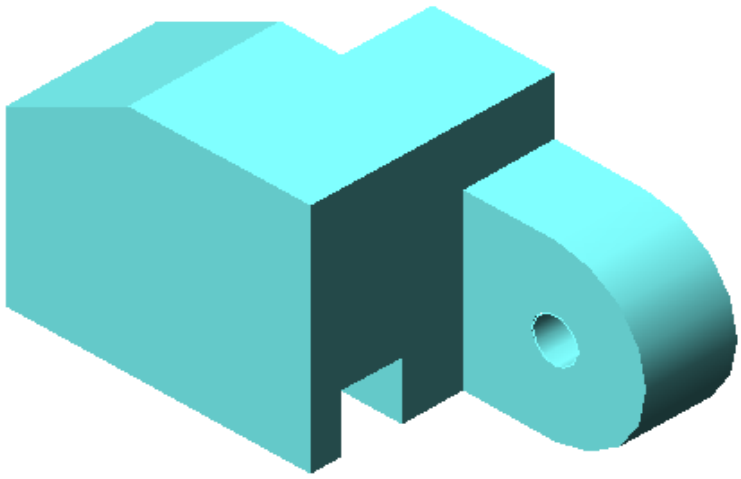


**Figure Step 3**
Completed Model
SE Isometric View

**Author's Comments:** Do not be concerned if your shaded model does not match the figures in the module exactly. There are many visual style settings that can be set to change the look of the shaded model. For now, all you should be concerned about is being able to surface the model. The advanced features of customizing visual styles are taught in the AutoCAD 3D Advanced eCourse.

| **Lab Exercise 13-3** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 13-3 | N/A | Inches |

**Step 1** Open the drawing AutoCAD 3D Lab 08-1.

**Step 2** Save the drawing with the name AutoCAD 3D Lab 13-3.

**Step 3** On layer Surface 1, create surfaces on each side including back and bottom. (Figure Step 3)

**Step 4** Freeze layer Construction and Model.

**Step 5** Set the current visual style to Realistic. Use the 3DORBIT command to check that the model is surfaced on all sides..

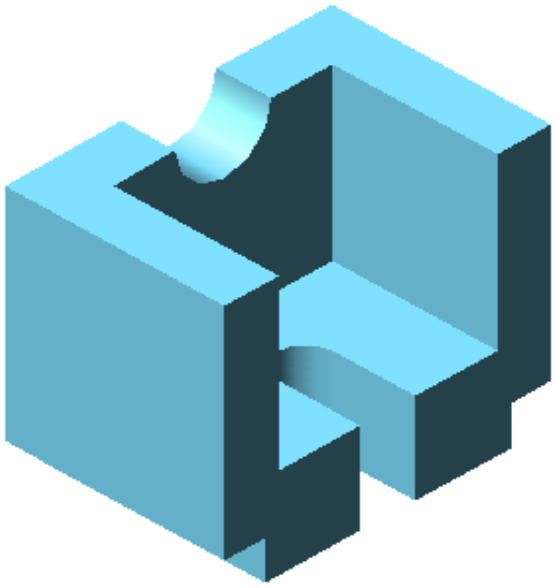


**Figure Step 3**
Completed Model
SE Isometric View

**Author's Comments:** Do not be concerned if your shaded model does not match the figures in the module exactly. There are many visual style settings that can be set to change the look of the shaded model. For now, all you should be concerned about is being able to surface the model. The advanced features of customizing visual styles are taught in the AutoCAD 3D Advanced eCourse.

| **Lab Exercise 13-4** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 13-4 | 3D Layout Metric | Millimeters |

**Step 1** On layer Pline, draw the cross section of the top half of the model on the right side UCS. (Figure Step 1A and 1B)

**Step 2** Create a surface revolution on layer Surface 1. (Figure Step 2)

**Step 3** Freeze layer Pline and Construction.

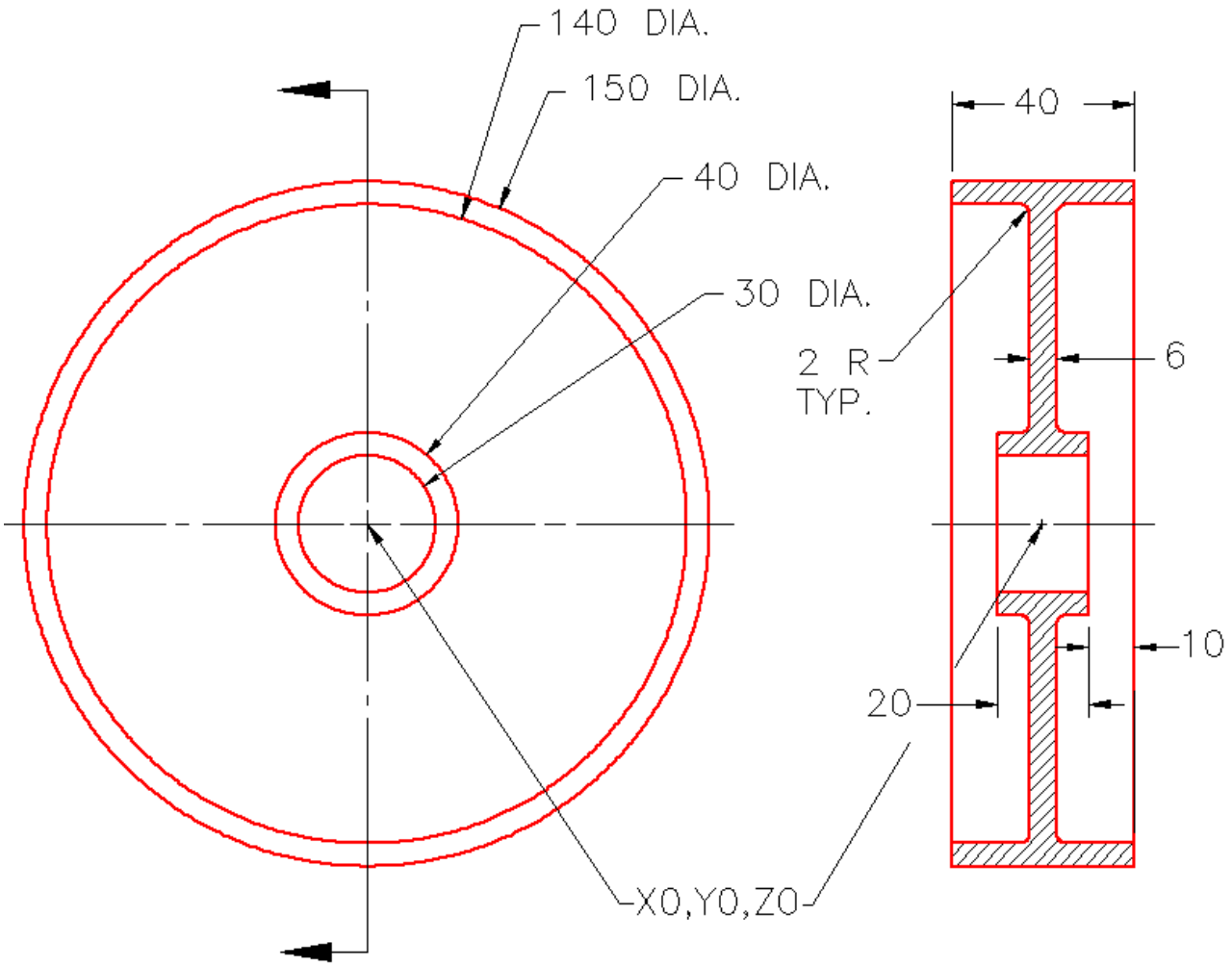



**Figure Step 1A**
Dimensioned Multiview Drawing

**Step 4** Set the current visual style to Realistic. Use the 3DORBIT command to check that the model is surfaced on all sides.

**Step 5** Set the Insertion Units, change the current UCS to World and check the model with the key.

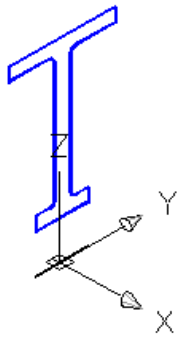



**Figure Step 1B**
View Of a Cross Section to Revolve

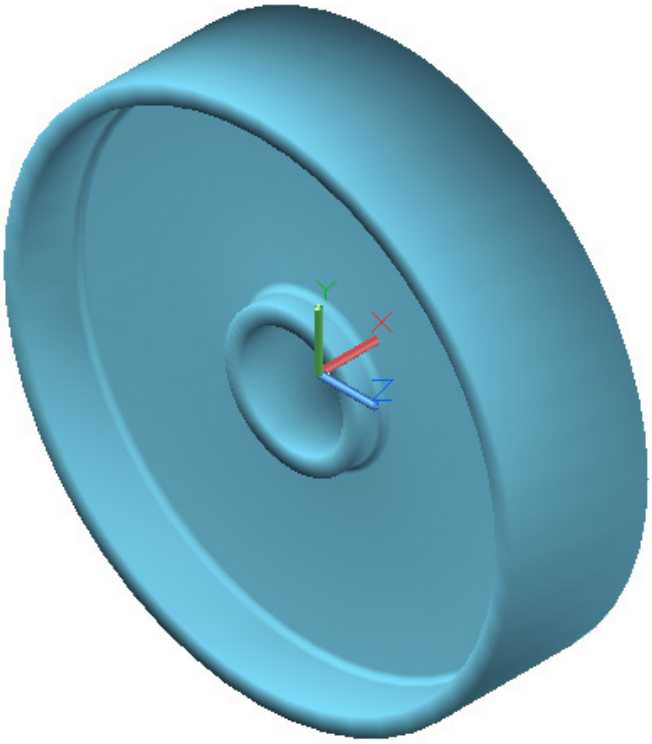


**Figure Step 2**
Complete Model
SE Isometric View

AutoCAD® Self-paced eCourse

# AutoCAD 3D

## Module 18

## Solid Modeling - Part 2

### Learning Outcomes

When you have completed this module, you will be able to:

1. Describe how solid models are created by extrusion or revolving.
2. Apply the EXTRUDE and REVOLVE commands to draw solid models.

### Constructing Solid Models Without Using Solid Primitives

Constructing most solid models using solid primitives would be to difficult and slow. It is much faster and simpler to construct most solid models using the EXTRUDE and/or the REVOLVE commands.

### Extruding

*Extruding* involves drawing a closed object and, using the EXTRUDE command, project it in the Z direction at a given distance. See Figure 18-1. The closed object can be a 2D polygon, a circle or an ellipse. Extruded solids can then be joined with the UNION command or subtracted using the SUBTRACT command to form the final solid model.

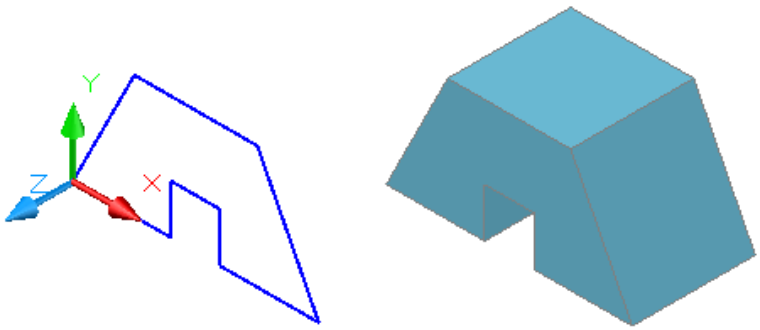



**Figure 18-1**
Extruding a Solid Model

### Revolving

Not all solid models can be extruded. A solid model that is symmetrical can be created by *revolving* a closed object. See Figure 18-2. The closed 2D object can be a polygon, a circle or an ellipse. It is then revolved around an axis. The contour of the object will create the solid as it is revolved around the axis. It can be revolved any angle from 1 degree to 360 degrees.

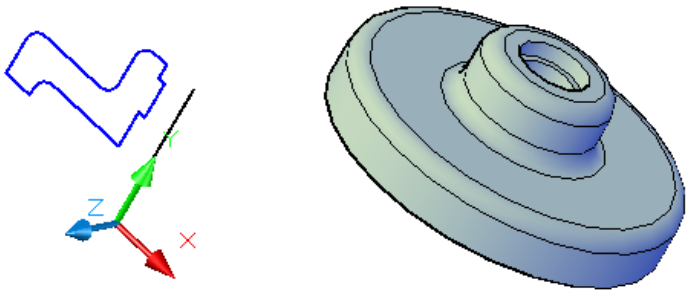



**Figure 18-2**
Revolving a Solid Model

## AutoCAD System Variable: DELOBJ

The DELOBJ system variable controls whether the EXTRUDE or REVOLVE command deletes or retains the closed object when the command is executed.

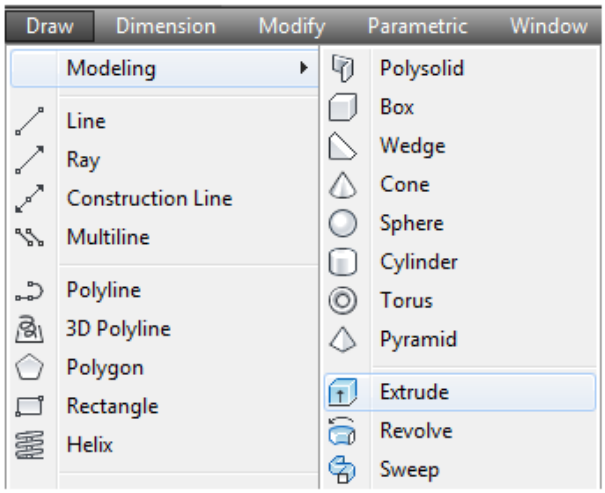
Command: **DELOBJ**
Enter new value for DELOBJ <0>:
Command:

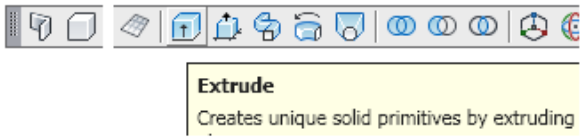
Set to:
0 - Will retain the closed polygon
1 - Will delete the closed polygon

## AutoCAD Command: EXTRUDE

The EXTRUDE command is used to create a solid by projecting a closed 2D object along the Z axis of the current UCS.

Shortcut: **EXT**



## Creating a Extruded Solid Model

WORK ALONG

**Step 1** Using the NEW command, start a new drawing using template 3D Layout English.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 18-1.

**Step 3** Set the current visual style to 2D Wireframe, the current layer to Pline, the current view to SE Isometric and the current UCS to World.

**Step 4** Draw the top contour of the wireframe model only. Use the multiview drawing as a reference. (Figure Step 4A and 4B)

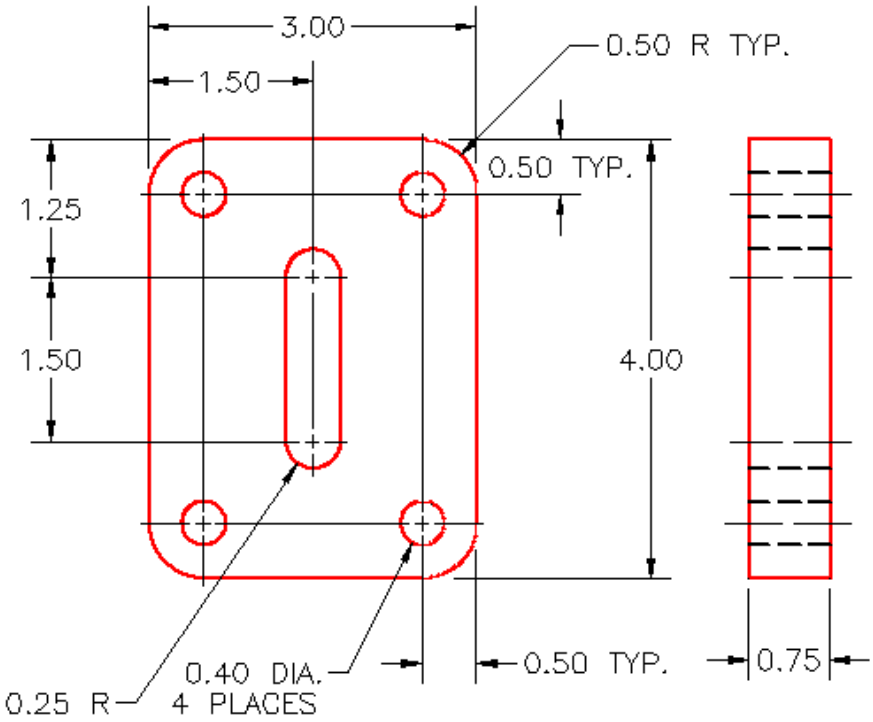



**Figure Step 4A**
Dimensioned Multiview Drawing

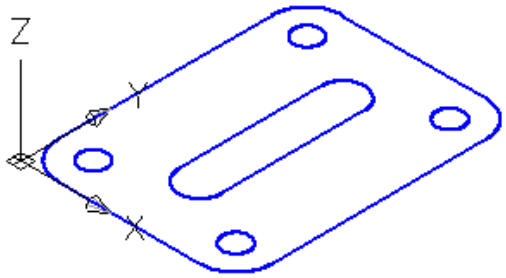



**Figure Step 4B**

**Step 5** Set the current UCS to Top and locate it at the center of the circle as shown in the figure. (Figure Step 5)

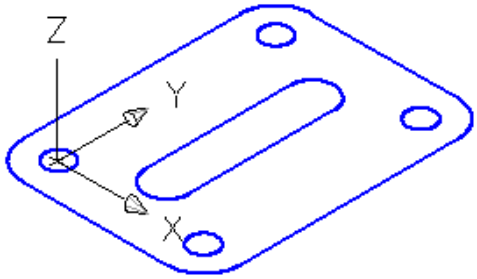



**Figure Step 5**

**Step 6** Enter the DELOBJ system variable as shown below. Ensure that it is set to 0.

Command: **DELOBJ**
Enter new value for DELOBJ <1>: **0**
Command:

**Author's Comments:** When the DELOBJ system variable is set to 0 the closed polylines that are used in the EXTRUDE and REVOLVE commands in that drawing will be not be deleted.

**Step 7** Using what was taught earlier in the eCourse, use the PEDIT command to convert the lines and arcs to closed polylines. Check the objects with the Properties window to ensure that they are closed polygons. (Figure Step 7)

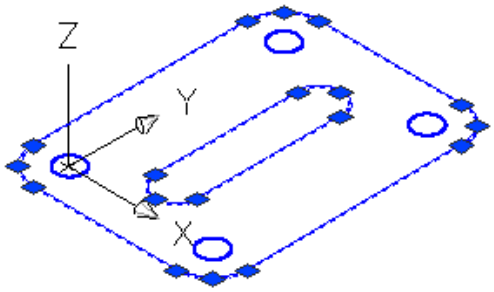



**Figure Step 7**

**Step 8** Set the system variable ISOLINES to 32, as shown below.

Command: **ISOLINES**
Enter new value for ISOLINES <4>: **32**
Command:

**Author's Comments:** The ISOLINES system variable is used set the number of contour lines that a curved surface solid model will be used when it is constructed.

**Step 9** Set the current layer to Solid 3. Enter the EXTRUDE command, as shown below, to create the solid model.

Command: **EXTRUDE**
Current wire frame density: ISOLINES=32
Select objects: 6 found
*(Select all of the objects in a window or pick then individually.)*
Select objects:
Specify height of extrusion or [Path]: **-0.75**
*(Use -0.75 since the extrusion in the negative Z direction.)*
Specify angle of taper for extrusion <0>:
*(Press Enter to select the default.)*
Command:

**Step 10** Turn layer Pline off and your model should appear as shown in the figure. (Figure Step 10)

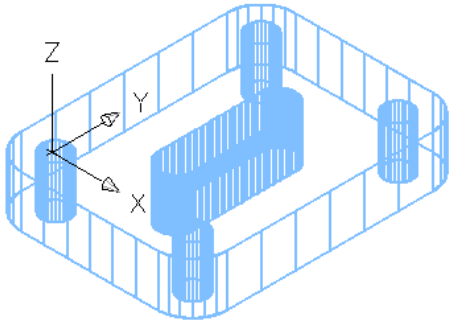



**Figure Step 10**

**Step 11** Set the current visual style to Realistic. (Figure Step 11)

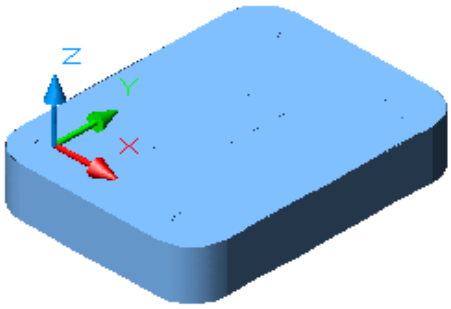



**Figure Step 11**

**Author's Comments:** You now have to subtract the inner solids from the overall solid to complete the model with its holes. To use the SUBTRACT command, first select the solid you want to subtract from, press Enter to change modes and then select the solids you want to subtract from it. In this model, it is easiest to subtract solids when the current visual style is set to 2D Wireframe. You may have to practice subtracting the solids a few times before you get good at doing it.

**Step 12** Set the current visual style to 2D Wireframe. Enter the SUBTRACT command to subtract the five inner solids from the larger solid. (Figure Step 12)

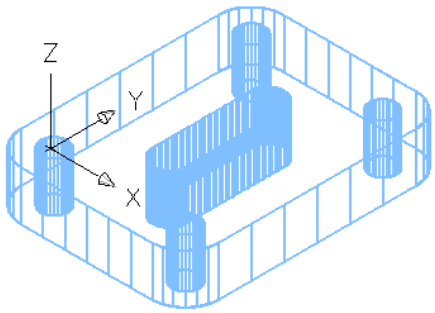



**Figure Step 12**

**Step 13** Set the current visual style to Realistic. Your model should now appear as shown in the figures. (Figure Step 13)

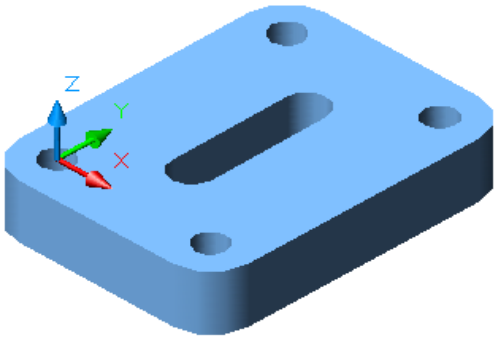


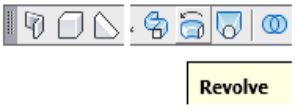

**Figure Step 13**
SE Isometric View

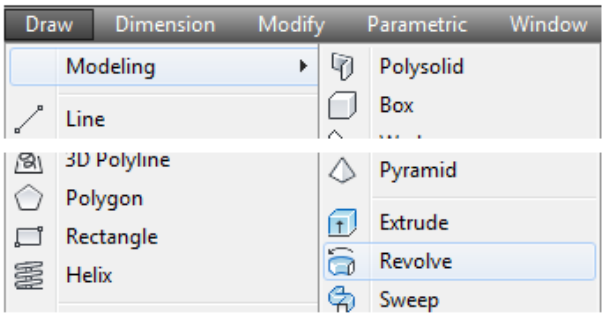
**Step 14** Save and close the drawing.

## AutoCAD Command: REVOLVE

The REVOLVE command is used to create a solid model by revolving a 2D object around an axis.

Shortcut: **REV**



## Creating a Revolved Solid Model

WORK ALONG

**Step 1** Using the NEW command, start a new drawing using template 3D Layout English.

**Step 2** Save and name the drawing AutoCAD 3D Workalong 18-2. (Figure Step 2)

**Step 3** Set the current layer to Pline and the current visual style to 2D Wireframe.

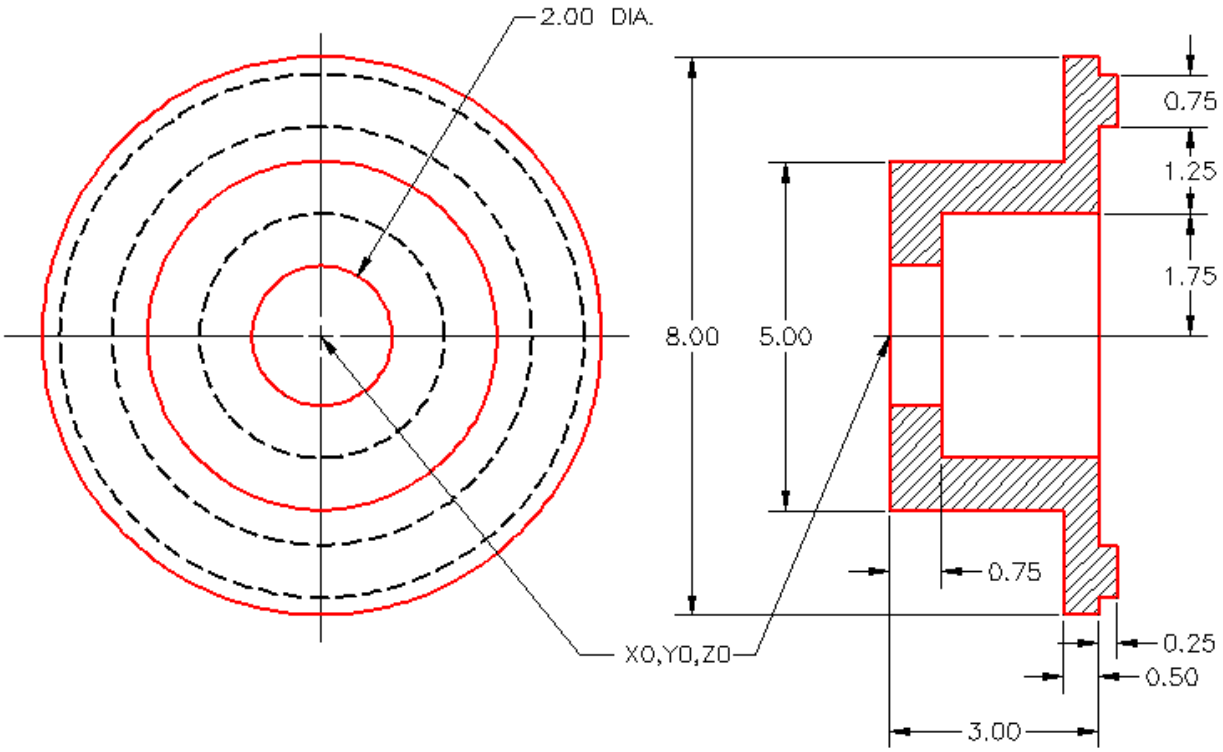



**Figure Step 2**
Dimensioned Multiview Drawing

**Step 4** Set the current view to SE Isometric and the current UCS to Right. (Figure Step 4)

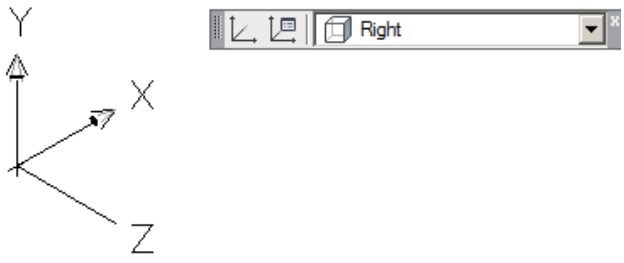



**Figure Step 4**

**Step 5** Using the multiview drawing as a reference, draw the one-half of the right side cross section of the solid part of the object. (Figure Step 5)

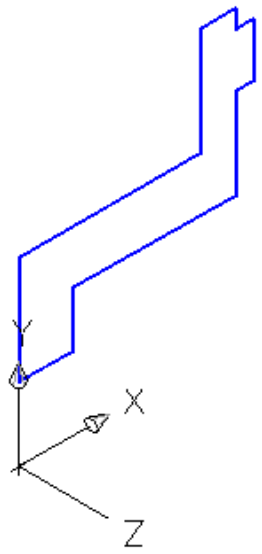



**Figure Step 5**

**Author's Comments:** You will be revolving this cross section 360 degrees to create a solid as it revolves. Therefore, only one-half of the section view is drawn.

**Step 6** On layer Construction, from 0,0,0 draw a line, of any length, along the X axis. Use ortho mode to draw it quicker. This will be the axis for the revolution and is the center line of the solid. (Figure Step 6)

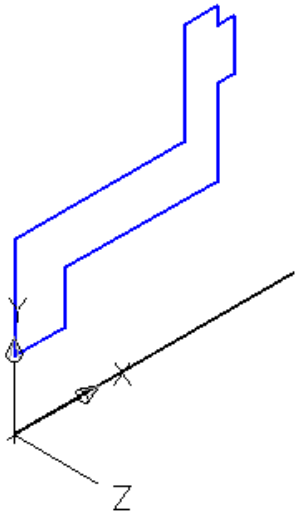



**Figure Step 6**

**Step 7** Using the PEDIT command, create a closed polygon from the lines. Ensure that it is closed by checking it with the Properties windows. (Figure Step 7)

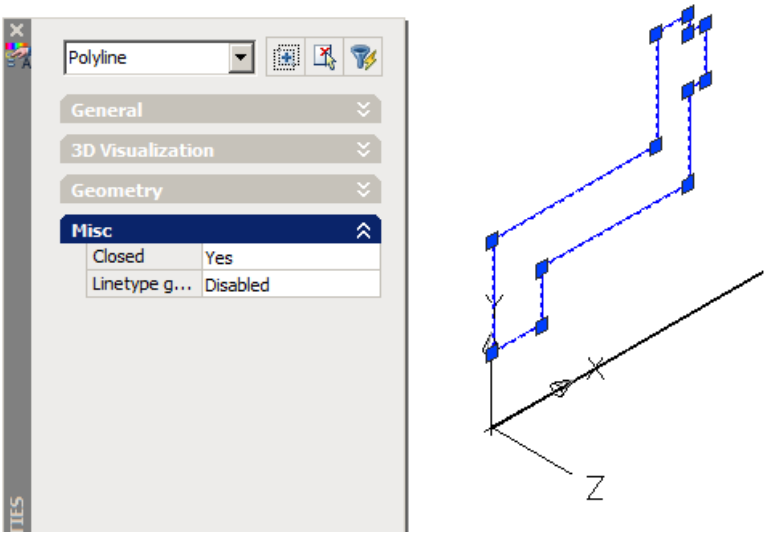



**Figure Step 7**

**Step 8** Set the ISOLINES system variable to 48 as shown below.

Command: **ISOLINES**
Enter new value for ISOLINES <4>: **48**
Command:

**Step 9** Set the current layer to Solid 2. Enter the REVOLVE command as shown below. After completing the command, the model should appear as shown in the figure. (Figure Step 9)

Command: **REVOLVE**
Current wire frame density: ISOLINES=48
Select objects: 1 found
*(Select the closed polyline.)*
Select objects:
*(Press Enter.)*
Specify start point for axis of revolution or define axis by [Object/X (axis)/Y (axis)]: **O**
Select an object:
*(Select the axis (the construction line.)*
Specify angle of revolution <360>:
*(Press Enter to select the default.)*
Command:

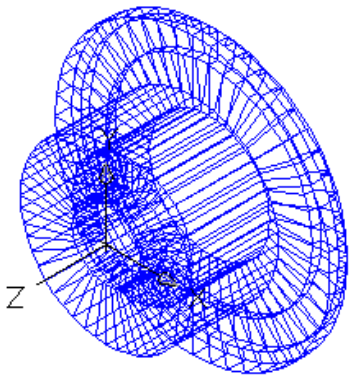



**Figure Step 9**

**Step 10** Turn off layers Construction and Pline and set the current visual style to Realistic. (Figure Step 10)

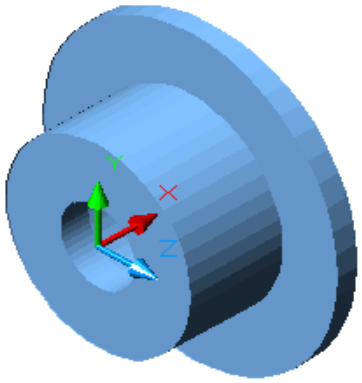


**Figure Step 10**

**Step 11** Using 3D Orbit, rotate the model as shown in the figure. (Figure Step 11).

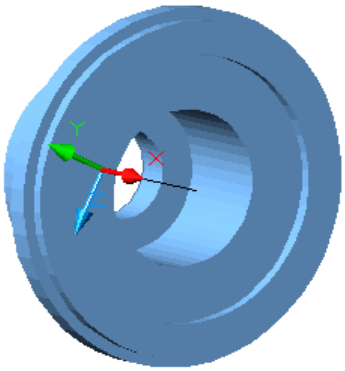


**Figure Step 11**

**Step 12** Save and close the drawing.

## The Key Principles in Module 18

**1** The object being extruded or revolved with the EXTRUDE and REVOLVE commands must be closed polyline, a circle, or an ellipse.
**2** Before entering the EXTRUDE command, ensure that UCS is located with the Z axis going in the direction of the extrusion.

| **Lab Exercise 18-1** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 18-1 | 3D Layout Metric | Millimeters |

**Step 1** Set the system variable DELOBJ to 0.

**Step 2** Draw the closed plines on layer Pline.

**Step 3** On layer Solid 1, draw a solid model of the object. (Figure Step 3A and 3B)

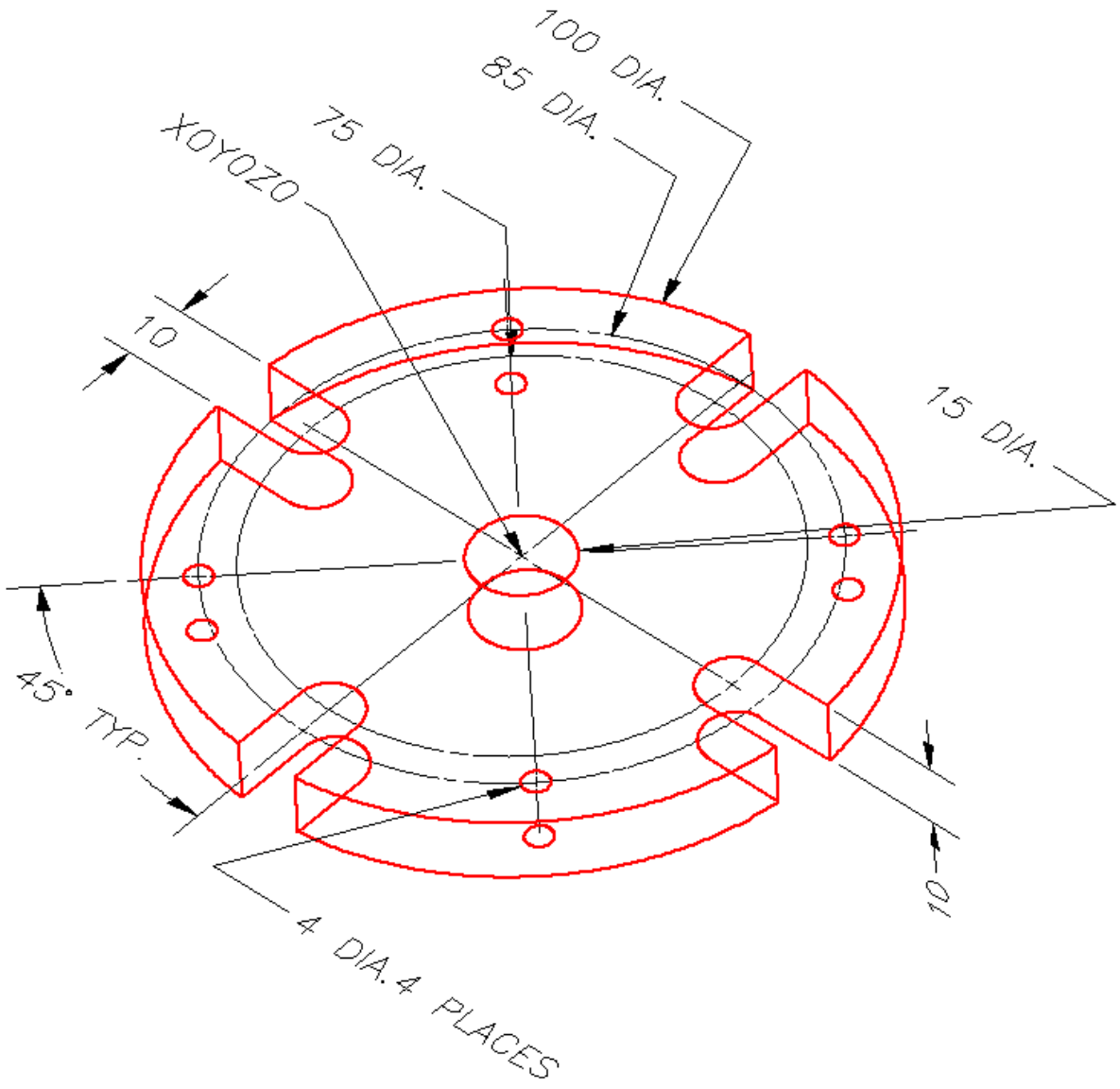



**Figure Step 3A**
Dimensioned Wireframe
SE Isometric View

**Step 4** Use the UNION and SUBTRACT commands to complete the solid model. When complete, the solid must be one object.

**Step 5** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 6** Set the Insertion Units, change the current UCS to World and check the model with the key.

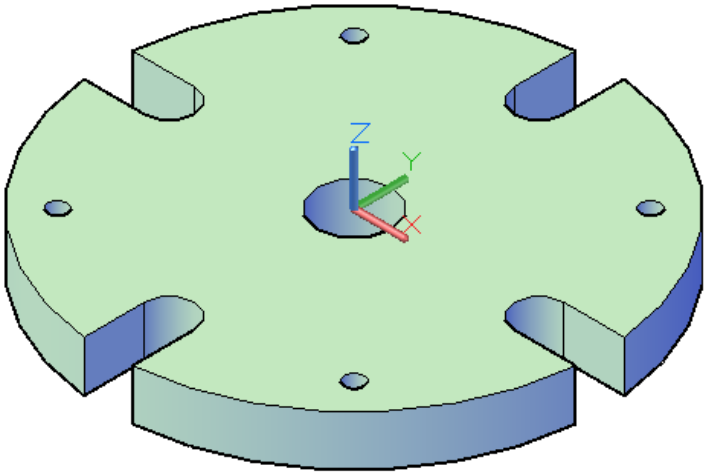



**Figure Step 3B**
Solid Model
SE Isometric View

| **Lab Exercise 18-2** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 18-2 | 3D Layout Metric | Millimeters |

**Step 1** Set the system variable DELOBJ to 0.

**Step 2** On layer Solid 3, draw a solid model of the object. (Figure Step 2A, 2B, 2C, and 2D)

**Step 3** On layer Pline, draw the closed plines.

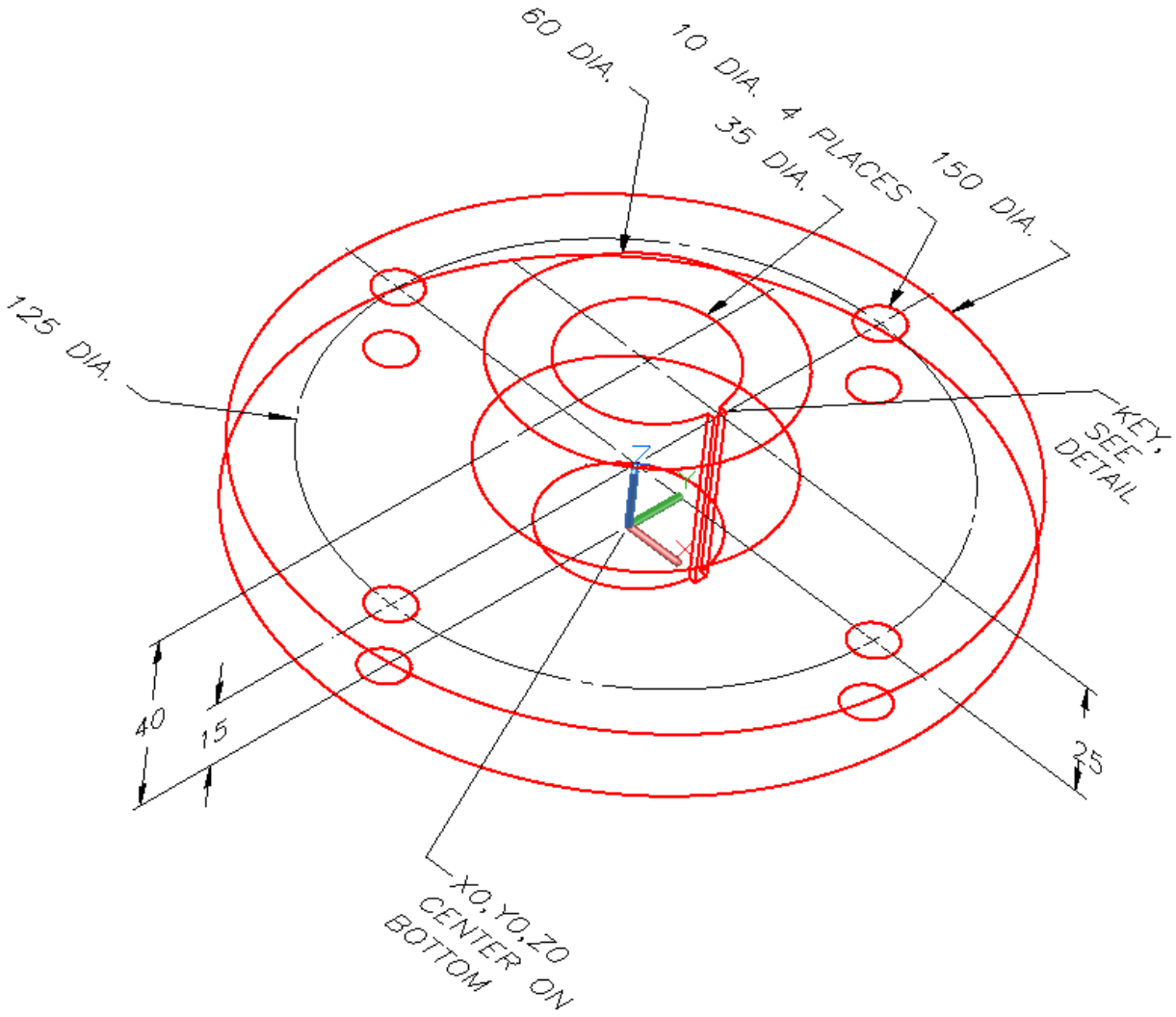



**Figure Step 3A**
Dimensioned Wireframe
SE Isometric View

**Step 4** Use the UNION and SUBTRACT commands to complete the solid model. When complete, the solid must be one object.

**Step 5** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 6** Set the Insertion Units, change the current UCS to World and check the model with the key.

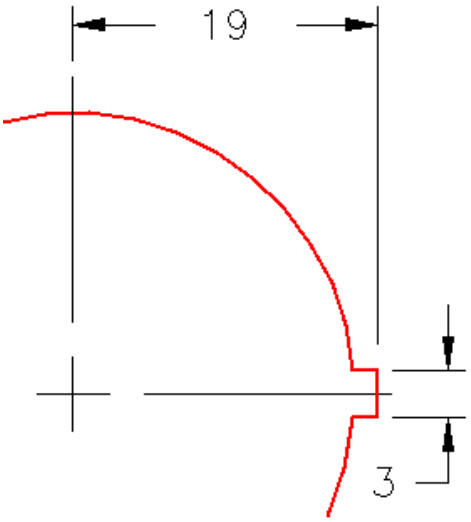



**Figure Step 2C**
Key Detail

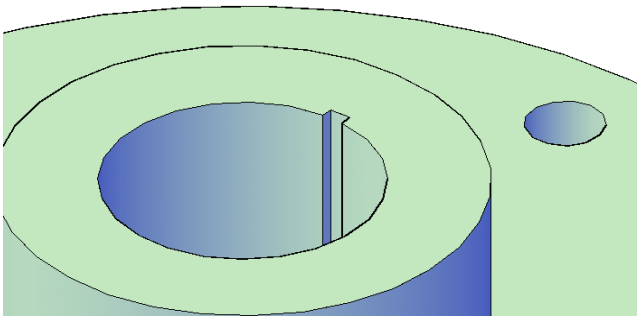


**Figure Step 2B**
View of Keyway - Rotated

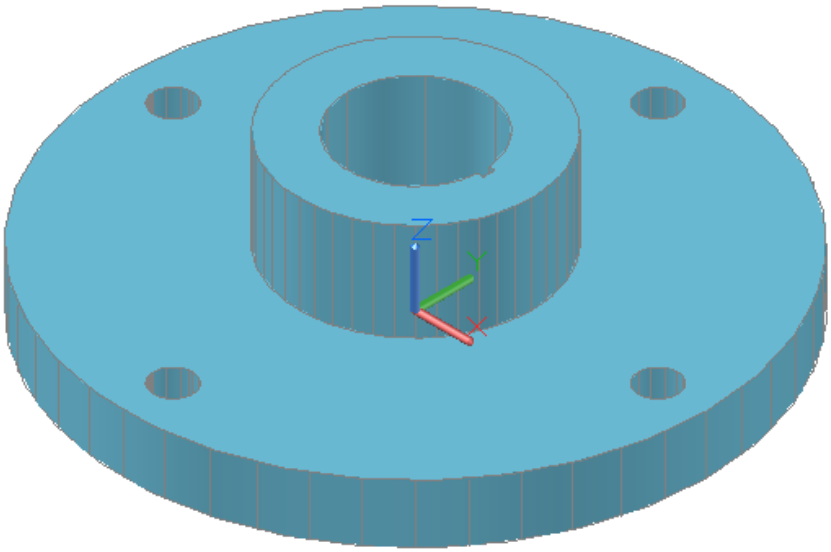


**Figure Step 2D**
Solid Model
SE Isometric View

| **Lab Exercise 18-3** | | **Time Allowed: 60 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 18-3 | 3D Layout English | Inches |

**Step 1** Set the system variable DELOBJ to 0.

**Step 2** On layer Solid 4, draw a solid model of the object. (Figure Step 2A, 2B and 2C)

**Step 3** On layer Pline, draw the closed plines.

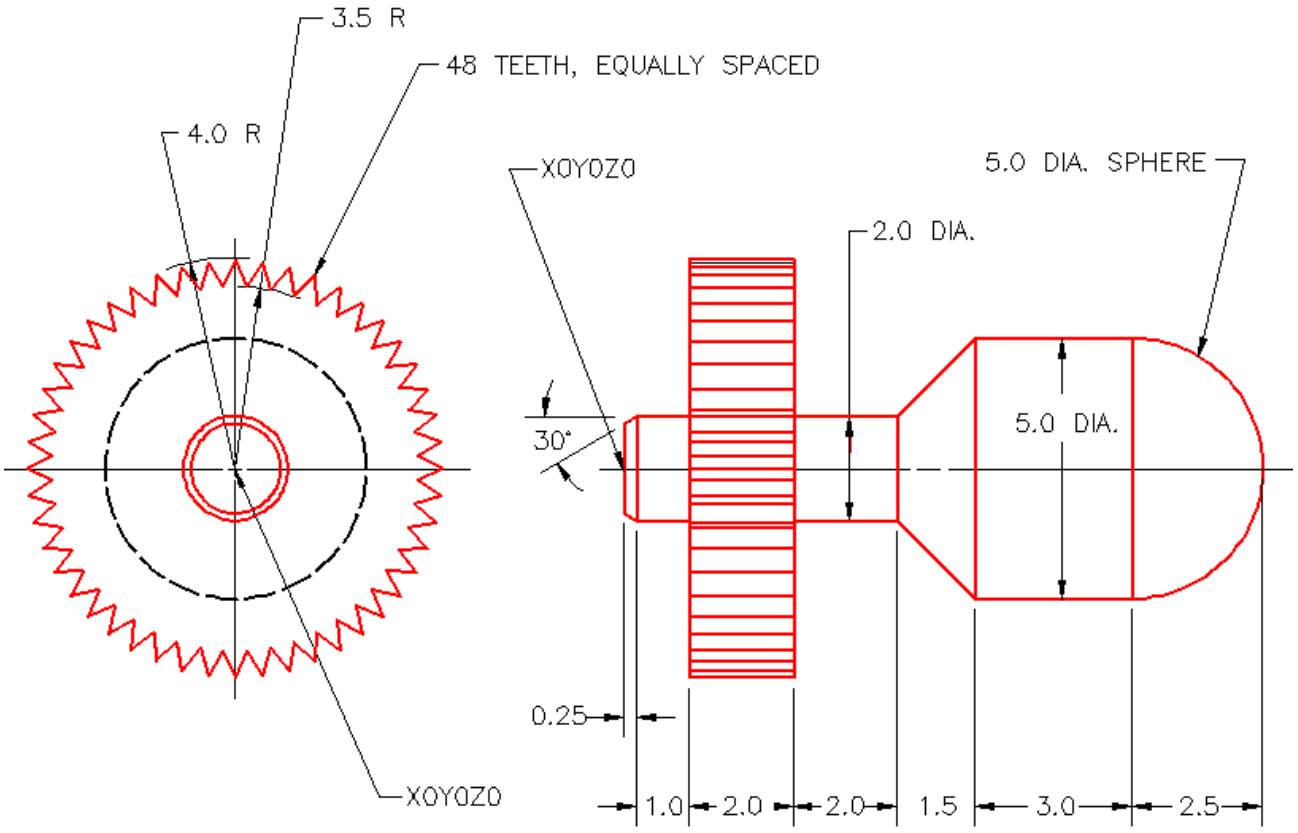



**Figure Step 2A**
Dimensioned Multiview Drawing

**Author's Comments:** I suggest that you construct the model in two parts. One extrusion and one revolution. UNION them together to form one solid model.

**Step 4** Use the UNION command to complete the solid model. When complete, the solid must be one object.

**Step 5** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 6** Set the Insertion Units, change the current UCS to World and check the model with the key.

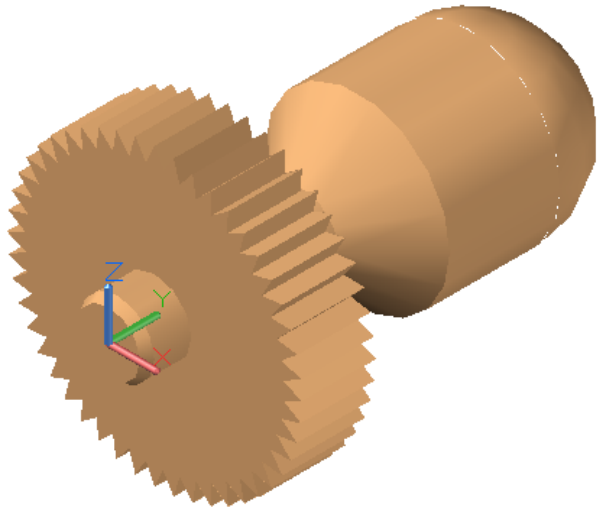



**Figure Step 2B**
Completed Solid Model
SE Isometric View

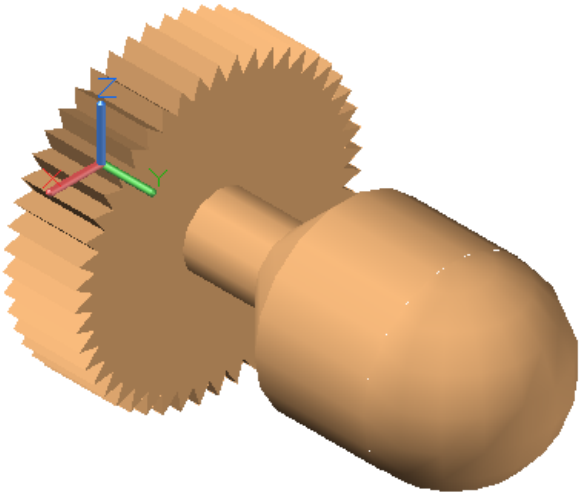



**Figure Step 2C**
Completed Solid Model
NE Isometric View

| **Lab Exercise 18-4** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 18-4 | 3D Layout Metric | Millimeters |

**Step 1** Set the system variable DELOBJ to 0.

**Step 2** On layer Solid 5, draw a solid model of the object.
(Figure Step 2A, 2B, and 2C)

**Step 3** On layer Pline, draw the closed pline.

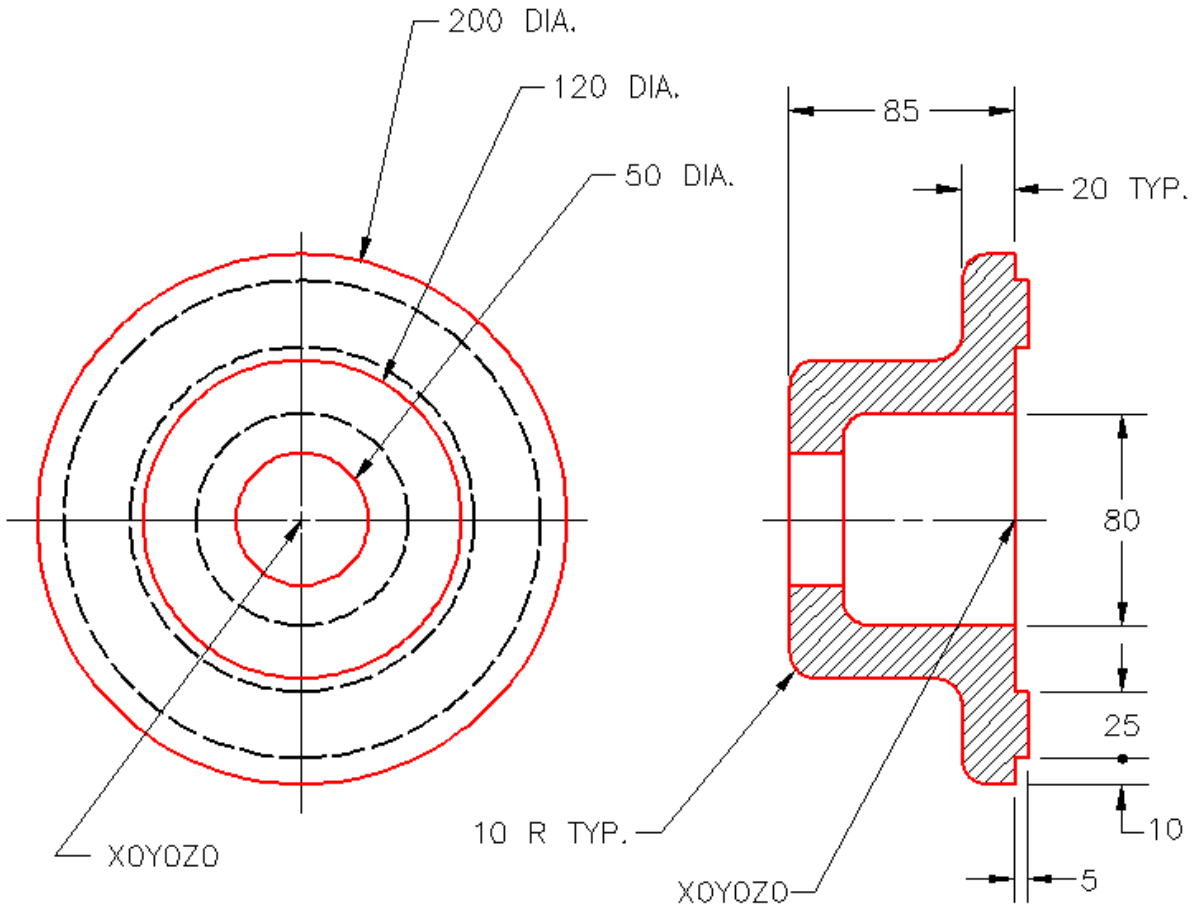



**Figure Step 2A**
Dimensioned Multiview Drawing

**Step 4** When complete, the solid model must be one object.

**Step 5** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 6** Set the Insertion Units, change the current UCS to World and check the model with the key.

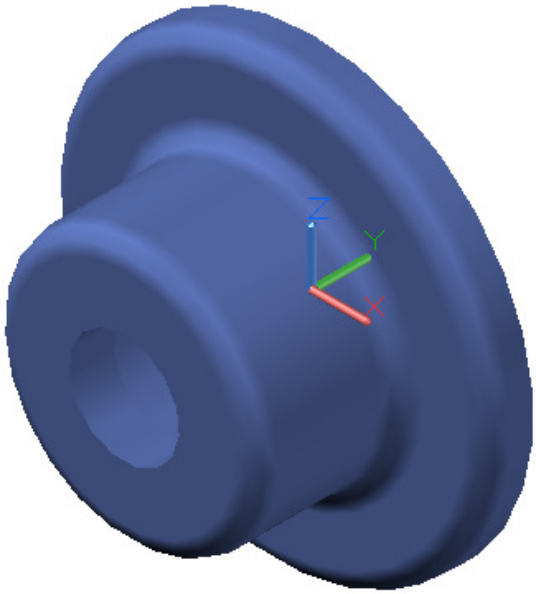


**Figure Step 2B**
Completed Solid Model
SE Isometric View

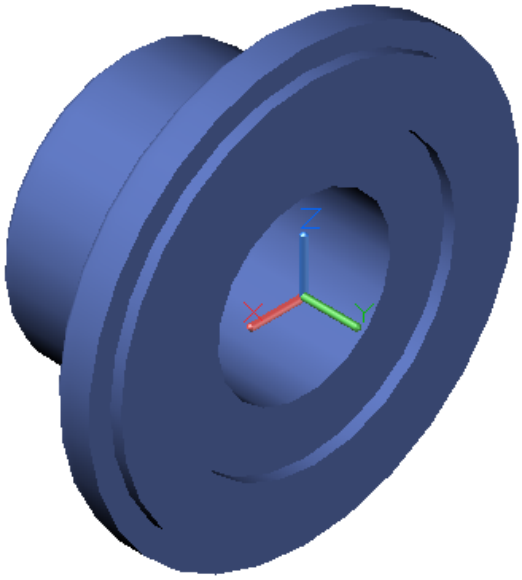


**Figure Step 2C**
Completed Solid Model
NE Isometric View

| **Lab Exercise 18-5** | | **Time Allowed: 45 Min.** |
|---|---|---|
| **Drawing Name** | **Template** | **Units** |
| AutoCAD 3D Lab 18-5 | 3D Layout English | Inches |

**Step 1** Set the system variable DELOBJ to 0.

**Step 2** On layer Solid 3, draw a solid model of the object. (Figure Step 2A, 2B, and 2C)

**Step 3** On layer Pline, draw the close plines.

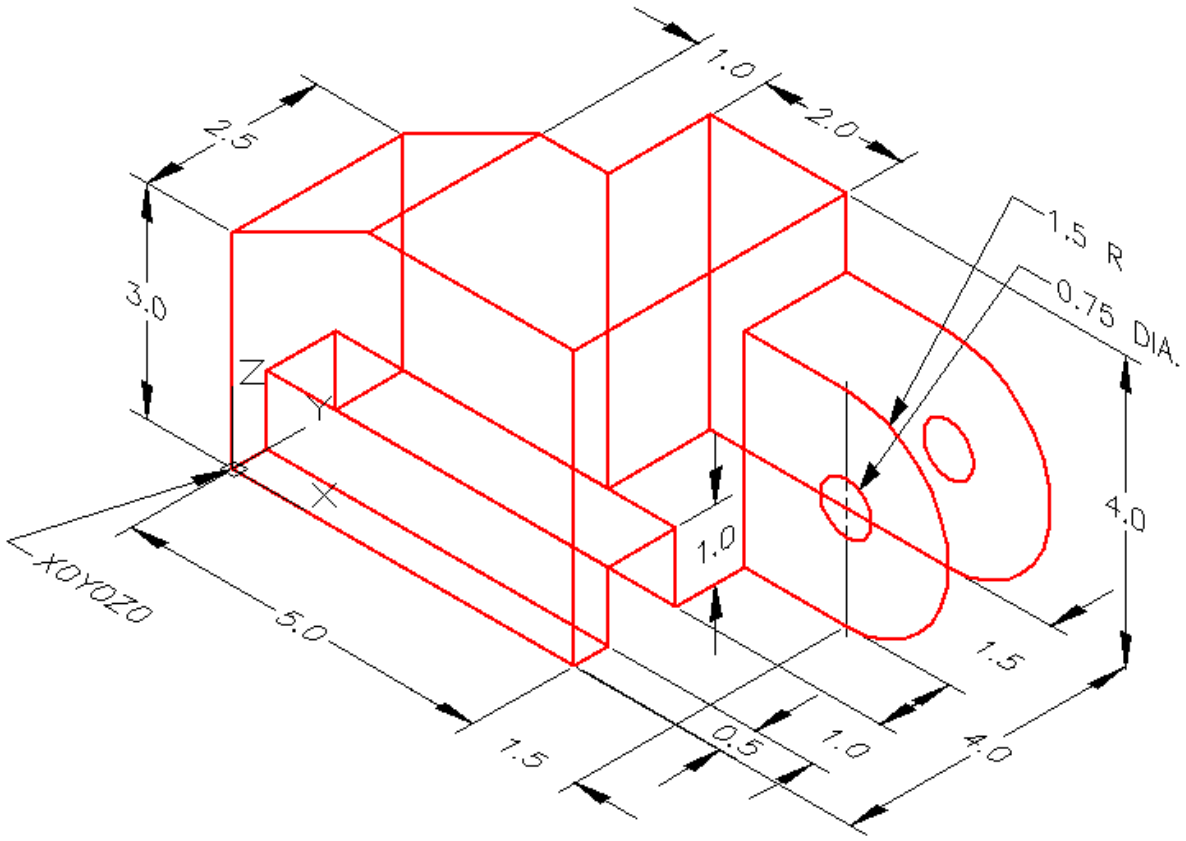



**Figure Step 2A**
Dimensioned Wireframe Model

**Step 4** Use the UNION and SUBTRACT commands to complete the solid model. When complete, the solid must be one object.

**Step 5** Turn layers Construction and Pline off and set the current visual style to Realistic.

**Step 6** Set the Insertion Units, change the current UCS to World and check the model with the key.


**Figure Step 2B**
Completed Solid Model
SE Isometric View


**Figure Step 2C**
Completed Solid Model
NW Isometric View