

# Chapter 3

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## Creating Solid Models

### Learning Objectives

**After completing this chapter, you will be able to:**

- Create standard solid primitives and polysolids
- Create regions
- Use Boolean operations
- Modify the visual styles of solids
- Define new UCS using the Dynamic UCS, DDUCS, ViewCube, and Ribbon
- Use the Extrude and Revolve tools to create solid models
- Create complex solid models using the Sweep and Loft tools
- Use the Presspull tool

### Key Terms

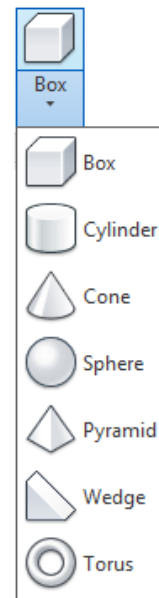
- |                    |                 |               |             |
|--------------------|-----------------|---------------|-------------|
| • Solid Primitives | • Pyramid       | • INTERFERE   | • Loft      |
| • Box              | • Polysolid     | • 3D Snap     | • Solid     |
| • Cone             | • Helix         | • Dynamic UCS | • Surface   |
| • Cylinder         | • Visual Styles | • Extrude     | • Presspull |
| • Sphere           | • Region        | • Mode        |             |
| • Torus            | • Union         | • Revolve     |             |
| • Wedge            | • Intersect     | • Sweep       |             |

## WHAT IS SOLID MODELING?

Solid modeling is the process of building objects that have all the attributes of an actual solid object. For example, if you draw a wireframe or a surface model of a bushing, it is sufficient to define the shape and size of the object. However, in engineering, the shape and size alone are not enough to describe an object. For engineering analysis, you need more information such as volume, mass, moment of inertia, and material properties (density, Young's modulus, Poisson's ratio, thermal conductivity, and so on). When you know these physical attributes of an object, it can be subjected to various tests to make sure that it performs as required by the product specifications. It eliminates the need for building expensive prototypes and makes the product development cycle shorter. Solid models also make it easy to visualize the objects because you always think of and see the objects as solids. With computers getting faster and software getting more sophisticated and affordable, solid modeling has become the core of the manufacturing process. AutoCAD solid modeling is based on the ACIS solid modeler, which is a part of the core technology.

## CREATING PREDEFINED SOLID PRIMITIVES

The Solid primitives form the basic building blocks for a complex solid. ACIS has seven predefined solid primitives that can be used to construct a solid model such as Box, Cylinder, Cone, Sphere, Pyramid, Wedge, and Torus. The number of lines in a solid primitive is controlled by the value assigned to the **ISOLINES** variable. These lines are called tessellation lines. The number of lines determine the number of computations needed to generate a solid. If the value is high, it will take significantly more time to generate a solid on the screen. Therefore, the value assigned to the **ISOLINES** variable should be realistic. When you invoke tools for creating solid primitives, AutoCAD Solids will prompt you to enter information about the part geometry. The height of the primitive is always along the positive Z axis and perpendicular to the construction plane. Similar to surface meshes, solids are also displayed as wireframe models unless you hide, render, or shade them. The **FACETRES** system variable controls the smoothness in the shaded and rendered objects and its value can go up to 10. The tools to create solid primitives are grouped in the **Solid Primitives** drop-down in the **Modeling** panel, as shown in Figure 3-1.



*Figure 3-1 Tools in the Solid Primitives drop-down*

### Creating a Solid Box

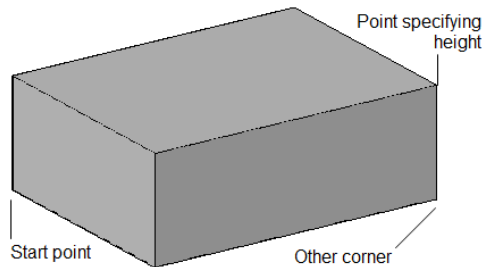
**Ribbon:** Home > Modeling > Solid Primitives Drop-down > Box  
**Menu Bar:** Draw > Modeling > Box     **Toolbar:** Modeling > Box  
**Command:** BOX



The **Box** tool is used to create a solid rectangular box or a cube. Start a new file using the *acad3D.dwt* template. In 3D drawing templates, you can dynamically preview the operations that you perform. The methods to create a solid box are discussed next.

## Creating a Box Dynamically

To create a box dynamically, choose the **Box** tool from the **Modeling** panel of the **Home** tab; you will be prompted to specify first corner. Specify the first corner point of the box and then specify the diagonally opposite corner point for defining the base of the box, refer to Figure 3-2. Now, specify the height of the box by moving the cursor away from the base. After getting the desired height, click in the drawing window to create the box or specify the height of the box in the dynamic input box, refer to Figure 3-2.



*Figure 3-2 Box created dynamically*

## Two Corner Option

This option is selected by default. You can use this option to create a solid box by defining the first corner of the box and then its other corner, refer to Figure 3-3. Note that the length of the box will always be taken along the *X* axis, the width along the *Y* axis, and the height along the *Z* axis. Therefore, in this case, when you specify the other corner, the value along the *X* axis will be taken as the length of the box, the value along the *Y* axis will be taken as the width of the box, and the value along *Z* axis will be taken as height of the box. Given below is the prompt sequence to draw a box of length 5 units and height 4 units.

Specify first corner or [Center] : *Specify start point.*

Specify other corner or [Cube/Length]: *Drag the cursor in any one of the quadrants and type 5 (Planar face of length 5 units is displayed).*

Specify height or [2Point]: 4

## Center-Length Option

The center of the box is the point where the center of gravity of the box lies. This option is used to create a box by specifying the center of the box followed by the length, width, and height of the box, refer to Figure 3-4. The following prompt sequence is displayed when you choose the **Box** tool:

Specify first corner or [Center] : **C**

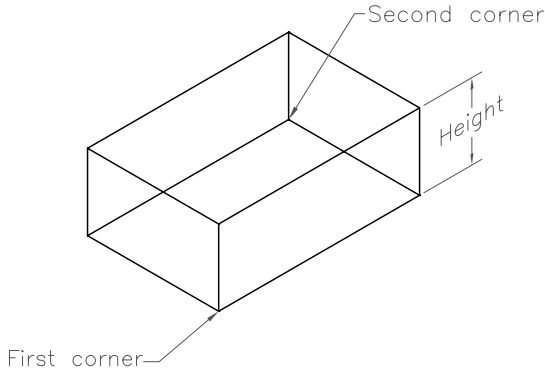
Specify center : **4,4**

Specify corner or [Cube/Length]: **L**

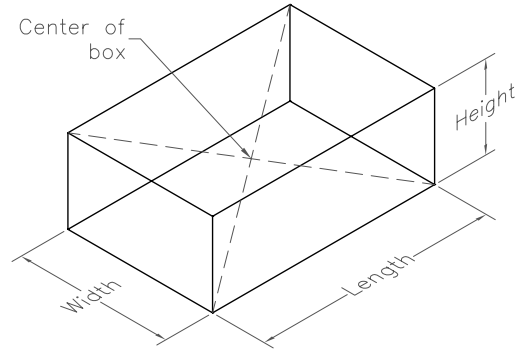
Specify length: **8**

Specify width: **6**

Specify height or [2point]: **3**



**Figure 3-3** Creating a box using the **Two Corner** option



**Figure 3-4** Creating a box using the **Center-Length** option



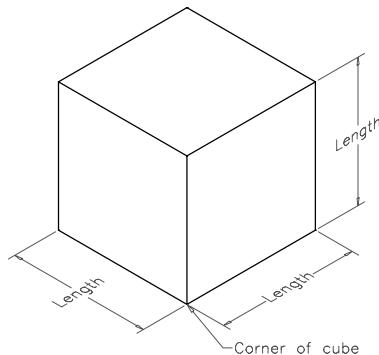
### Note

1. The **Corner-Length** option is similar to the **Center-Length** option with the only difference that in the **Corner-Length** option, you will define the first corner of the box and then the length, width, and height of the box.
2. In the **Two Corner** option, you need to specify the height of the box by specifying 2 points using the pointing device.

### Corner-Cube Option

This option is used to create a cube starting from a specified corner, as shown in Figure 3-5. As you are creating a cube, you will be prompted to enter the length of the cube that will also act as the width and height. The prompt sequence for creating the cube using the **Corner-Cube** option is given next.

Specify first corner or [Center] : **2,2**  
 Specify other corner or [Cube/Length]: **C**  
 Specify length: **5**



**Figure 3-5** Creating a cube using the **Corner-Cube** option

**Note**

The **Center-Cube** option is similar to the **Corner-Cube** option with the only difference that in the **Center-Cube** option you will have to define the center and the length of the cube.

## Creating a Solid Cone

**Ribbon:** Home > Modeling > Solid Primitives drop-down > Cone

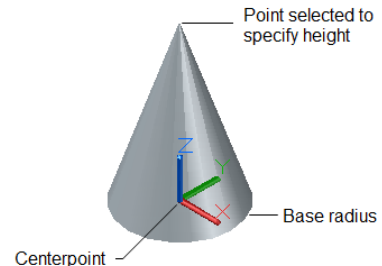
**Menu Bar:** Draw > Modeling > Cone    **Toolbar:** Modeling > Cone

**Command:** CONE



The **Cone** tool creates a solid cone with an elliptical or circular base. This tool provides you the option of defining the cone height or the location of the cone apex. Defining the location of the apex will also define the height of the cone and the orientation of the cone base from the *XY* plane.

To create a cone, start a new file using the *acad3D.dwt* template file and choose the **Cone** tool from the **Modeling** panel and specify the center point and the radius of the base, as shown in Figure 3-6. Next, specify the height of the cone by moving the cursor away from the base. After getting the desired height, click in the drawing window to create the cone. You can also enter all parameters defining the cone in the dynamic input box. Figure 3-6 shows a cone created dynamically.



**Figure 3-6** Cone created dynamically

Different methods to create a cone are discussed next.

### Creating a Cone with Circular Base

The options for defining the circular base are Center Radius, Center Diameter, 3 Point, 2 Point, and Tangent tangent radius. The prompt sequence that will be displayed when you choose the **Cone** tool is given next.

Specify center point of base or [3P/2P/Ttr/Elliptical]: *Specify the center of the base.*

The default option to define a cone with circular base is Center Radius. In this option, after specifying the center point, enter the radius value and then the height of the cone. If you need to enter the diameter value, then enter **D** at the **Specify base radius or [Diameter]** prompt and specify the diameter value followed by the height. The prompt sequence for using this option is given below.

Specify center point of base or [3P/2P/Ttr/Elliptical]: *Specify the center of the base.*

Specify base radius or [Diameter] <default>: *Specify the radius or enter **D** to specify the diameter of the cone.*

Specify height or [2Point/Axis endpoint/Top radius]<default>: *Specify the height of the cone or enter an option or press the ENTER key to accept the default value.*

If you want to create a cone by specifying two ends of the circular base, then type **2P** at the **Specify center point of base or [3P/2P/Ttr/Elliptical]** prompt and then specify the two ends

of the diameter. Similarly, if the base of the cone is tangent to two circles, choose **Ttr** at the **Specify center point of base or [3P/2P/Ttr/Elliptical]** prompt, select the circles in succession, and then specify the radius.

### Creating a Cone with Elliptical Base

To create a cone with elliptical base as shown in Figure 3-7, choose the **Elliptical** option at the **Specify center point of base of cone or [3P/2P/Ttr/Elliptical]** prompt. On selecting this option, the **Specify endpoint of first axis or [Center]** prompt will be displayed. Now, you can create the elliptical base by specifying the endpoints of axis, the location of the minor axis, and then the height. If you know the centerpoint of the ellipse, enter **C** at the **Specify endpoint of first axis or [Center]** prompt and specify the centerpoint, endpoint of the other two axes in succession, and finally the height; a cone with elliptical base will be created.

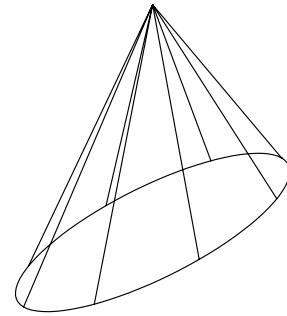


Figure 3-7 An elliptical cone

### Creating a Cone with Apex

To create a cone with apex, first specify the base of the cone. Then, specify the height of the cone by choosing an option at the **Specify height or [2Point/Axis endpoint/Top radius]** prompt. By default, you will be prompted to specify the height of the cone. Enter the height of the cone or specify a location in the drawing area; the cone will be created.

To specify the height using the **2Point** option, enter **2P** at this prompt and specify two points in the drawing area. The distance between these two specified points will be considered as the height of the cone. The prompt sequence that will follow is given next.

Specify height or [2Point/Axis endpoint/Top radius] <current>: **2P**

Specify first point: *Specify the first point.*

Specify second point: *Specify the second point on the screen.*

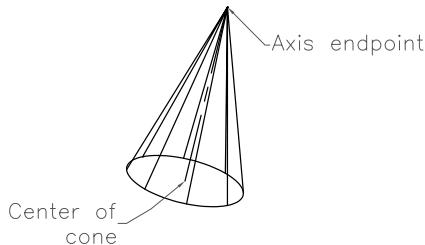
To specify the height using the **Axis endpoint** option, choose the **Axis endpoint** option at the **Specify height or [2Point/Axis endpoint/Top radius]** prompt. On selecting this option, you can specify the endpoint of the axis, whose start point is the center of the base. Apart from fixing the height of the cone, this option is also used to specify the orientation of the cone in 3D space. This means you can also create an inclined cone, refer to Figure 3-8. The prompt sequence is as follows:

Specify axis endpoint: *Specify the location of the apex or axis endpoint of the right circular cone in 3D space.*

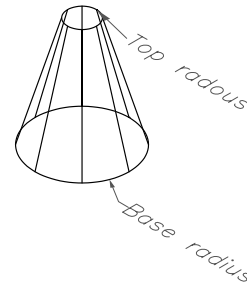
### Creating the Frustum of a Cone

To create the frustum of a cone, choose the **Top radius** option at the **Specify height or [2Point/Axis endpoint/Top radius]** prompt; you will be prompted to specify the top radius. Specify the radius of the top of the frustum as the top radius; you will be prompted to specify the height. Specify the height as discussed earlier; a frustum of a cone will be created, refer to Figure 3-9. The prompt to create a frustum of a cone is given next.

Specify top radius <default>: *Specify the radius for the top of the cone frustum.*  
 Specify height or [2Point/Axis endpoint] <default>: *Specify the height of the frustum or choose an option.*



**Figure 3-8** Creating a cone using the **Axis endpoint** option



**Figure 3-9** Creating a cone using the **Top radius** option



#### Tip

*In AutoCAD, when you select a primitive shape, grips are displayed on it. You can modify the dimensions of the primitive by dragging these grips.*

## Creating a Solid Cylinder

**Ribbon:** Home > Modeling > Solid Primitives drop-down > Cylinder

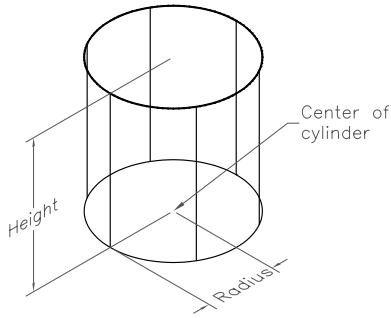
**Menu Bar:** Draw > Modeling > Cylinder **Toolbar:** Modeling > Cylinder

**Command:** CYL (CYLINDER)

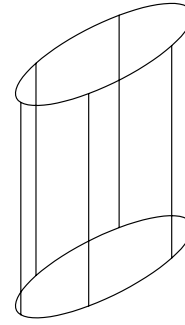


To create a cylinder, start a new drawing using the *acad3D.dwt* template file and choose the **Cylinder** tool from the **Solid Primitives** drop-down of the **Modeling** panel. Next, specify the center point of the base and then specify the radius of the base, as shown in Figure 3-10. Now, specify the height of the cylinder by moving the cursor away from the base. After getting the desired height, click in the drawing window to create the cylinder. You can also enter all parameters in the dynamic input box to define the cylinder.

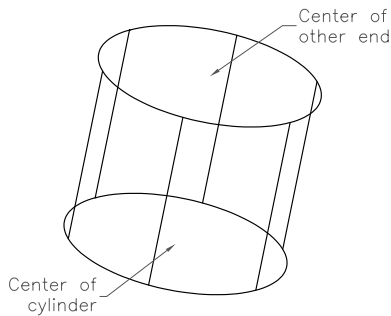
Similar to the **Cone** tool, this tool provides you two options for creating the cylinder: circular cylinder and elliptical cylinder; refer to Figures 3-10 and 3-11. This tool also allows you to define the height of a cylinder dynamically or specify the height by using the **2Point** or **Axis endpoint** options. On selecting the **Axis endpoint** option, you can specify the endpoint of the axis, whose start point is the center of the base. Apart from fixing the height of the cylinder, this option is also used to specify the orientation of the cylinder in 3D space. This means you can also create an inclined cylinder, as shown in Figures 3-12 and 3-13.



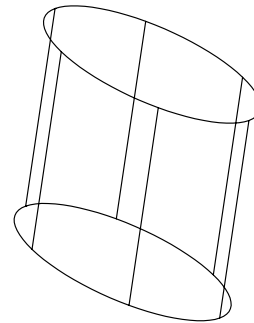
**Figure 3-10** Creating a circular cylinder



**Figure 3-11** Creating an elliptical cylinder



**Figure 3-12** Creating an inclined cylinder with circular base



**Figure 3-13** Creating an inclined cylinder with elliptical base

## Creating a Solid Sphere

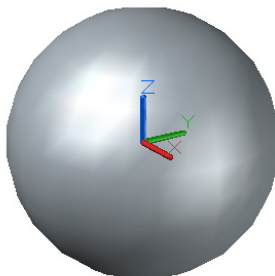
**Ribbon:** Home > Modeling > Solid Primitives drop-down > Sphere

**Menu Bar:** Draw > Modeling > Sphere    **Toolbar:** Modeling > Sphere

**Command:** SPHERE



To create a sphere, choose the **Sphere** tool from the **Modeling** panel of the **Home** tab; you will be prompted to specify the center of the sphere. After specifying the center, you can create the sphere by defining its radius or diameter, as shown in Figure 3-14. Instead of specifying the center of the sphere, you can specify its circumference by choosing any one of the **3P/2P/Ttr** options as discussed earlier.



**Figure 3-14** Solid sphere created




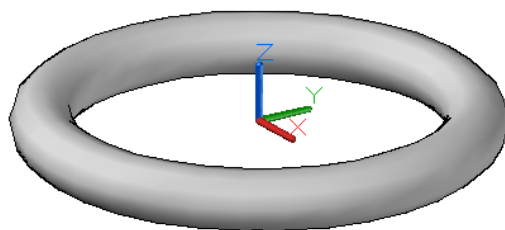
## Creating a Solid Torus

**Ribbon:** Home > Modeling > Solid Primitives drop-down > Torus

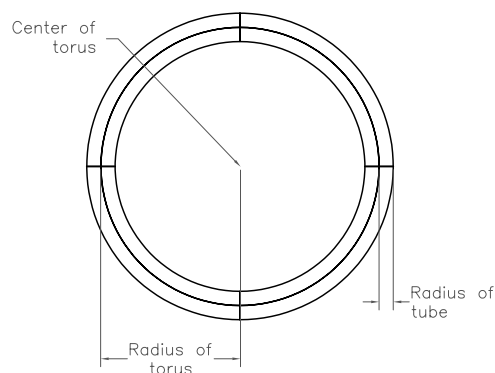
**Menu Bar:** Draw > Modeling > Torus    **Toolbar:** Modeling > Torus

**Command:** TOR (TORUS)

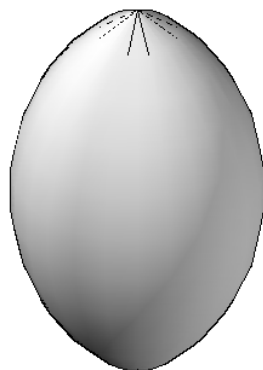
 You can use the **Torus** tool to create a torus, refer to Figure 3-15. A torus is centered on the construction plane. The top half of the torus is above the construction plane and the other half is below it. To create a torus, choose the **Torus** tool from the **Modeling** panel; you will be prompted to enter the diameter or the radius of the torus and the diameter or the radius of tube, refer to Figure 3-16. The radius of torus is the distance from the center of the torus to the center-line of the tube. This radius can have a positive or a negative value. If the value is negative, the torus will have a rugby-ball like shape, refer to Figure 3-17. A torus can be self-intersecting. If both the radii of the tube and the torus are positive and the radius of the tube is greater than the radius of the torus, the resulting solid looks like an apple, refer to Figure 3-18. Instead of specifying the radius or diameter of the torus, you can specify the points through which the circumference of the torus will pass by choosing any one of the **3P**, **2P**, and **Ttr** options. These options are discussed earlier.



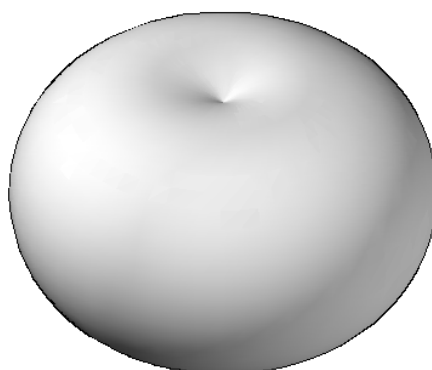
**Figure 3-15** Torus created dynamically



**Figure 3-16** Parameters associated with a torus



**Figure 3-17** Torus with a negative radius value



**Figure 3-18** Torus with radius of tube more than the radius of torus

## Creating a Solid Wedge

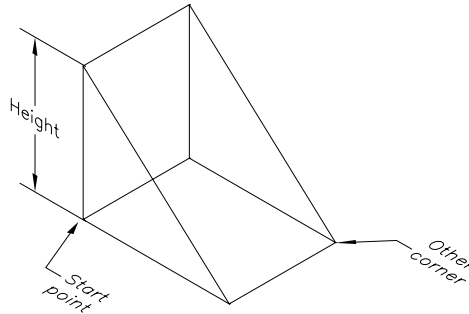
**Ribbon:** Home > Modeling > Solid Primitives drop-down > Wedge

**Menu Bar:** Draw > Modeling > Wedge **Toolbar:** Modeling > Wedge

**Command:** WEDGE



You can create a solid wedge by using the **Wedge** tool. To create a wedge by using this tool, you need to specify the start point, the diagonally opposite point, and the height of the wedge, refer to Figure 3-19. The other options to create a wedge are similar to those that are used to create a box.



*Figure 3-19 Parameters of a wedge*

## Creating a Pyramid

**Ribbon:** Home > Modeling > Solid Primitives drop-down > Pyramid

**Menu Bar:** Draw > Modeling > Pyramid

**Toolbar:** Modeling > Pyramid

**Command:** PYR (PYRAMID)



The **Pyramid** tool is used to create a solid pyramid where all faces, other than the base, are triangular and converge at a point called apex, refer to Figure 3-20. The base of a pyramid can be any polygon but generally it is a square. To create a pyramid, choose the **Pyramid** tool from the **Modeling** panel and follow the prompt sequence given next.

Specify center point of base or [Edge/Sides]: *Specify the center point.*

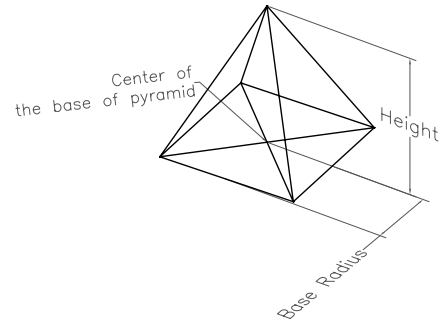
Specify base radius or [Inscribed] <Current Value>: *Specify the base radius.*

Specify height or [2Point/Axis endpoint/Top radius] <Current Value>: *Specify the height to create the pyramid,* refer to Figure 3-20.

Different methods for creating a solid pyramid are discussed next.

On invoking the **Pyramid** tool, you need to specify the center point of the base polygon or the length of the edges, or the number of sides of the polygon. If you select the **Edge** option in the Command prompt, you will be prompted to pick two points from the drawing area that determine the length and orientation of the edge of the base polygon. If you select the **Sides** option, you will be prompted to specify the number of sides of the base polygon. Note that in AutoCAD, the number of sides of a pyramid can vary from 3 to 32.

Next, you need to specify the base radius of the circle in which the base polygon is created. The base polygon is either circumscribed around a circle or inscribed within a circle. By default, the base of the pyramid is circumscribed. After specifying the base radius, you need to specify the height of the pyramid or select an option.



**Figure 3-20** Parameters associated with a pyramid

You can also create the frustum of a pyramid by selecting the **Top radius** option at the **Specify height or [2Point/Axis endpoint/Top radius]** Command prompt. On selecting this option, you are prompted to specify the radius of the top of the pyramid frustum. Then, you need to specify the height of the frustum either dynamically or by selecting the **2Point** or the **Axis endpoint** option.

## Creating a Polysolid

**Ribbon:** Home > Modeling > Polysolid **Menu Bar:** Draw > Modeling > Polysolid  
**Command:** POLYSOLID or PSOLID



The **Polysolid** tool is similar to the **Polyline** tool with the only difference that this tool is used to create a solid with a rectangular cross-section of a specified width and height.

This tool can also be used to convert existing lines, 2D polylines, arcs, and circles into a polysolid feature. To create a polysolid, choose the **Polysolid** tool from the **Modeling** panel and follow the prompt sequence given next.

Height = current, Width = current, Justification = current

Specify start point or [Object/Height/Width/Justify]<Object>: *Specify the start point for the profile of the polysolid. Else, press the ENTER key to select an object to convert it into a polysolid or enter an option.*

The options available at the Command prompt are discussed next.

### Next Point of Polysolid

When you specify the start point for the profile of the solid, this option is displayed. This option is used to specify the next point of the current polysolid segment. If additional polysolid segments are added to the first polysolid, AutoCAD automatically makes the endpoint of the previous polysolid, the start point of the next polysolid segment. The prompt sequence is given next.

Specify start point or [Object/Height/Width/Justify] <Object>: *Specify the start point.*

Specify next point or [Arc/Undo]: *Specify the endpoint of the first polysolid segment.*

Specify next point or [Arc/Close/Undo]: *Specify the endpoint of the second polysolid segment or press the ENTER key to exit the tool.*

**Arc.** This option is used to switch from drawing linear polysolid segments to drawing curved polysolid segments. The prompt sequence that will follow is given next.

Specify next point or [Arc/Close/Undo]: **A** 

Specify end point of the arc or [Close/Direction/Line/Second point/Undo]: *Specify the endpoint of the arc or choose an option to create the arc.*

The **Close** option closes the polysolid by creating an arc shaped trajectory from the most recent endpoint to the initial start point and exits the **Polysolid** tool. Usually, the arc drawn with the **Polysolid** tool is tangent to the previous polysolid segment. This means that the starting direction of the arc is the ending direction of the previous segment. The **Direction** option allows you to specify the tangent direction of your choice for the arc segment to be drawn. You can specify the direction by specifying a point. The **Line** option switches the command to the **Line** mode. The **Second point** option selects the second point of the arc in the **3P** arc option. The **Undo** option reverses the changes made in the previously drawn polysolid.

**Close.** This option is available when at least two segments of the polysolid are drawn. It closes the polysolid segment by creating a linear polysolid from the recent endpoint to the initial point.

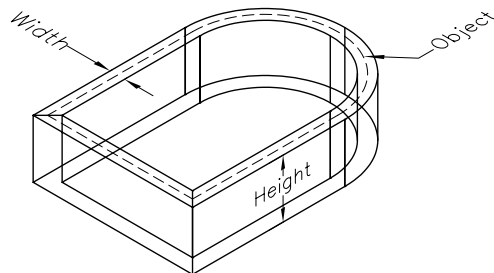
**Undo.** This option is used to erase the most recently drawn polysolid segment. You can use this option repeatedly until you reach the start point of the first polysolid segment.

## Object

This option is used to convert an existing 2D object into a polysolid. The 2D objects that can be converted into a polysolid include lines, 2D polylines, arcs, and circles. Figure 3-21 shows a polysolid object created by converting a 2D polyline. Note that the polysolid is displayed in the **Realistic** visual style by default, but for clarity, it has been displayed in the **Wireframe** visual style. The prompt sequence for using this option is given next.

Specify start point or [Object/Height/Width/Justify]<Object>: 

Select object: *Select an object to convert it into a polysolid.*



**Figure 3-21** Object converted to a polysolid by using the **Object** option

## Height

This option is used to specify the height of the rectangular cross-section of the polysolid. The value that you specify will be set as the default value for this tool. The prompt sequence for this option is given next.

Specify start point or [Object/Height/Width/Justify]<Object>: **H** 

Specify height <current>: *Specify the value of the height or press the ENTER key to accept the current value.*

Specify start point [Object/Height/Width/Justify]<Object>: *Specify the start point of the polysolid or choose an option.*

## Width

This option is used to specify the width of the rectangular cross-section of a polysolid. The prompt sequence for this option is given next.

Specify start point [Object/Height/Width/Justify]<Object>: **W** 

Specify width <current>: *Specify the width or press the ENTER key to accept the current value.*

Specify start point [Object/Height/Width/Justify]<Object>: *Specify the start point of the polysolid or choose an option.*

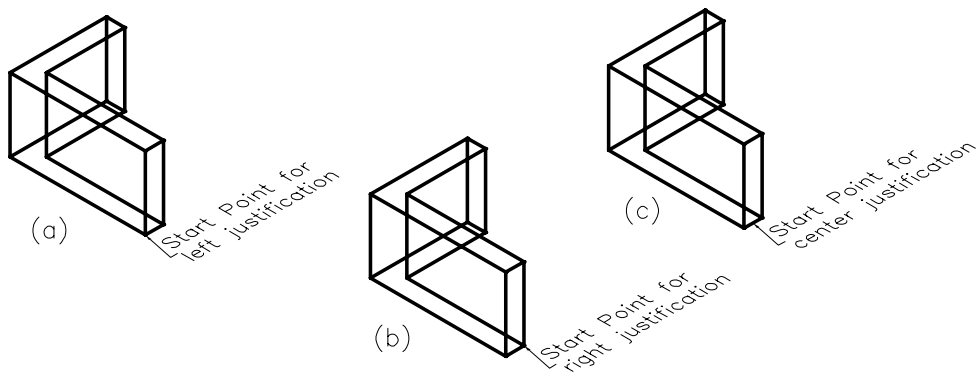
## Justify

The justification option determines the position of the created polysolid with respect to the starting point. The three justifications that are available for a **Polysolid** tool are **Left**, **Right**, and **Center**.

**Left.** This justification produces a polysolid with its left extent fixed at the start point and the width added to the right of the start point when the polysolid is viewed from the direction of its creation, refer to Figure 3-22(a).

**Right.** This justification produces a polysolid with its right extent fixed at the start point and the width added to the left of the start point, when you view the polysolid from the direction of its creation, refer to Figure 3-22(b).

**Center.** This justification produces a polysolid with its center fixed at the start point and the width added equally to both the sides of the start point when you view the polysolid from the direction of its creation, refer to Figure 3-22(c).



**Figure 3-22** Start point for the **Left**, **Right**, and **Center** justifications of a polysolid

## Creating a Helix

**Ribbon:** Home > Draw > Helix  
**Menu Bar:** Draw > Helix

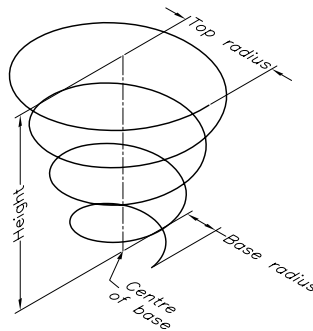
**Toolbar:** Modeling > Helix  
**Command:** HELIX



The **Helix** tool is used to create a 3D helical curve. To generate a helical curve, you need to first specify the center for the base of the helix. Next, you need to specify the base radius, radius at the top of the helix, and height of the helix. A helix of converging or diverging shape can also be generated by specifying different values for the base and top radius. You can also control the number of turns in a helix and specify whether the twist will be in the clockwise direction or counter clockwise direction. Figure 3-23 shows a helix with the parameters to be defined.

The prompt sequence displayed on choosing the **Helix** tool is given next.

Specify center point of base: *Specify a point for the center of the helix base.*  
 Specify base radius or [Diameter] <default>: *Specify the value for the base radius, enter **D** to specify the diameter, or press the ENTER key to select the default value for the radius.*  
 Specify top radius or [Diameter] <current>: *Specify the value for the top radius of the helix, enter **D** to specify the diameter, or press the ENTER key to select the current value of the base radius.*  
 Specify helix height or [Axis endpoint/Turns/turn Height/tWist] <default>: *Specify the height of the helix or press the ENTER key to select the default value or choose an option.*



**Figure 3-23** Helix with associated parameters

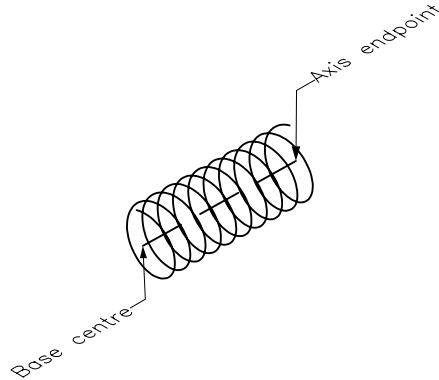
The options available at the Command prompt are discussed next.

### Axis endpoint

To specify the height using the **Axis endpoint** option, choose the **Axis endpoint** option at the **Specify helix height or [Axis endpoint/Turns/turn Height/tWist]** prompt. Using this option, you can specify the endpoint of the axis, whose start point is assumed to be at the center of the base of the helix. Apart from specifying the height of the helix, this option is also used to specify the orientation of the helix in 3D space or in other words, you can also create an inclined helix, refer to Figure 3-24.

## Turns

To specify the number of turns in the helix, choose the **Turns** option at the **Specify helix height or [Axis endpoint/Turns/turn Height/tWist]** prompt. Using this option, you can change the number of turns in the helical curve. The default number of turns for the **Helix** tool is three.



*Figure 3-24 Helix created using the **Axis endpoint** option*



### Note

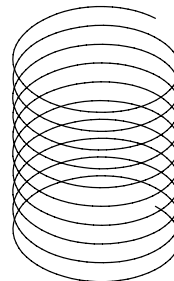
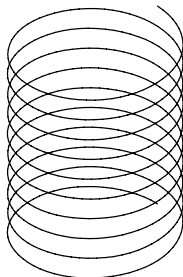
*In a helical curve, the number of turns cannot be more than 500.*

## turn Height

To specify the pitch of the helix, choose the **turn Height** option at the **Specify helix height or [Axis endpoint/Turns/turn Height/tWist]** prompt. Using this option, instead of specifying the whole height of the helix, you can specify the height of one complete single turn of the helix. The helical curve will be generated with the total height equal to the turn height multiplied by the number of turns.

## tWist

To specify the starting direction of the helical curve, choose the **tWist** option from the shortcut menu at the **Specify helix height or [Axis endpoint/Turns/turn Height/tWist]** prompt. By using this option, you can specify whether the curves will be generated in the clockwise or the counterclockwise direction. Figure 3-25 shows a helix with counterclockwise turns and Figure 3-26 shows a helix with clockwise turns. The default value for the starting direction of the helical curve is counterclockwise.



*Figure 3-25 Helix created using the **CCW** option      Figure 3-26 Helix created using the **CW** option*

**Tip**

You can use the generated helix as a trajectory for the **Sweep** tool. This tool will be discussed later in this chapter.

## MODIFYING THE VISUAL STYLES OF SOLIDS

**Ribbon:** Home > View > Visual Styles drop-down > Visual Styles Manager

**Menu Bar:** Tools > Palettes > Visual Styles

**Command:** VISUALSTYLES

AutoCAD provides you with various predefined modes of visual styles. These visual styles are grouped together in the **VISUAL STYLES MANAGER**, refer to Figure 3-27. To invoke the **VISUAL STYLES MANAGER**, select the **Visual Styles Manager** option from the **Visual Styles** drop-down list in the **View** panel. Alternatively, click on the inclined arrow at the bottom right of the **Visual Styles** panel in the **Visualize** tab. There are ten visual styles available in the **Available Visual Styles in Drawing** rollout of the **VISUAL STYLES MANAGER**. To apply a visual style, you need to double-click on it. Alternatively, select the desired visual style from the **Visual Styles** drop-down list in the **View** panel; the model will be updated automatically to the new visual style.

The properties of the selected visual style will be displayed below the **Available Visual Styles in Drawing** rollout. You can modify these properties depending upon your requirement. You can also create a user-defined visual style based on the current visual style applied to the model. To do so, choose the **Create New Visual Style** button from the tool strip at the bottom of the **Available Visual Styles in Drawing** rollout; the **Create New Visual Style** dialog box will be displayed. Enter a new name and description for the newly created visual style. Next, choose **OK**; a new visual style will be created. Set the properties of the new visual style by modifying the default properties. Alternatively, set the properties of the visual style and then select **Save as a New Visual Style** from the **Visual Styles** drop-down list in the **Visualize** tab; you will be prompted to specify a name to save the current visual style. Enter a name and press ENTER; the new visual style will be saved.

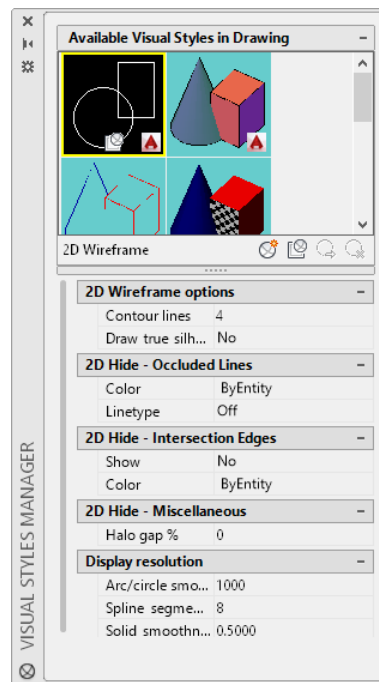


Figure 3-27 The **VISUALSTYLES MANAGER**

**Tip**

In AutoCAD, you can also use the **In-canvas Viewport controls** displayed on the top left corner of the drawing area for changing the visual style of a solid by simply clicking on the **Visual Style Controls** and selecting **Visual Styles Manager** which is the last option available in the flyout displayed.



## Available Visual Styles in Drawing

The options available in this rollout are discussed next.

### 2D Wireframe

On applying this visual style, all hidden lines will be displayed along with the visible lines in the model. Sometimes, it becomes difficult to recognize the visible lines and hidden lines if you set this visual style for complex models.

### Conceptual

In this visual style, the model will be displayed as shaded and the edges of the visible faces of the model will also be displayed.

### Hidden

On applying this visual style, the hidden lines in the model will not be displayed and only the edges of the faces that are visible in the current viewport will be displayed.

### Realistic

This visual style is the same as **Conceptual** but with a more realistic appearance. Moreover, if materials are applied to a model, this visual style will display the model along with the materials applied.

### Shaded

In this visual style, smooth shading is applied to the faces of a model. In this case, the edges of the visible faces are not visible.

### Shaded with edges

In this visual style, smooth shading is applied to the faces of a model and the edges of the visible faces are visible.

### Shades of Gray

In this visual style, a single shade (grey) is applied to all faces of a model.

### Sketchy

In this visual style, a model appears as if it is hand sketched.

### Wireframe

This visual style is used to display a solid model as a wireframe model. You can see through the solid model while the model is being rotated in the 3D orbit view.

### X-Ray

This visual style is used to display the model with shading and mild transparency. In this case, the hidden lines will be visible.

## 2D Wireframe options

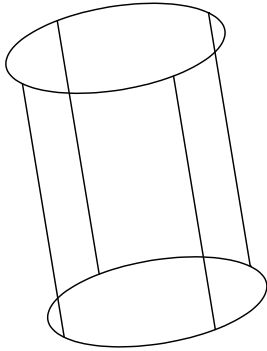
The options in this area are discussed next.

### Contour Lines

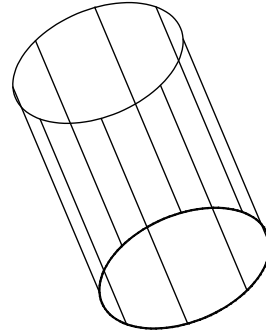
The lines that are displayed on the curved surface of a solid are known as contour lines. The default value for the number of contours to be displayed on each curved surface is 4 and it is controlled by system variable **ISOLINES**. Figure 3-28 shows a cylinder with 4 contour lines and Figure 3-29 shows a cylinder with 8 contour lines.

### Draw true silhouettes

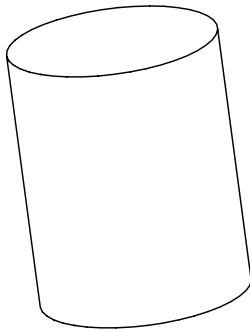
This option is used to specify whether or not to display the true silhouette edges of a model when it is hidden by using the **Hide** tool. If you select **Yes** from this drop-down list, the silhouette edges will be displayed when you hide the model, refer to Figure 3-30. However, when you select **No** from this drop-down list, the silhouette edges will not be displayed when you hide the model, refer to Figure 3-31.



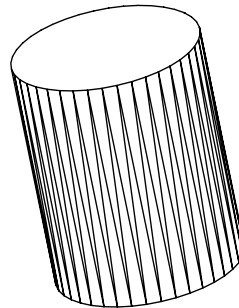
*Figure 3-28* Cylinder with 4 contour lines



*Figure 3-29* Cylinder with 8 contour lines



*Figure 3-30* Model with the true silhouette edges on



*Figure 3-31* Model with the true silhouette edges off

## 2D Hide - Occluded Lines

The options in this area are used to set the linetype and color of the hidden lines (also called occluded lines).

### Linetype

This drop-down list is used to set the linetype for the obscured lines. You can select the desired linetype from this drop-down list. The linetype of the hidden lines can also be modified using the **OBSCUREDLYTYPE** system variable. The default value of this variable is 0. As a result, the hidden lines are suppressed when you invoke the **Hide** tool. You can set any value between 0 and 11 for this system variable. The following table gives the details of the different values of this system variable and the corresponding linytypes that will be assigned to the hidden lines:






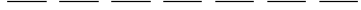





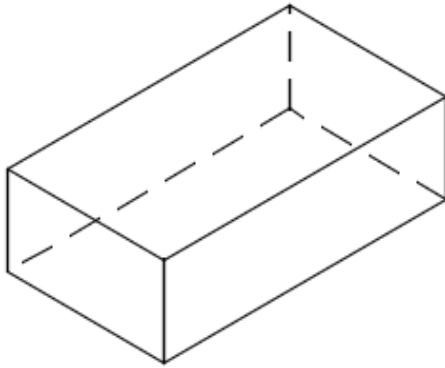
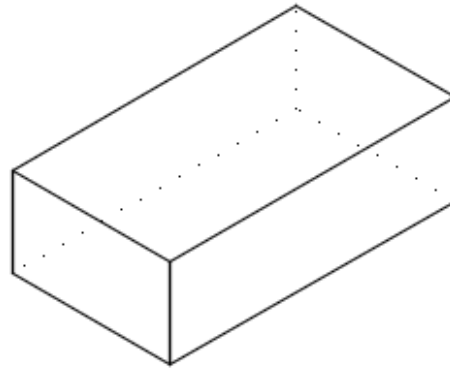
Value	Linetype	Sample
0	Off	None
1	Solid	
2	Dashed	
3	Dotted	
4	Short Dash	
5	Medium Dash	
6	Long Dash	
7	Double Short Dash	
8	Double Medium Dash	
9	Double Long Dash	
10	Medium Long Dash	
11	Sparse Dot	

Figure 3-32 shows a model with a hidden linetype changed to dashed lines and Figure 3-33 shows the same model with hidden lines changed to dotted lines.



**Figure 3-32** Model with hidden lines changed to dashed lines



**Figure 3-33** Model with hidden lines changed to dotted lines

## Color

The **Color** drop-down list is used to define the color for the obscured lines. If you define a separate color, the hidden lines will be displayed with that color, when you invoke the **Hide** tool. You can select the required color from this drop-down list. This can also be done by using the **OBSCUREDCOLOR** system variable. Using this variable, you can define the color to be assigned to the hidden lines. The default value is 257. This value corresponds to the **ByEntity** color. You can enter the number of any color at the sequence that will follow when you enter this system variable. For example, if you set the value of the **OBSCUREDTYPE** variable to **2**, and that of the **OBSCUREDCOLOR** to **1**, the hidden lines will appear in red dashed lines when you invoke the **Hide** tool.



### Note

*The linetype and the color for the hidden lines defined using the previously mentioned variables are valid only when you invoke the **Hide** tool. They do not work if the model is regenerated.*

## 2D Hide - Intersection Edges

The options in this area are used to display a 3D curve at the intersection of two surfaces. Note that the 3D curve is displayed only after invoking the **Hide** tool. These options are discussed next.

### Show

If you select **Yes** from the **Show** drop-down list, a 3D curve will define the intersecting portion of the 3D surfaces or solid models.

### Color

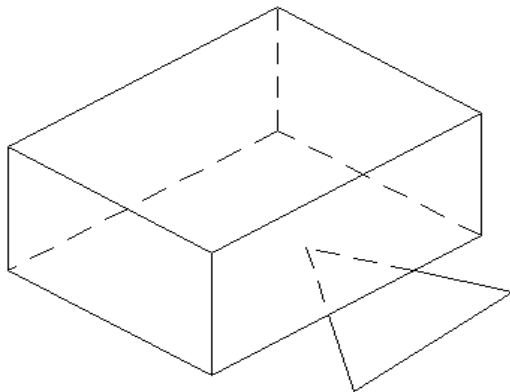
The **Color** drop-down list is used to specify the color of the 3D curve that is displayed at the intersection of the 3D surfaces or solid models.

## 2D Hide - Miscellaneous

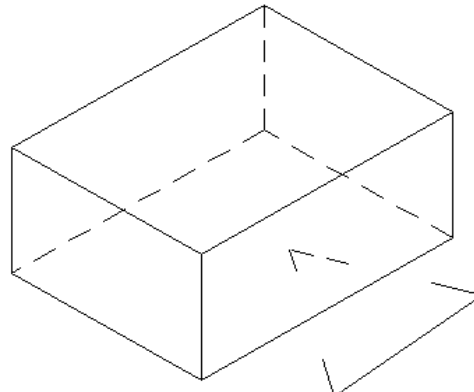
This head in the **Visual Styles Manager** is used to set the percentage for halo gap.

### Halo gap %

The **Halo gap %** area is used to specify the distance in terms of percentage of unit length by which the edges that are hidden by a surface or solid model will be shortened, refer to Figures 3-34 and 3-35.



**Figure 3-34** Hiding lines with halo gap % as 0



**Figure 3-35** Hiding lines with halo gap % as 40



#### Note

The obscured linetype in Figures 3-34 and 3-35 has been changed to dashed.

### Display resolution

The options in this area are used to set the resolutions for the curves, splines, and solids. These options are discussed next.

### Arc/circle smoothing

This option is used to vary the smoothness of the curved surfaces of a 3D model. By default the value for smoothing of the curves or circles is 1000. You can change the value as per your requirement and this smoothness is controlled by the system variable **VIEWRES**.

### Spline segments

This option is used to set the number of segments in a polyline that can be fitted in the spline curve. By default, the number of segments that are displayed in a spline are 8. You can also set the number of segments by using the **SPLINESEGS** variable.

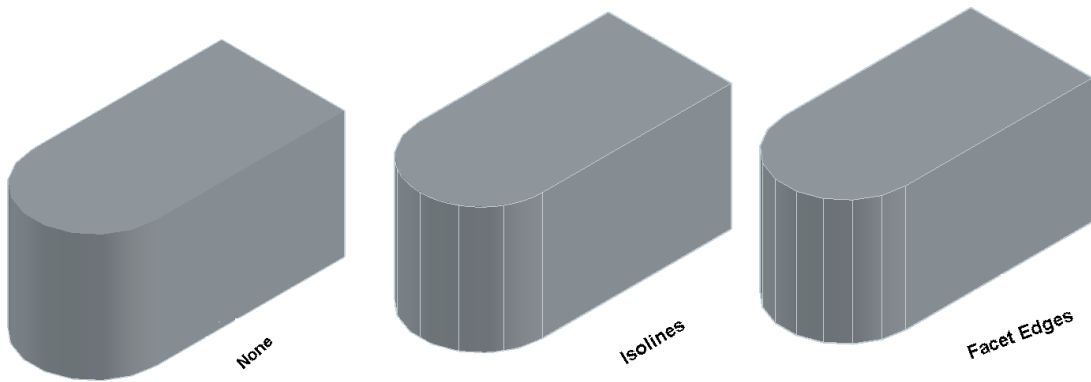
### Solid smoothness

The **Solid smoothness** area is used to specify the smoothness of the surfaces of the 3D model. By default 0.5 is specified as the smoothness value for the surfaces and you can change this value from **0.01** to **10**. This solid smoothness can also be controlled by system variable **FACETRES**.

Similarly, you can specify the settings for faces, edges, and environment required for other visual styles. These settings are discussed next.

## Controlling the Settings of Edges

You can control display settings of the edges by using the **Edge Settings** rollout in the **Available Visual Styles in Drawing** palette. Note that this rollout will not be available for the **2D Wireframe** visual styles. Figure 3-36 shows different types of edge display. The **Show** field in this rollout has three options: **None**, **Isolines**, and **Facet Edges**. On selecting the **Isolines** option, the contour lines on the surface of the solid will be displayed. Also, the **Always on top** field will be available in the **Edge Settings** rollout. On selecting the **Yes** option in this field, all isolines in the model will be displayed. If you do not want the edges to be displayed, choose **None** in the **Show** field. On selecting the **Facet Edges** option in the **Show** field, the edges between the planar surfaces will be displayed. You can also set other options in the sub rollout. Note that some of the sub rollouts will not be available for the **Shaded** and **Realistic** visual styles.



*Figure 3-36 Different types of edge display*

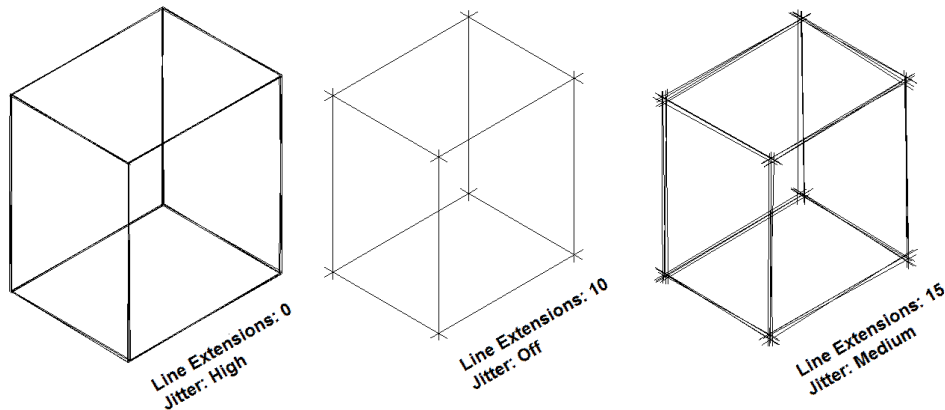
The **Occluded Edges** sub rollout is used to control the display of hidden edges. Select the **Yes** option in the **Show** field to display the hidden edges. You can also set the color and the line type of the hidden edges in the **Color** and **Linetype** fields, respectively.

The options in the **Intersection Edges** sub rollout are used to control the display of the resulting curve when two surfaces intersect. Select the **Yes** option in the **Show** field to display the curve at the intersection. You can also set the color and the line type of the resulting curve in the **Color** and **Linetype** fields, respectively.

The **Silhouette Edges** sub rollout is used to control the display of the silhouette edges. Select the **Yes** option in the **Show** field to display the silhouette edges. You can set the width of the silhouette edges in the **Width** field. This value ranges from 1 to 25.

The **Edge Modifiers** sub rollout is used to assign special effects such as **Line Extensions** and **Jitter** to edges. Both the effects exhibit a hand-drawn effect with the only difference that the sketches drawn in **Line Extensions** extend beyond the model, whereas in **Jitter**, the edges look as if they were drawn using pencil and has multiple lines. Note that you need to choose the **Line Extension edges** and **Jitter edges** buttons from the title bar of the sub rollout to enable these options. You can set the value for the extension line from the vertices by using the **Line Extensions** spinner. Similarly, you can control the effect of jitter by using the options in the **Jitter** drop-down list. Figure 3-37 shows the effect of line extensions and jitter edges. The **Crease angle**

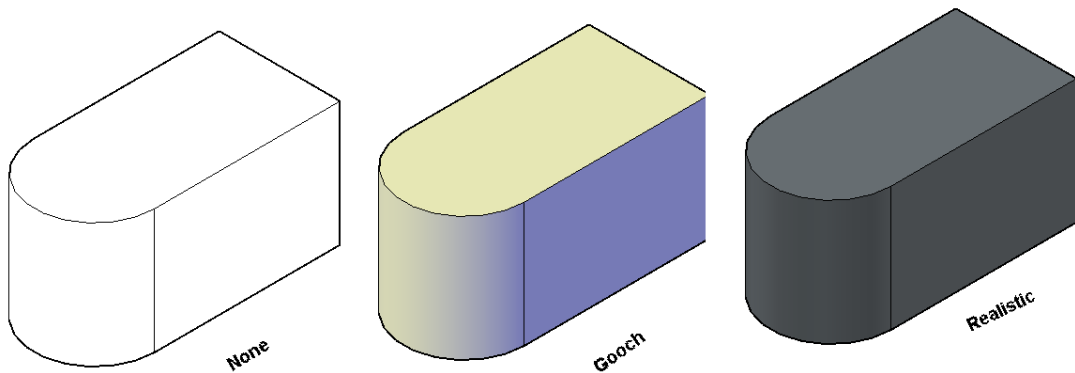
field will be displayed only if you choose the **Facets Edges** option in the **Edge Settings** rollout. Note that the Facets edges will be displayed only if the angle between the facets is smaller than the specified crease angle.



*Figure 3-37 The **Line Extensions** and **Jitter** effects of the edges*

## Controlling the Face Display

AutoCAD enables you to control the display of faces by providing options to apply color effects and shading to solids or surfaces. The shading of models can be controlled by using the **Face style** field. The options in this field are **None**, **Gooch**, and **Realistic**, refer to Figure 3-38. By default, the **Realistic** option is chosen and therefore gives a real world effect to the model. The **Gooch** effect enhances the display by using light colors, instead of dark colors. If the **None** option is chosen, then no style will be applied to the model and only the edges will be displayed.



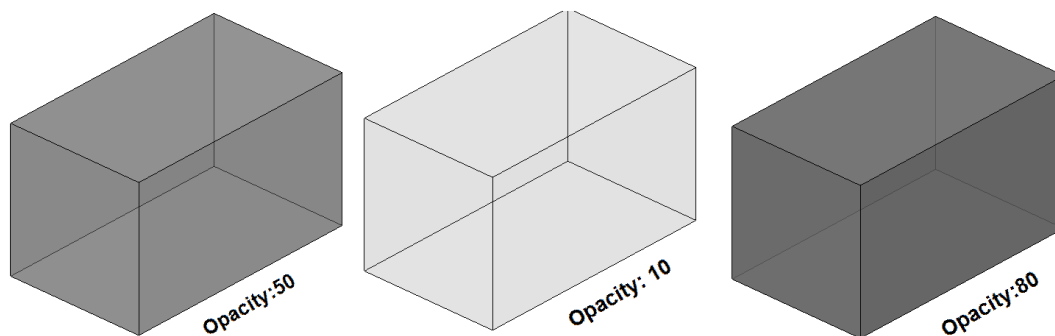
*Figure 3-38 Different face styles*

You can also control the appearance of faces in solids or surfaces using the **Lighting quality** field. The options available in this field are **Faceted**, **Smooth**, and **Smoothest**. On selecting the **Faceted** option, the color is applied to each face, thereby making the object to appear flat. On selecting the **Smooth** option, the color applied is the gradient between the two vertices of the face. This option is selected by default. On selecting the **Smoothest** option, the color is calculated for per pixel lighting.

You can apply different color settings to faces by selecting an option from the **Color** drop-down list in the **Face Settings** rollout. The options in this drop-down list are **Normal**, **Monochrome**, **Tint**, and **Desaturate**. No face color will be applied if the **Normal** option is selected. If you select the **Monochrome** option, all faces will be shaded with a single color. If you want to use the same color to shade all faces by changing the hue and saturation values of the color, then select the **Tint** option. The hue and saturation values can be changed by using the **Tint Color** drop-down list. Select the **Desaturate** option to soften the color by reducing the saturation by 30%.

You can also control the opacity of solid models by choosing the **Opacity** button in the title bar of the **Facet Settings** rollout. On doing so, the **Opacity** field will be enabled. Specify the desired transparency level. Figure 3-39 shows an object with different opacity values.

The shininess of an object is set by using the options in the **Lighting** rollout. To set the shininess, choose the **Highlight intensity** button on the title bar of this rollout and set the required value in the **Highlight intensity** spinner. Note that you cannot set this value when a material is applied on it.



*Figure 3-39 An object with different opacity values*

Shadows provide a real effect at rendering. Shadows are generated when light is applied. Lights can be user-defined lights or the sunlight. The options in this drop-down list are **Off**, **Ground Shadow**, and **Mapped Object shadows**. The Ground Shadows are the shadows that an object casts on the ground. The Mapped Object shadows are the shadows cast by one object on other objects. Shadows appear darker when they overlap. Use of shadows can slow down the system performance. So, you need to turn off the shadows while working, and turn them on when you need shadows. The shadows will be explained in detail in later chapters.

## Controlling the Backgrounds

You can control the display of background by using the option in the **Environment Settings** rollout. You can turn on or off the background by using the **Backgrounds** drop-down list in this rollout. The background can be a single solid color, a gradient fill, an image, or the sun and the sky. This is explained in detail in Chapter 8 (Rendering and Animating Designs).



### Note

*In AutoCAD, the default visual style applied to a model is **Realistic**. However, in this textbook, the **Wireframe** visual style is applied to models for clarity of printing.*



## CREATING COMPLEX SOLID MODELS

Until now you have learned how to create simple solid models using the standard solid primitives. However, the real-time designs are not just the simple solid primitives but complex solid models. These complex solid models can be created by modifying the standard solid primitives with the boolean operations or directly by creating complex solid models by extruding or revolving the regions. All these options of creating complex solid models are discussed next.

### Creating Regions

**Ribbon:** Home > Draw > Region  
**Command:** REG(REGION)

**Menu Bar:** Draw > Region



The **Region** tool is used to create regions from the selected loops or closed entities. Regions are the 2D entities with properties of 3D solids. You can apply the Boolean operation on the regions and you can also calculate their mass properties. Bear in mind that the 2D entity you want to convert into a region should be a closed loop. Once you have created regions, the original object is deleted automatically. However, if the value of the **DELOBJ** system variable is set to **0**, the original object is retained. The valid selection set for creating the regions are closed profile created from polylines, lines, arcs, splines, circles, or ellipses. The current color, layer, linetype, and lineweight will be applied to the regions.

## CREATING COMPLEX SOLID MODELS BY APPLYING BOOLEAN OPERATIONS

You can create complex solid models by applying the Boolean operations on the standard solid primitives. The Boolean operations that can be performed are union, subtract, intersect, and interfere. The tools used to apply these Boolean operations are discussed next.

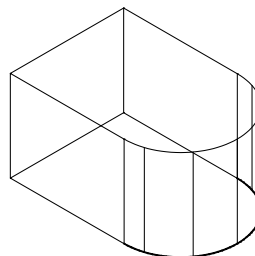
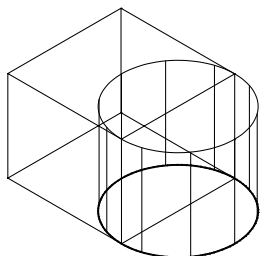
### Combining Solid Models

**Ribbon:** Home > Solid Editing > Solid, Union  
**Command:** UNI(UNION)

**Menu Bar:** Modify > Solid Editing > Union  
**Toolbar:** Modeling / Solid Editing > Union



The **Solid, Union** tool is used to apply the Union Boolean operations on the selected set of solids or regions. You can create a composite solid or region by combining them using this tool. You can combine any number of solids or regions. When you invoke this tool, you will be prompted to select the solids or regions to be added. Figure 3-40 shows two solid models before union and Figure 3-41 shows the composite solid created after union.



*Figure 3-40 Solid models before union*

*Figure 3-41 Composite solid created after union*

## Subtracting One Solid From the Other

**Ribbon:** Home > Solid Editing > Solid, Subtract

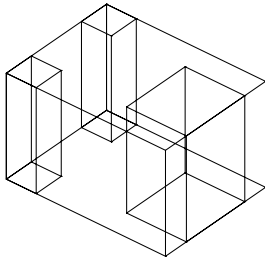
**Menu Bar:** Modify > Solid Editing > Subtract

**Toolbar:** Modeling / Solid Editing > Subtract

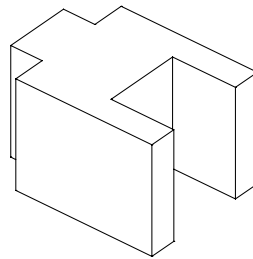
**Command:** SUBTRACT

The **Subtract** tool is used to create a composite solid by removing the material common to the selected set of solids or regions. On invoking this tool, you will be prompted to select the set of solids or regions to subtract from. After selecting it, press ENTER; you will be prompted to select the solids or regions to subtract. After selecting it, press ENTER again.

The material common to the first selection set and the second selection set is removed from the first selection set. The resultant object will be a single composite solid, refer to Figures 3-42 and 3-43.



*Figure 3-42 Solid models before subtracting*



*Figure 3-43 Composite solid created after subtracting*

## Intersecting Solid Models

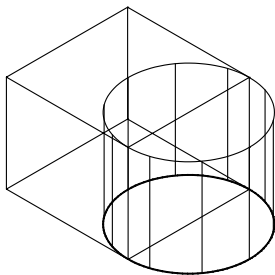
**Ribbon:** Home > Solid Editing > Solid, Intersect

**Menu Bar:** Modify > Solid Editing > Intersect

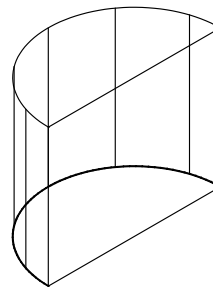
**Toolbar:** Modeling / Solid Editing > Intersect

**Command:** INTERSECT

The **Solid, Intersect** tool is used to create a composite solid or region by retaining the material common to the selected set of solids or regions. When you invoke this tool, you will be prompted to select the solids or regions to intersect. The material common to all the selected solids or regions will be retained to create a new composite solid, refer to Figures 3-44 and 3-45.



*Figure 3-44 Solid models before intersecting*



*Figure 3-45 Solid model created after intersecting*

## Checking Interference in Solids

**Ribbon:** Home > Solid Editing > Interfere

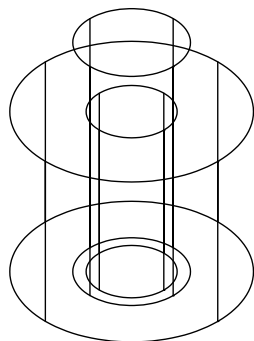
**Menu Bar:** Modify > 3D Operations > Interference Checking

**Command:** INTERFERE

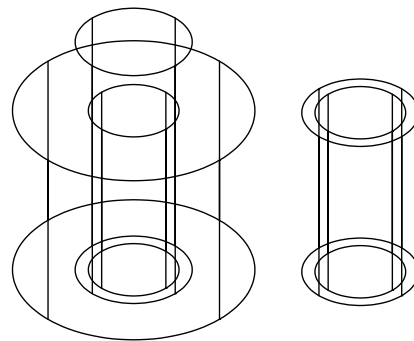


The **Interfere** tool is used to create a composite solid model by retaining the material common to the selected sets of solids. This tool is generally used for analyzing interference between the mating parts of an assembly. On invoking this tool, you will be prompted to select the first set of objects. Once you have selected them, press ENTER; you will be prompted to select the second set of objects. Select the second set of objects and press ENTER; the **Interference Checking** dialog box will be displayed. Also, the interference will be highlighted in the drawing area. The **Interfering objects** area in this dialog box displays the number of objects selected in both the first and second sets and the number of interferences found between them. Choose the **Previous** or the **Next** button in the **Highlight** area to view the previous or next interferences. If the **Zoom to pair** check box is selected in this area, the interference is zoomed while cycling through the interference objects. You can also use the navigation tools in the **Interference Checking** dialog box to view the interfering area clearly. Clear the **Delete interference objects created on close** check box, if you need to retain the interference objects after closing the dialog box. Close this dialog box by choosing the **Close** button.

If you clear the **Delete interference objects created on Close** check box and then close the **Interference Checking** dialog box, you can move the interfering objects by using the **Move** tool. Figure 3-46 shows two mating components of an assembly with interference between them and Figure 3-47 shows the interference solid created and moved out.



**Figure 3-46** Two mating components with interference

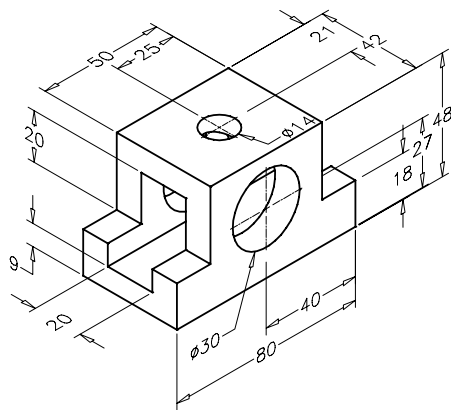


**Figure 3-47** Interference solid created using the **Interfere** tool

You can also specify the visual style and color for the interfering objects. To do so, invoke the **Interfere** tool, type **S** at the **Select first set of Objects or [Nested selection/Settings]** prompt and press ENTER; the **Interference Settings** dialog box will be displayed. In this dialog box, specify the required parameters.

## Example 1

In this example, you will create the solid model shown in Figure 3-48.



*Figure 3-48 Solid model for Example 1*

1. Increase the drawing limits to 100,100. Zoom to the limits of the drawing.
2. Enter **UCSICON** at the Command prompt. The following prompt sequence is displayed:  
  
Enter an option [ON/OFF/All/Noorigin/ORigin/Selectable/Properties] <ON>: **N**
3. Right-click on the ViewCube and then choose the **Parallel** option.
4. Invoke the ortho mode, if it is not turned on.
5. Choose **Wireframe** from **Home > View > Visual Styles** drop-down to set the visual style as Wireframe.
6. Choose the **Box** tool from **Home > Modeling > Solid Primitives** drop-down and follow the prompt sequence given next.

Specify first corner or [Center] : **10,10**  
 Specify other corner or [Cube/Length]: **L**  
 Specify length: (*Move the cursor along Y axis*) **80**  
 Specify width: **42**  
 Specify height: **48**

7. Again, invoke the **Box** tool and follow the prompt sequence given below.

Specify first corner or [Center] : **10,10, 18**  
 Specify other corner or [Cube/Length]: **L**

Specify length: *(Move the cursor along X axis)* **42**  
 Specify width: **15**  
 Specify height: **30**

8. Right-click on the **3D Object Snap** button in the Status Bar and then choose the **Vertex** option. Clear the other options in this shortcut menu.
9. Turn the **3D Object Snap** on by choosing it, if it is not already on.
10. By using the **Copy** tool and the **Vertex** option of the **3D Object Snap**, copy the new box to the other side of the box, refer to Figure 3-49.
11. Choose the **Solid, Subtract** tool from the **Solid Editing** panel and follow the prompt sequence given next.

Select solids, surfaces, and regions to subtract from.

Select objects: *Select the bigger box.*

Select objects:

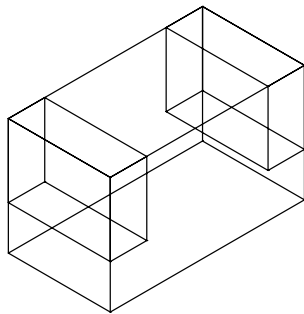
Select solids and regions to subtract.

Select objects: *Select one of the smaller boxes.*

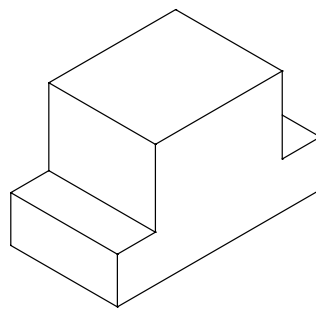
Select objects: *Select other smaller boxes.*

Select objects:

12. Change the visual style to **Hidden** from the **In-canvas Visual Style controls**. The model after subtracting the boxes should look similar to the one shown in Figure 3-50.



**Figure 3-49** Boxes moved inside the bigger box using midpoints



**Figure 3-50** Model after subtracting the smaller boxes

13. Again, change the visual style to **Wireframe**. Then, choose the **Box** tool and follow the prompt sequence given next.

Specify first corner or [Center] : **21,10, 9**  
 Specify other corner or [Cube/Length]: **L**  
 Specify length: *(Move the cursor along the X axis)* **20**  
 Specify width: **80**  
 Specify height: **29**

The box created is shown in Figure 3-51.

14. Choose the **Solid, Subtract** tool from the **Solid Editing** panel and follow the prompt sequence.

Select solids and regions to subtract from.

Select objects: *Select the model.*

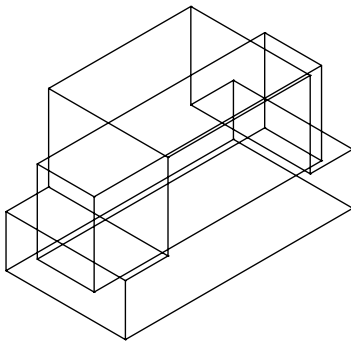
Select objects:

Select solids, surfaces, and regions to subtract.

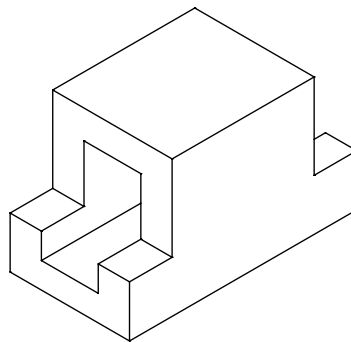
Select objects: *Select the box.*

Select objects:

The model after changing the visual style to Hidden should look similar to the one shown in Figure 3-52.



**Figure 3-51** Model before subtraction



**Figure 3-52** Model after subtraction

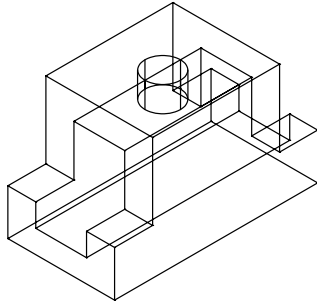
15. Right-click on the **3D Object Snap** button in the Status Bar and choose the **Center of face** option. Clear the other options in this shortcut menu.
16. Choose the **Cylinder** tool from **Home > Modeling > Solid Primitives** drop-down and follow the command sequence given next to create the cylinder, as shown in Figure 3-53.

Specify center point of base or [ 3P / 2P / Ttr/ Elliptical]: *Move the cursor on top face of the model and snap the center of the top face.*

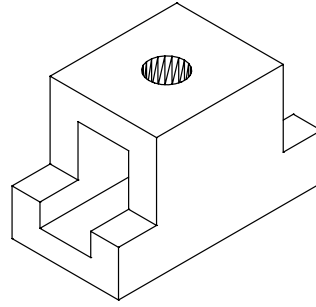
Specify base radius or [Diameter]: **7**

Specify height or [2Point / Axis endpoint]: *Move the cursor vertically downward and enter 10*

17. Subtract this cylinder from the existing model, refer to Figure 3-54.



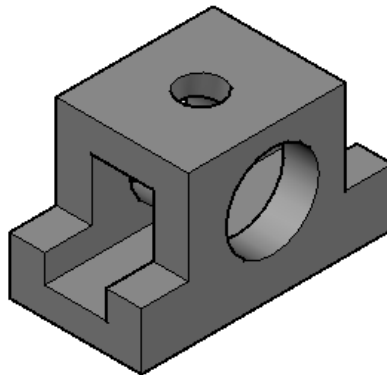
**Figure 3-53** Model before subtraction



**Figure 3-54** Model after subtraction

18. Create a new UCS by clicking on **Right** in the ViewCube.
19. Choose **Cylinder** from **Home > Modeling > Solid Primitives** drop-down in the **Ribbon**. The following command sequence will be displayed:  

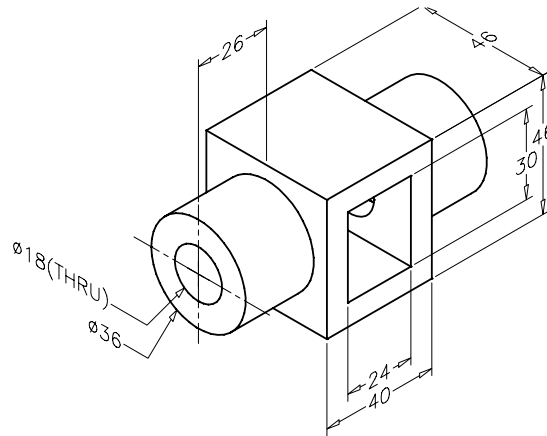
Specify center point of base or [3P / 2P / Ttr/ Elliptical]: Use the **From** option to specify the center point of the cylinder at a distance of **27** units from the midpoint of the longer edge of the base.  
Specify base radius or [Diameter]: **15**  
Specify height or [2Point / Axis endpoint]: **-42**
20. Subtract this cylinder from the model and change the visual style to **Shades of Gray**. The final model should look similar to the one shown in Figure 3-55.



**Figure 3-55** Final solid model for Example 1

## Exercise 1

In this exercise, you will create the solid model shown in Figure 3-56. Save this drawing with the name *C-03\_Exercise1.dwg*.

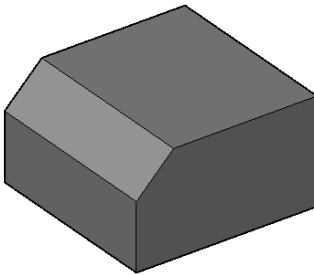


*Figure 3-56 Solid model for Exercise 1*

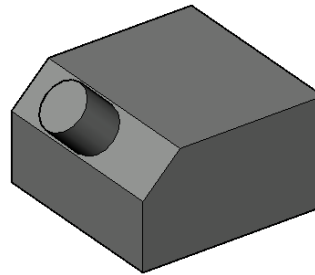
## DYNAMIC UCS

This option is used to temporarily align the XY plane of the current UCS with the selected face of an existing solid. Choose the **Dynamic UCS** toggle button from the Status Bar to turn it on. Now, invoke a tool and move the cursor near the face on which you want to create the new sketch or solid; the face will be highlighted in dashed lines. Click the left mouse button on the desired face; the XY plane of the UCS will automatically be aligned with the selected face. Now, you can create the sketch or solid at the selected face. After the completion of the sketch or feature, the UCS will again move automatically to its original position.

For example, if you want to create a cylinder on the slant face of the model shown in Figure 3-57, choose the **Dynamic UCS** button from the Status Bar to turn it on. Then, choose the **Cylinder** tool from the **Solid Primitives** drop-down in the **Modeling** panel. Next, move the cursor near the slant face of the model; the slant face of the model will be highlighted. Next, left-click on that face and create the cylinder, as shown in Figure 3-58.



*Figure 3-57 Model with UCS at the origin*



*Figure 3-58 UCS dynamically moved on the slant face of the model*

If you want a better visualization of how the X, Y, and Z axes of the UCS will be oriented, right-click in the drawing area and choose **Options** from the shortcut menu; the **Options** dialog



box will be displayed. Choose the **3D Modeling** tab from the dialog box and select the **Show labels for dynamic UCS** check box in the **3D Crosshairs** area. This will enable you to see the X, Y and Z labels attached with the axes and they will keep on changing as you move the cursor to different faces.



#### Note

*The **Dynamic UCS** option works only when any tool is active.*



#### Tip

*To toggle between the on and off states of the **Dynamic UCS** button, use the F6 function key. To temporarily deactivate the **Dynamic UCS** button, press and hold the **SHIFT+Z** keys.*

## DEFINING THE NEW UCS USING THE ViewCube AND THE RIBBON

In the earlier chapters, you learned how to create new UCS using the **UCS** tool. You can also define a new UCS whose XY plane is parallel to the current viewing plane by using the ViewCube and the **Ribbon**. To define a new UCS whose XY plane is parallel to the current viewing plane, click on a hotspot in the ViewCube; the view corresponding to the hotspot will become normal to the screen. Next, choose **WCS > New UCS** from the **WCS** flyout in the ViewCube; you will be prompted to specify the origin. Enter **V** at the Command prompt and press **ENTER**; a new UCS will be created at the current viewing plane. Now, if you draw a sketch, it will be in the new UCS. To save the new UCS, choose the **UCS, Named UCS** tool from the **Coordinates** panel in the **Home** tab; the **UCS** dialog box will be displayed with the **Unnamed** option. Rename it and choose **OK**; the new name of the UCS will be saved and also displayed in the **WCS** flyout of the ViewCube.

To define a new UCS using the **Ribbon**, choose any one of the predefined orthographic views from the 3D Navigation drop-down list in the **View** panel of the **Home** tab; the model will orient to that view. Also, you will notice that the ViewCube is also oriented according to the selected view, but **Top** is displayed as the view and **Unnamed** is displayed at the **WCS** flyout. Now, if you draw a sketch, it will be in the new UCS. However, if there are different faces parallel to the new UCS, you can draw sketches on those faces.

## CREATING EXTRUDED SOLIDS

**Ribbon:** Home > Modeling > Solid Creation drop-down > Extrude

**Menu Bar:** Draw > Modeling > Extrude **Toolbar:** Modeling > Extrude

**Command:** EXT (EXTRUDE)



Sometimes, the shape of a solid model is such that it cannot be created by just applying the Boolean operations on the standard solid primitives. In such cases, you can use the tools from the **Solid Creation** drop-down, as shown in Figure 3-59. These tools are also available in the **Solid** panel of the **Solid** tab. Using these tools, you can create solid models of any complex shape.

The **Extrude** tool is used to create a complex solid/surface model by extruding a 2D entity or a region along the Z axis or any specified direction or about a specified path. On invoking this tool, following prompt sequence will be displayed.

Select objects to extrude or [MOde]: **\_MO** Closed profiles creation mode [SOlid/Surface] **<Solid>: \_SO**  
Select objects to extrude or [MOde]:

In AutoCAD, you can specify mode to extrude an object. There are two modes available: **Solid** and **Surface**. If you need to change the mode, enter **MO** at the **Select objects to extrude or [MOde]** prompt and specify the mode. Note that if the original entity is a closed loop or a region, you can extrude it as a solid/surface model. If the 2D entity is an open loop, then you can extrude it as a surface only. After specifying the mode, select the objects to be extruded and press ENTER; the **Specify height of extrusion or [Direction/Path/Taper angle/Expression]** prompt will be displayed. Specify the depth of extrusion or select other options to specify the depth. Different methods to extrude an object by using the options at the Command prompt are discussed next.

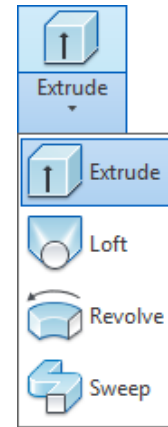


Figure 3-59 Tools in the Solid Creation drop-down

## Extruding along the Normal

This is the default option and is used to create a model by extruding a 2D entity or a region along the normal. Figure 3-60 shows the region to be converted into an extruded solid and Figure 3-61 shows the solid created on extruding the region. The prompt sequence that will be displayed when you choose the **Extrude** tool is given next.

Select objects to extrude: *Select the region.*

Select objects to extrude:

Specify height of extrusion or [Direction /Path /Taper angle/Expression]: *Specify the height.*

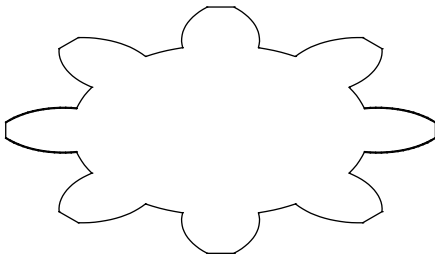


Figure 3-60 Region for extruding

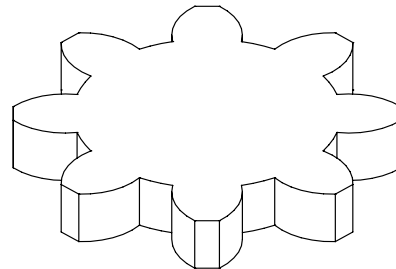


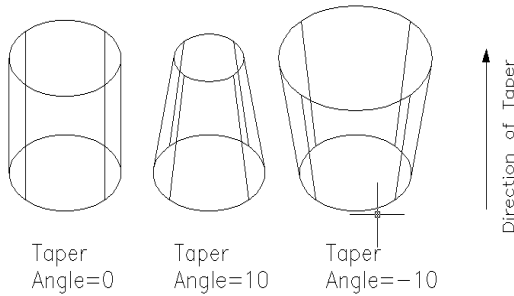
Figure 3-61 Solid created on extruding

## Extruding with a Taper Angle

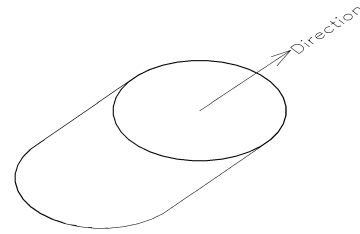
You can specify the taper angle for an extruded solid/surface by selecting the **Taper angle** option at the **Specify height of extrusion or [Direction/Path/Taper angle/Expression]** prompt. The positive value of the taper angle will taper in from the base object and the negative value will taper out of the base object, refer to Figure 3-62.

## Extruding along a Direction

This option is used to create a solid by extruding a 2D entity or a region in any desired direction by specifying two points. You can create an inclined extruded object by selecting a start point and an endpoint. The distance between the start point and endpoint acts as the height of the extrusion. Figure 3-63 shows an object extruding along a direction.



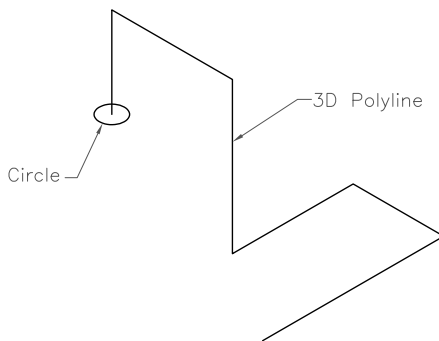
**Figure 3-62** Results of various taper angles



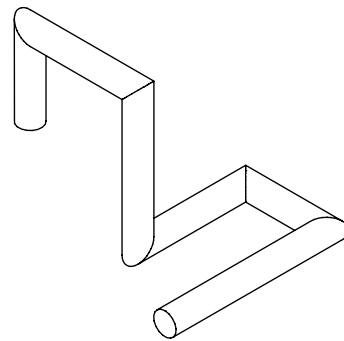
**Figure 3-63** Object extruding along a direction

## Extruding along a Path

This option is used to extrude a 2D entity or a region about a specified path. Bear in mind that the path of extrusion should be normal to the plane of the base object. If the path consists of more than one entity, all of them should be first joined using the **Edit Polyline** tool so that the path remains a single entity. This option is generally used for creating complex pipelines and also by architects and interior designers for creating beadings. The path used for extrusion can be a closed entity or an open entity and the valid entities that can be used as path are lines, circles, ellipses, polygons, arcs, polylines, or splines. You cannot specify the taper angle when you use a path. Figure 3-64 shows a base object and a path about which the base object has to be extruded and Figure 3-65 shows the solid created upon extruding the base entity about the specified path.



**Figure 3-64** The base object and the path for extrusion



**Figure 3-65** Solid model created on extruding the base entity about the specified path

## Extruding using Expressions

This option is used to specify the extrusion depth in terms of formula or equations as you have created parametric drawings.

## CREATING REVOLVED SOLIDS

**Ribbon:** Home > Modeling > Solid Creation drop-down > Revolve  
**Menu Bar:** Draw > Modeling > Revolve **Toolbar:** Modeling > Revolve  
**Command:** REV(REVOLVE)



The **Revolve** tool is used to create a complex model by revolving 2D entities or regions about a specified revolution axis. The entire 2D entity should be on one side of the revolution axis. Self-intersecting and crossed entities cannot be revolved using this tool. Remember that the direction of revolution is determined using the right-hand thumb rule. The axis of rotation is defined by specifying two points using the *X* or *Y* axis of the current UCS, or using an existing object. Similar to the **Extrude** tool, you can create a solid/surface model by specifying the mode after invoking the **Revolve** tool. On specifying the mode and selecting the object, the **Specify axis start point or define axis by [Object/X/Y/Z]** prompt will be displayed. Specify the axis of revolution. After setting the revolution axis option, you will be prompted to specify the angle of revolution. The default value is 360°. You can enter the required value at this prompt.

The options that are used to specify the axis are discussed next.

### Start Point for the Axis of Revolution

This option is used to define the axis of revolution using two points: the start point and the endpoint of the axis of revolution. The positive direction of the axis will be from the start point to the endpoint and the direction of revolution will be defined using the right-hand thumb rule. Before revolving, make sure the complete 2D entity is on one side of the axis of revolution.

### Object

This option is used to create a revolved model by revolving a selected 2D entity or a region about a specified object. The valid entities that can be used as an object for defining the axis of revolution can be a line or a single segment of a polyline. If the polyline selected as the object consists of more than one entity, then AutoCAD draws an imaginary line from the start point of the first segment to the endpoint of the last segment. This imaginary line is then taken as the object for revolution.

### X

This option uses the positive direction of the *X* axis of the current UCS for revolving the selected entity. If the selected entity is not completely on one side of the *X* axis, it will give you an error message that it cannot revolve the selected object.

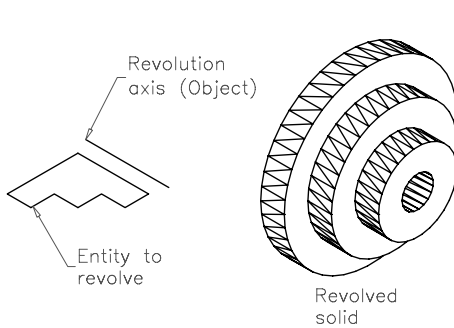
### Y

This option uses the positive direction of the *Y* axis of the current UCS as the axis of revolution for creating the revolved solid.

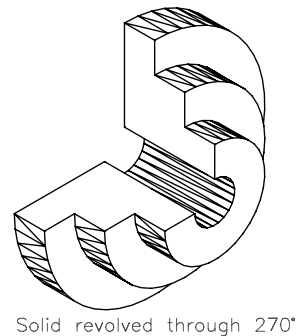
**Z**

This option uses the positive direction of the Z axis of the current UCS as the axis of revolution for creating the revolved solid.

Figure 3-66 shows the entity to be revolved and the revolution axis along with the revolved solid. Figure 3-67 shows the same solid revolved through an angle of 270°.



*Figure 3-66 Creating a revolved solid*



*Figure 3-67 Solid revolved to an angle*

## CREATING SWEEP SOLIDS

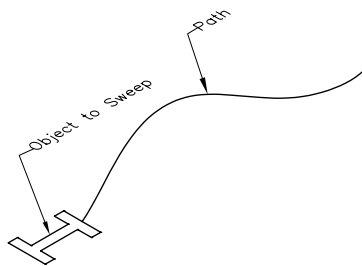
**Ribbon:** Home > Modeling > Solid Creation drop-down > Sweep

**Menu Bar:** Draw > Modeling > Sweep **Toolbar:** Modeling > Sweep

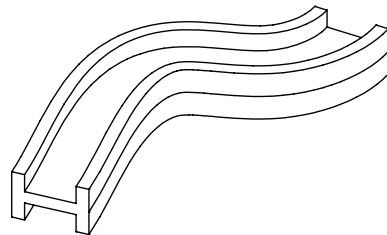
**Command:** SWEEP



The **Sweep** tool is used to sweep an open or a closed profile along a path. This tool is also available in the **Solid** panel of the **Solid** tab. To create this model by using this tool, you need an object and a path. The object is a cross-section for the sweep feature and the path is the course taken by the object while creating the swept solid. Figure 3-68 shows the object to be swept and the path to be followed and Figure 3-69 shows the resulting sweep feature.



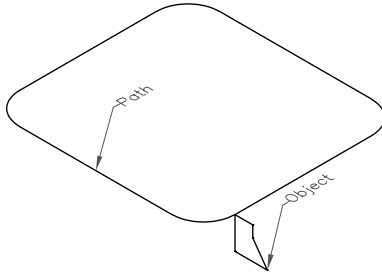
*Figure 3-68 Object to be swept and the path*



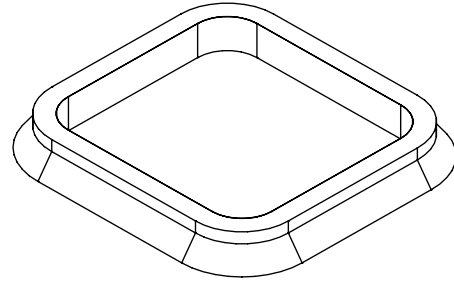
*Figure 3-69 Resulting sweep feature*

The path specified for the profile and the object for the cross-section of the swept model can be open or closed. If the object for the cross-section is open, or closed but not forming a single

region, the generated feature will result in a surface sweep. If the object for the section is closed and it forms a single region, the generated feature will be a solid. Figure 3-70 shows the object and the closed path and Figure 3-71 shows the resulting sweep feature.



**Figure 3-70** Object to be swept with a closed path



**Figure 3-71** Resulting sweep feature



#### Note

The path selected for the **Sweep** tool should not form a self-intersecting loop.

You can select more than one section at a time to be swept along a path, but all these sections should be drawn on the same plane. To create a sweep, draw the cross section profile, path, and select the **Sweep** tool. Then, follow the prompt sequence given next.

Select objects to sweep or [MMode]: *Select the object to be swept.*

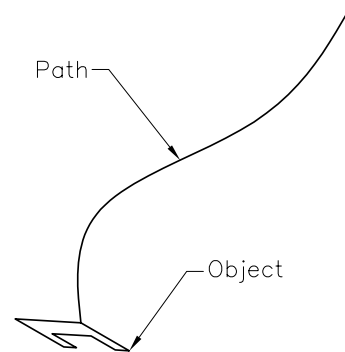
Select objects to sweep or [MMode]: *Select more objects to be swept or press ENTER.*

Select sweep path or [Alignment/Base point/Scale/Twist]: *Select the path to be followed by the object or enter an option.*

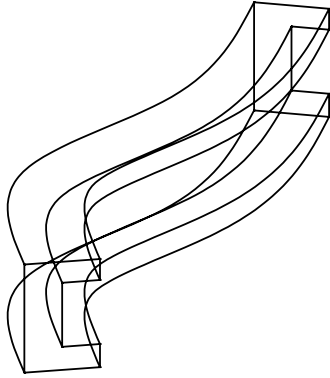
Depending on your requirement, you can invoke the following options at the **Select sweep path** or **[Alignment/Base point/Scale/Twist]** prompt:

### Alignment

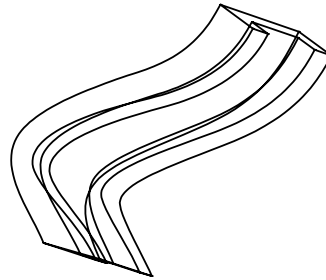
This option is used to specify whether the object will be oriented normal to the curve at the start point. By default, the sweep feature is created with a section normal to the path at the start point. To avoid this, choose **No** from the shortcut menu at the **Align sweep object perpendicular to path before sweep [Yes/No]** prompt. Figure 3-72 shows the object and the path for the sweep tool. Figure 3-73 shows the resulting sweep feature on choosing the aligned option **Yes** and Figure 3-74 shows the resulting sweep feature on choosing the aligned option **No**.



**Figure 3-72** Object and path for sweep command



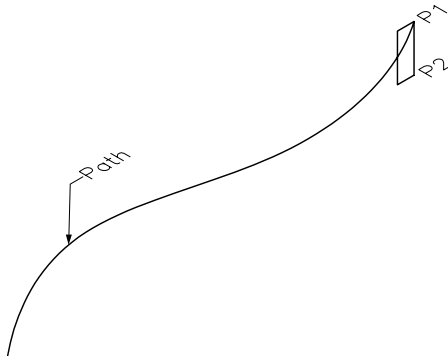
**Figure 3-73** Swept solid with the aligned option *Yes*



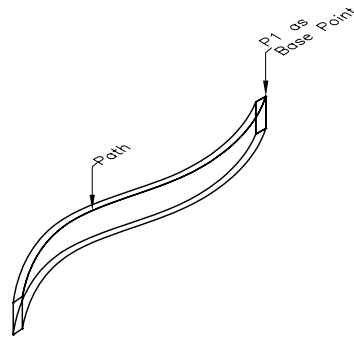
**Figure 3-74** Swept solid with the aligned option *No*

## Base Point

This option is used to specify a point on the object that will be attached to the path while sweeping it. You can specify the location of the cross-section while sweeping it when prompted to specify the base point. Figure 3-75 shows the path and the cross-section with base points P1 and P2. Figure 3-76 shows the resulting sweep feature with P1 as the base point and Figure 3-77 shows the resulting sweep feature with P2 as the base point.



**Figure 3-75** Path with object and P1 and P2 as base points



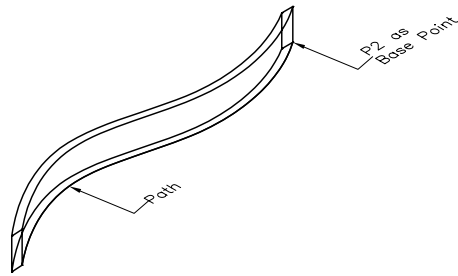
**Figure 3-76** Sweep with P1 as base point

## Scale

This option is used to scale an object uniformly from the start of the path to the end of the path while sweeping it. Note that the size of the start section will remain the same and then end section will be scaled by the specified value. Also, the transition from the beginning to the end is smooth. Figure 3-78 shows a pentagon swept along a path with a scale factor of 0.25.

## Twist

You can rotate an object about a path uniformly from the start to the end with a specified angle. The value of the twist should be less than 360 degrees. Figure 3-79 shows a sweep feature with 300 degrees of twist.

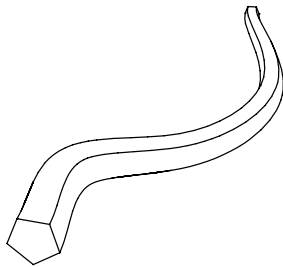


**Figure 3-77** Sweep with P2 as the base point

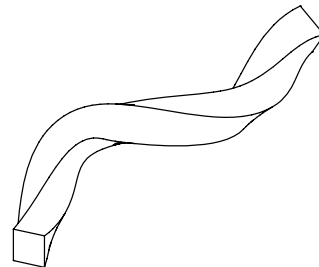


**Note**

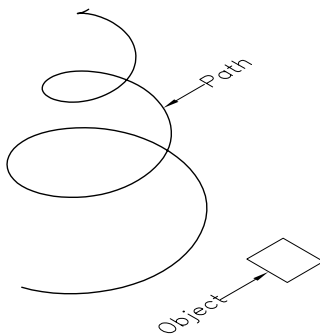
A helix can also be used as the path for the **Sweep** tool. Figure 3-80 shows the object and a helical path generated using the **Helix** tool and Figure 3-81 shows the resulting swept solid.



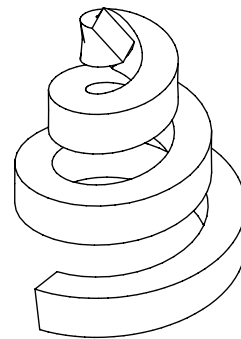
**Figure 3-78** Sweep with the **Scale** option



**Figure 3-79** Sweep with the **Twist** option



**Figure 3-80** Helical path and object to be swept



**Figure 3-81** Sweep feature with the helical path



## CREATING LOFTED SOLIDS

**Ribbon:** Home > Modeling > Solid Creation drop-down > Loft

**Menu Bar:** Draw > Modeling > Loft      **Toolbar:** Modeling > Loft

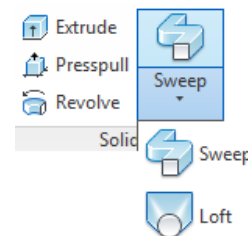
**Command:** LOFT

The **Loft** tool is used to create a feature by blending two or more similar or dissimilar cross-sections together to get a free form shape. These similar or dissimilar cross-sections may or may not be parallel to each other. To create a loft feature, choose the **Loft** tool from the **Solid** panel, refer to Figure 3-82; the following prompt sequence will be displayed:

Select cross sections in lofting order or [POint/Join multiple edges/MOde]: \_MO

Closed profiles creation mode [SOLid/SURface] <Solid>: \_SO

Select cross sections in lofting order or [POint/Join multiple edges/MOde]



**Figure 3-82** Selecting the **Loft** tool from the **Sweep** drop-down in the **Solid** panel

Next, select at least two sections in a sequence in which you want to blend them. The prompt sequence that will be followed after choosing the **Loft** tool is given next.

Select cross sections in lofting order or [POint/Join multiple edges/MOde]: 1 found

Select cross sections in lofting order or [POint/Join multiple edges/MOde]: 1 found, 2 total

Select cross sections in lofting order or [POint/Join multiple edges/MOde]: 2 cross sections selected

Enter an option [Guides/Path/Cross sections only/Settings] <Cross sections only>:



### Note

As you are prompted to select cross-sections while creating a loft, you can select open or closed sections. Note that if you select an open section first, all subsequent sections should be open. The model thus created will be a surface. Similarly, if you select a closed section, all subsequent sections should be closed. The model created using these sections can be solid/surface. By default, a loft model is solid. Therefore, if cross sections selected are closed profiles and you need a surface model, then first you need to change the mode by entering **MO** at the **Select cross sections in lofting order or [POint/Join multiple edges/MOde]** prompt.

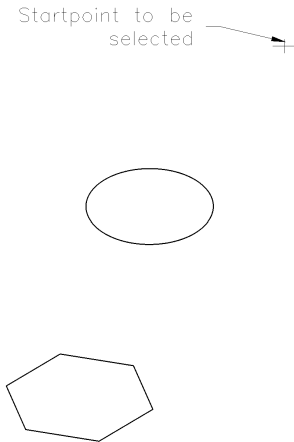
After specifying the mode, you can select the cross sections, an imaginary point as the start point of the loft, or multiple edges on a solid model.

These options are discussed next.

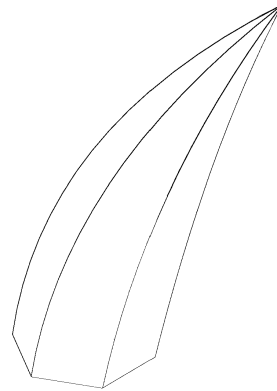
### Point

In AutoCAD, you can start a loft such that it begins from an imaginary point and passes through different sections. To do so, enter **PO** at the **Select cross sections in lofting order or [POint/Join multiple edges/MOde]** prompt and specify the start point of the loft, as shown in Figure 3-83. Next, select the cross sections in succession and press ENTER after selecting all cross sections; the

preview of the loft feature will be displayed. Also, a Look up grip near the last cross section and the **Enter an option [Guides/Path/Cross sections only/Settings/COntinuity/Bulge magnitude] <Cross sections only>** prompt will be displayed. Select the **Cross sections only** option and press ENTER; the loft will be created, as shown in Figure 3-84.



**Figure 3-83** Sections and the imaginary start point to be selected



**Figure 3-84** Loft feature created by using the **PO** option

## Join multiple edges

In AutoCAD, you can create a loft feature between the edges of a solid model and a profile. To do so, enter **J** at the **Select cross sections in lofting order or [POint/Join multiple edges/MOde]** prompt; the cursor will have the symbol of solid and you will be prompted to select edges that are to be joined to a single cross section. Select the edges in succession, and press ENTER, refer to Figure 3-85. Then, select the cross sections and press ENTER; the preview of the loft will be displayed. One look up grip at the start of the loft surface and other look up grip near the base of the model will be displayed. The Look up grip at the start of the loft will have the surface continuity symbol, and the other Look up grip will have the Loft symbol, refer to Figure 3-86. Click on the Look up grip that has the surface continuity symbol and select the required option from the flyout displayed. The options in the other look up grip will be discussed later.

Given below is the prompt sequence to select the edges on the top face of the cuboid and a circle as the cross section.

Select cross sections in lofting order or [POint/Join multiple edges/MOde]: **J**

Select edges that are to be joined into a single cross section: (Select the first edge) 1 found

Select edges that are to be joined into a single cross section: (Select the second edge) 1 found, 2 total

Select edges that are to be joined into a single cross section: (Select the third edge) 1 found, 3 total

Select edges that are to be joined into a single cross section: (Select the fourth edge) 1 found, 4 total

Select edges that are to be joined into a single cross section:

Select cross sections in lofting order or [P]oint/[J]oin multiple edges/[M]ode: 1 found

Select cross sections in lofting order or [P]oint/[J]oin multiple edges/[M]ode:

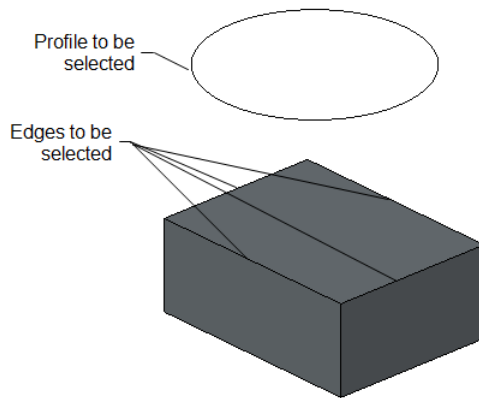
2 cross sections selected

Enter an option [G]uides/[P]ath/[C]ross sections only/[S]ettings/[C]ontinuity/[B]ulge magnitude]

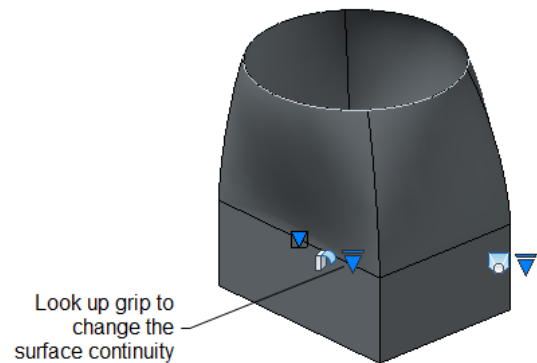
<Cross sections only>:  (Preview of the loft will be displayed with grips, refer to Figure 3-86.

Press ENTER; the loft surface will be created, refer to Figure 3-87.

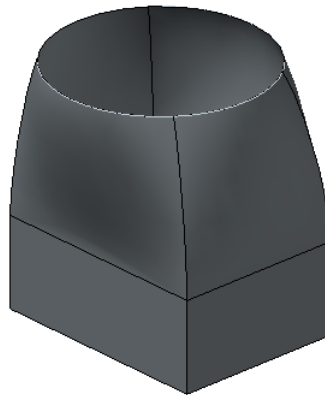
After selecting all cross sections and on pressing ENTER, the **Enter an option [Guides/Path/Cross sections only/Settings/Continuity/Bulge magnitude] <Cross sections only>** prompt will be displayed. The **C**ontinuity and **B**ulge magnitude options will be displayed in the Command prompt only if you have selected the edges of a model as one of the cross sections. Depending on requirement, you can invoke any one of those options. These options are discussed next.



**Figure 3-85** Edges and the profile to be selected



**Figure 3-86** Look up grips displayed

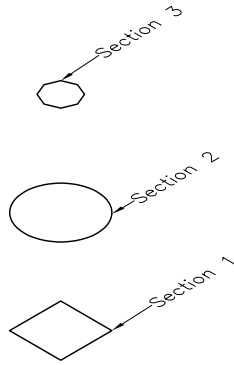


**Figure 3-87** Loft surface created

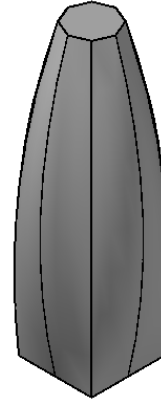
## Guide

AutoCAD enables you to select guide curves between the sections of the loft feature. These guide curves define the shape of the material addition between the selected sections for the loft feature. Guide curves also specify the points of different sections to be joined while adding material between them. This reduces the possibility of an unnecessary twist in the resulting feature. You

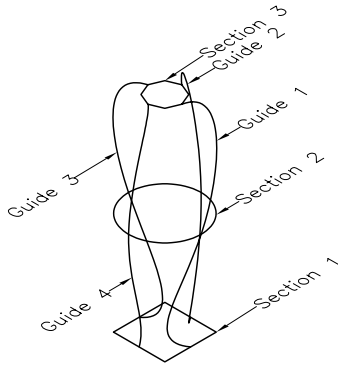
can select as many guide curves as you require. But these guide curves should pass through or should touch each section that you selected for loft feature. Also the guides should start from the first section and terminate at the last section. Figure 3-88 shows three sections for the loft feature. Figure 3-89 shows the resulting loft feature. Figure 3-90 shows the sections to be lofted and the guide curves and Figure 3-91 shows the resulting model.



**Figure 3-88** Three section curves for the loft feature



**Figure 3-89** Resulting loft feature



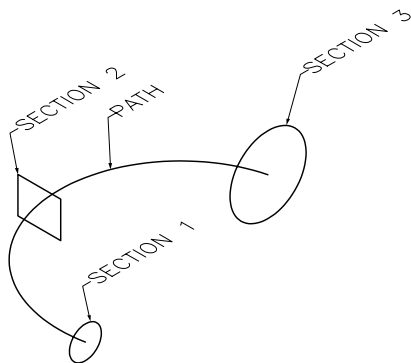
**Figure 3-90** Sections and guide curves for the loft feature



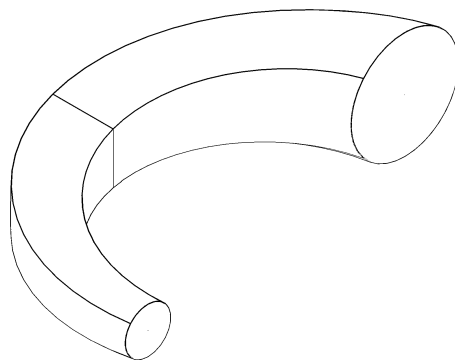
**Figure 3-91** The loft feature created by using the guide curve

## Path

The path option is used to create a loft feature by blending more than one section along the direction specified by the path curve. Note that you can select only one path curve. The selected path curve may or may not touch all sections, but it should pass through all sketching planes of the sections. Figure 3-92 shows the sections and the path along which the blending of material will propagate and Figure 3-93 shows the resulting loft feature.



**Figure 3-92** Sections and path to be used for the **Loft** option



**Figure 3-93** Resulting loft feature after using the **Path** option

## Cross sections only

This is the default option displayed at the **Enter an option [Guides/Path/Cross sections only/Settings/COntinuity/Bulge magnitude] <Cross sections only>** prompt. If you need to create a loft without a guide or path, press ENTER; the loft feature will be created by using the cross sections only.

## Settings

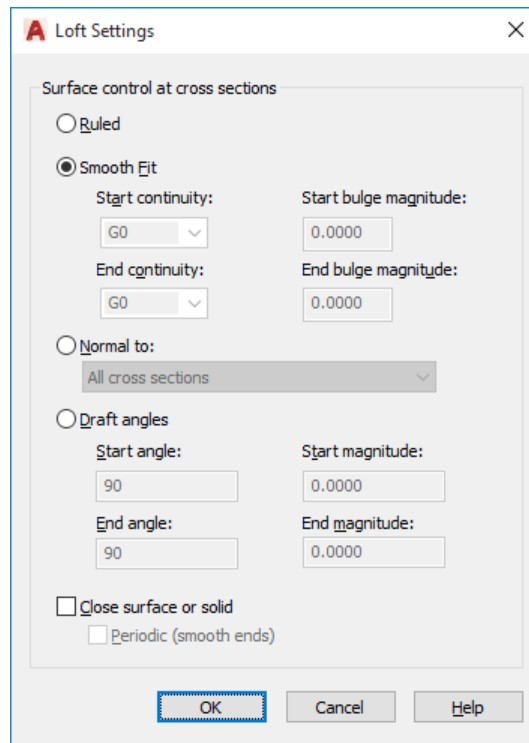
When you select **Settings**, the **Loft Settings** dialog box will be displayed, as shown in Figure 3-94. This dialog box is used to control the shape of the material addition between sections without specifying any guide curve or path. You can also select these options from the Look up grip displayed along with the preview. Various options in the **Loft Settings** dialog box are discussed next.

## Ruled

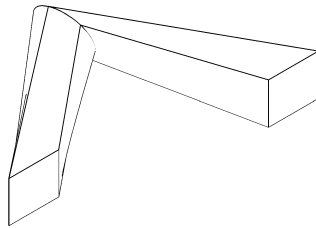
If you select the **Ruled** radio button, a straight blend will be created by connecting different sections with straight lines. The loft feature created by this option will have sharp edges at the sections. Figure 3-95 shows the loft feature when the **Ruled** radio button is selected.

## Smooth Fit

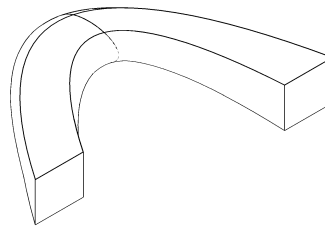
If you select the **Smooth Fit** radio button, a smooth loft will be created between sections. The loft feature created by this option will have smooth edges at the intermediate section. Figure 3-96 shows the loft feature when the **Smooth Fit** radio button is selected.



*Figure 3-94 The Loft Settings dialog box*



*Figure 3-95 Loft solid with the Ruled radio button selected*

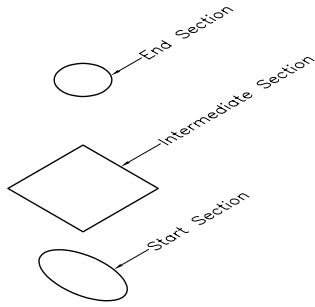


*Figure 3-96 Loft solid with the Smooth Fit radio button selected*

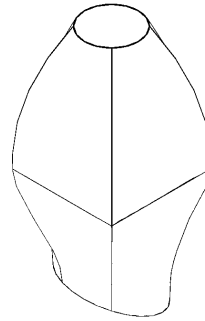
## Normal to

This option controls the shape of the loft between the sections. When you select this radio button, the drop-down list will be enabled. The following options are available in this drop-down list:

**Start cross section.** In this option, the normal of the lofted feature is normal to the start section. The loft feature starts normal to the start section and follows a smooth polyline as it approaches the next section. Figure 3-97 shows the section selected to create the loft and Figure 3-98 shows the loft created by specifying the **Start cross section** option.



**Figure 3-97** Start and end sections to create loft

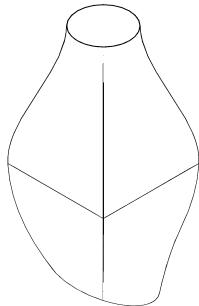


**Figure 3-98** Loft solid created by blending material normal to the start section

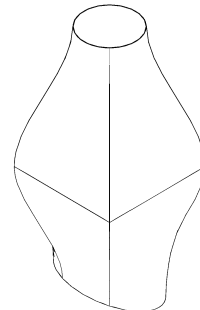
**End cross section.** In this option, the normal to the blending material is normal to the end section. At the second last section, the blending material starts along a spline and while reaching up to end section, it becomes normal to it, as shown in Figure 3-99.

**Start and End cross sections.** In this option, the normal to the blending material is normal to both the start and end sections.

**All cross sections.** In this option, the normal to the blending material always remains normal to all cross-sections, as shown in Figure 3-100.



**Figure 3-99** Loft solid created by blending material normal to the end section

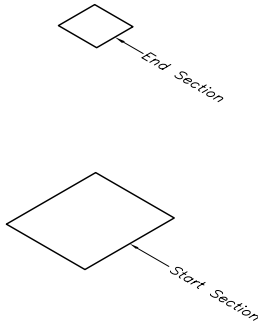


**Figure 3-100** Loft solid created by blending material normal to all sections

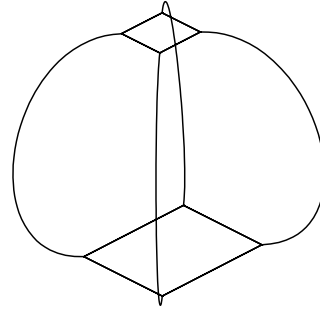
## Draft angles

In this option, you can define the angle at the start section and the end section of the loft. Remember that you cannot define an angle for the intermediate sketches. You can also specify the distance up to which the blending material will follow this draft angle before bending toward the intermediate sections. The various options for specifying the draft angle are discussed next.

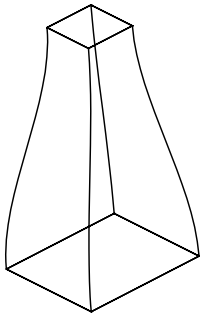
**Start angle.** This edit box is used to specify the draft angle at the start section of the loft. Figure 3-101 shows the two sections to be blended and Figure 3-102 shows the loft with the start and end angles as 0-degree. Figures 3-103 and 3-104 show the loft feature with the start angle as 90-degree and 180-degree, respectively.



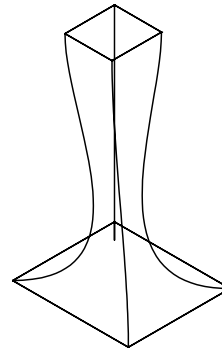
**Figure 3-101** Start and end sections of the loft feature



**Figure 3-102** Loft feature with 0-degree start and end angles



**Figure 3-103** Loft feature with 90-degree start and end angles



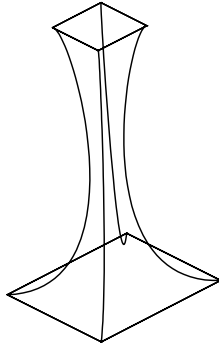
**Figure 3-104** Loft feature with 180-degree start angle and 90-degree end angle

**Start magnitude.** The value specified in this region signifies the distance up to which the blending material will follow the start angle before bending toward the next section. Figure 3-105 shows a loft feature with 180-degree as the start and end angles, and 15 as the start magnitude. Figure 3-106 shows a loft feature with 180-degree as the start and end angles and 2 as the start magnitude. Notice the difference in the extent up to which the blended material follows the start angle in the two figures.

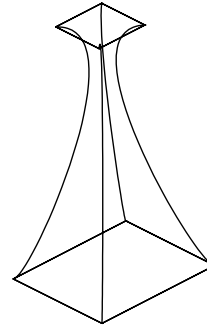
**End angle.** This edit box is used to specify the draft angle at the end section of the loft. Figure 3-101 shows two sections to be blended and Figure 3-102 shows the loft with the start and end angle as 0-degree. Figure 3-103 and Figure 3-104 show the loft feature with the end angle as 90-degree.

**End magnitude.** The value specified in this region signifies the distance up to which the blending material will follow the end angle before approaching the last section. Figure 3-105 shows a loft feature with 180-degree as the start and end angle, and 2 as the end magnitude. Figure 3-106 shows a loft feature with 180-degree as the start and end angle, and 10 as the end magnitude. Notice the difference in the extent up to which the blended material follows the end angle in the two figures.





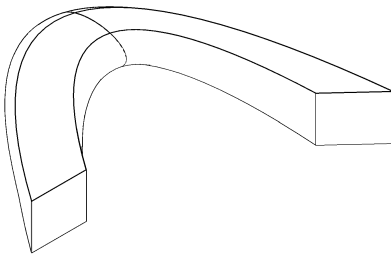
**Figure 3-105** Loft feature with 180-degree as the start and end angle, 15 as the start magnitude, and 2 as the end magnitude



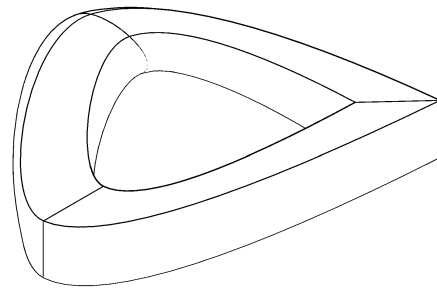
**Figure 3-106** Loft feature with 180-degree as the start and end angle, 2 as the start magnitude, and 10 as the end magnitude

### Close surface or solid

The **Close surface or solid** check box is selected to close a loft feature by joining the end section with the start section. Figure 3-107 shows a loft feature created with this check box cleared and Figure 3-108 shows the same sections lofted by this check box selected.



**Figure 3-107** Loft solid with the **Close surface or solid** check box cleared



**Figure 3-108** Loft solid with the **Close surface or solid** check box selected



#### Note

To visualize the effect of the **Close surface or solid** option, the loft feature should contain at least three sections. If not so, the extra blending material will be added at the same location where the loft feature would have been created without selecting this check box, thereby resulting in no change.

**Periodic (smooth ends).** If this check box is selected, the seam of the closed surface will not buckle, if you alter the shape of the surface.



#### Tip

You can also use a point as a section for the loft feature, but it should always be the start section or the end section of the loft feature.

## Continuity

Continuity defines the smoothness of the loft surface between two cross sections, if one of the cross sections is an edge of a model. Continuity can be set to **G0** (position continuity), **G1** (tangency continuity), or **G2** (curvature continuity). **G0** maintains the position of the selected edges, **G1** maintains tangency of the loft surface where it meets edges, and **G2** maintains the same curvature. By default, the continuity is set to G0. To edit the continuity setting of a loft, enter **CO** at the **Enter an option [Guides/Path/Cross sections only/Settings/COntinuity/Bulge magnitude] <Cross sections only>** prompt and press ENTER; you will be prompted to specify the continuity. Enter the required option and press ENTER.

You can also set the surface continuity by using the Continuity grip.

## Bulge magnitude

The bulge magnitude determines the roundness or the amount of bulge between two cross sections, if one of the cross sections is an edge of a model. By default, the bulge magnitude is set to 0.5. If you want to edit the bulge magnitude, enter **B** at the **Enter an option [Guides/Path/Cross sections only/Settings/COntinuity/Bulge magnitude] <Cross sections only>** prompt and press ENTER; you will be prompted to enter the loft bulge magnitude at the start. Enter a value and press ENTER. If there is only one solid edge as a cross section, then the bulge will be created. If there are two solid edges as cross sections (one at the start and the other at the end), then you will be prompted to enter the bulge magnitude at the start and end. Type a value and press ENTER; the bulge will be created. If you need to change the bulge magnitude while creating, then click the Bulk magnitude Look up grip; a dot with a leader will be displayed. Drag the dot dynamically to change the bulk magnitude.

Figure 3-109 shows the edges on the top faces of two solids as well as the region which needs to be selected for creating a loft feature. Figure 3-110 shows the preview of the loft feature with grips. Figure 3-111 shows the loft feature with bulge magnitude added at the start and end.

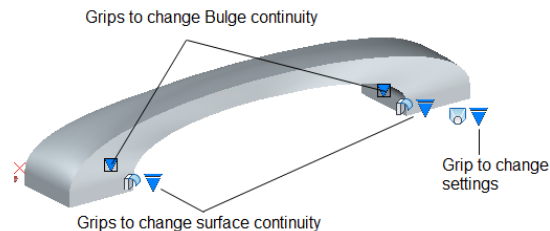


### Note

You can also set the surface continuity and the bulge continuity in the **Loft Settings** dialog box.



**Figure 3-109** Two solids and a region to create a loft



**Figure 3-110** Preview of the loft and the grips displayed



Figure 3-111 Loft surface created

## CREATING PRESSPULL SOLIDS

**Ribbon:** Home > Modeling > Presspull  
**Command:** PRESSPULL

**Toolbar:** Modeling > Presspull

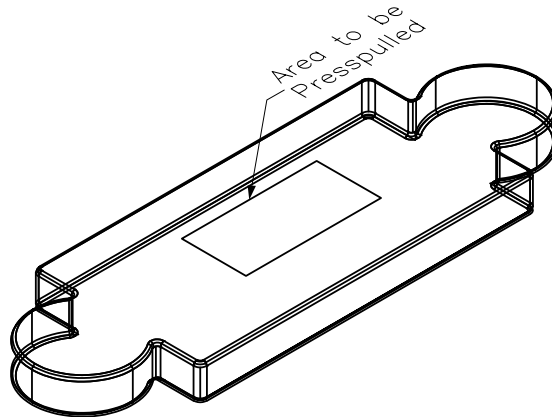


The **Presspull** tool is used to remove or add material of any desired shape in a model. As the name presspull indicates, if you press a closed boundary inside an existing model, it will remove the material of the shape of the closed boundary. However, if you pull a closed boundary outside an existing model, it will add material to the model. To perform this operation, choose the **Presspull** tool from the **Modeling** panel. Next, click inside a closed boundary that you want to press or pull and then move the mouse in the desired direction. You can specify the desired height by entering a value or by clicking the mouse. Figure 3-112 shows the solid model with the closed area to be presspulled. Figure 3-113 shows the model created by pressing the closed region and Figure 3-114 shows the model created by pulling the closed area.

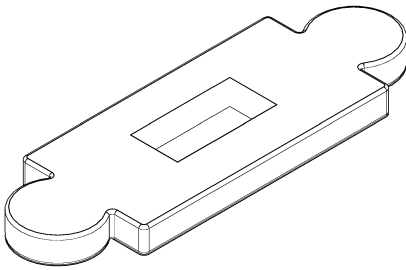
Given below is the prompt sequence displayed while creating the presspull feature.

Select object or bounded area : *Select any closed bounded area that you want to presspull*  
Specify extrusion height or [Multiple] : *Click anywhere to specify the height of extrusion*  
Select object or bounded area :

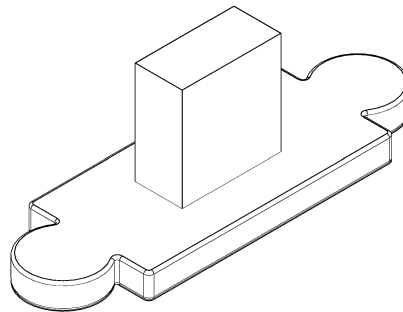
If the sketch that you select to press or pull has nested loops, as shown in Figure 3-115, the inner closed loops will be deleted from the outer loop, as shown in Figure 3-116. The closed area you select for the presspull should consist of lines, polylines, 3D face, edges, regions, and faces of a 3D solid. But all these entities should form a coplanar closed area.



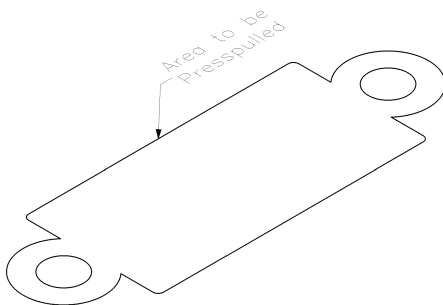
**Figure 3-112** Model with closed area to be presspulled



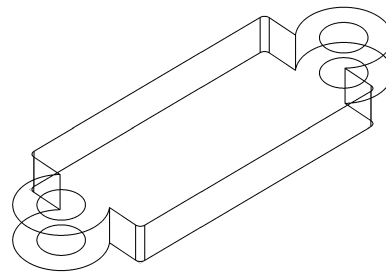
**Figure 3-113** Model with the closed area pressed



**Figure 3-114** Model with closed area pulled



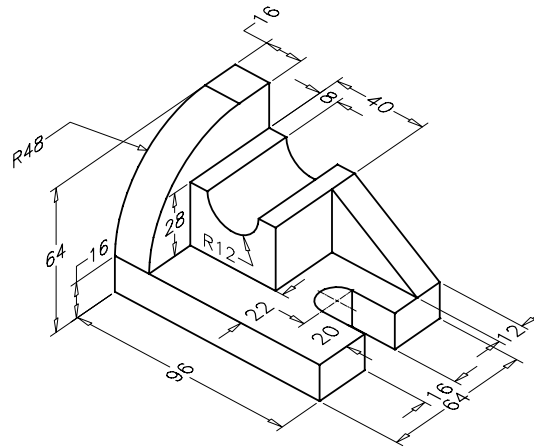
**Figure 3-115** Area to be presspulled with closed boundary inside it



**Figure 3-116** The model after the presspull operation is performed

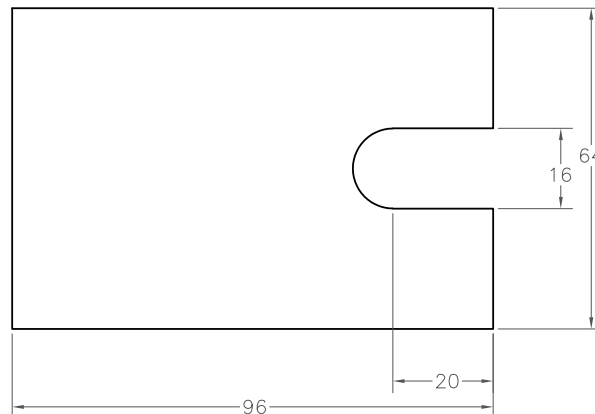
## Example 2

In this example, you will create the solid model shown in Figure 3-117.



**Figure 3-117** Solid model for Example 2

1. Start a new file using the *acad3D.dwt* template.
2. Set the drawing limits of the workspace to 120,120. Next, type ZOOM or Z at the command prompt and select **All** option from the options displayed.
3. Set the view to SE Isometric by using the ViewCube. Then, right-click on the ViewCube and choose the **Parallel** option.
4. Switch on the ortho mode. Using lines and arc, create the base of the model with the dimensions shown in Figure 3-118.



**Figure 3-118** Base for the solid model

- Choose the **Region** tool from the **Draw** panel in the **Home** tab and follow the prompt sequence given next to convert the sketch drawn into a region.

Select objects: *Select the complete base.*

Select objects:

1 loop extracted.

1 Region created.



#### Note

*You can also use the **Polyline** tool to create this sketch. In that case, you do not need to convert it into a region.*

- Choose the **Extrude** tool from **Home > Modeling > Solid Creation** drop-down and follow the prompt sequence given next to extrude the region.

Current wire frame density: ISOLINES=4, Closed profiles creation mode = Solid

Select objects to extrude or [MOde]: \_MO Closed profiles creation mode [Solid/Surface]

<Solid>: \_SO

Select objects to extrude or [MOde]: *Select the region*

1 found

Select objects to extrude or [MOde]:

Specify height of extrusion or [Direction/Path/Taper angle/Expression]: **16**

- Change the visual style to Wireframe by choosing the **Wireframe** option from the **Visual Styles** drop-down list in the **In-canvas Viewport control**.
- Choose the **Wedge** tool from **Home > Modeling > Solid Primitives** drop-down and follow the prompt sequence given next to create the next feature.

Specify first corner or [Center]: *Pick a point on the screen.*

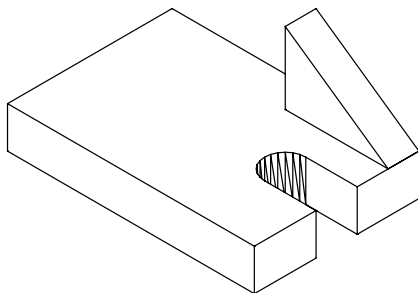
Specify other corner or [Cube/Length]: **L**

Specify length: **40**

Specify width: **12**

Specify height or [2Point]: **28**

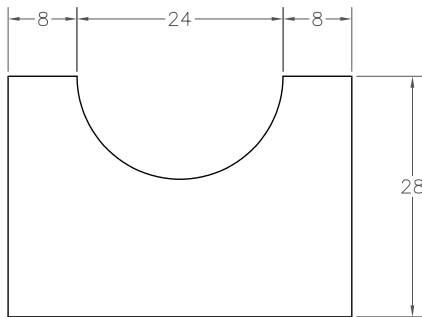
- Move this wedge and align it with the base. Use the **Vertex** option of the **3D Object Snap** to snap the vertex. The model after applying the **Hidden** visual style is shown in Figure 3-119.



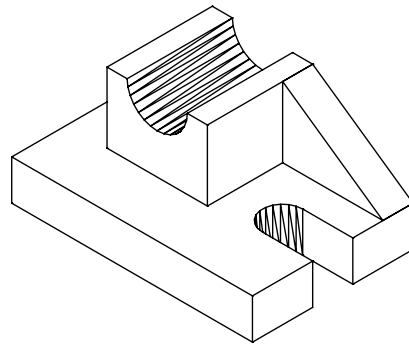
**Figure 3-119** Wedge aligned with the base

10. Orient the view to **Front** by clicking on **Front** in the ViewCube and choose **WCS > New UCS** from the drop-down list below it; you are prompted to specify the origin.
11. Enter **V** at the **Specify origin of UCS or [Face/Named/Object/Previous/View/World/X/Y/Z/ZAxis] <World>** prompt and press ENTER.
12. Draw the profile shown in Figure 3-120 at any place in the drawing area and then convert it into a region.
13. Choose the **Extrude** tool from **Home > Modeling > Solid Creation** drop-down and extrude the region to a depth of 42 units.
14. Move this extrude feature and align it with the wedge feature. Use the **Vertex** option of the **3D Object Snap** to snap the vertex of the wedge feature.

The SE isometric view of the model after aligning the extrude feature is shown in Figure 3-121.

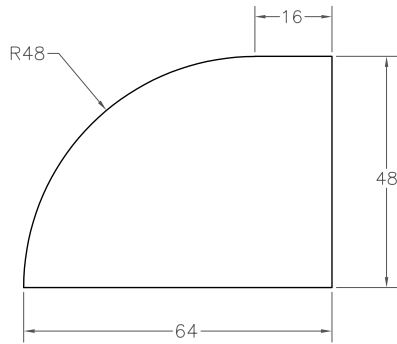


**Figure 3-120** The region to be extruded

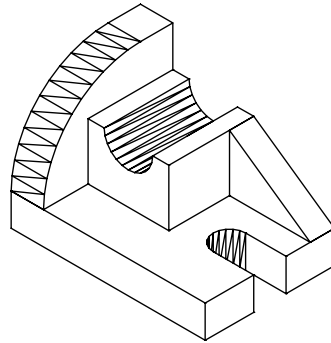


**Figure 3-121** Solid aligned with the base

15. Orient the view to **Right** by clicking **Right** in the ViewCube and choose **WCS > New UCS** from the drop-down list below it; you are prompted to specify the origin.
16. Enter **V** at the **Specify origin of UCS or [Face/Named/Object/Previous/View/World/X/Y/Z/ZAxis] <World>** prompt and press ENTER.
17. Draw the profile shown in Figure 3-122 at any place in the drawing area and then convert it into a region.
18. Extrude the region to a depth of 16 units and then move it so that it is properly aligned with the base, refer to Figure 3-123.



**Figure 3-122** The region before extrusion



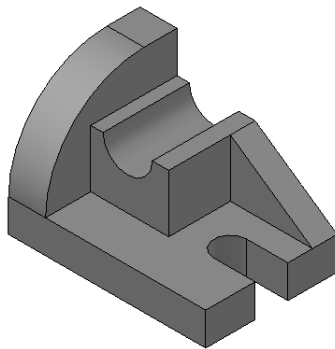
**Figure 3-123** Solid aligned with the base

19. Choose the **Solid, Union** tool from the **Solid Editing** panel and follow the prompt sequence given next:

Select objects: *Select all objects.*

Select objects:

20. Change the visual style by selecting the **Shades of Gray** option from the **Visual Styles** drop-down list in the **In-canvas Viewport Controls**. The final solid model should look similar to the one shown in Figure 3-124.



**Figure 3-124** Solid model for Example 2



### Example 3

In this example, you will create the solid model shown in Figure 3-125.

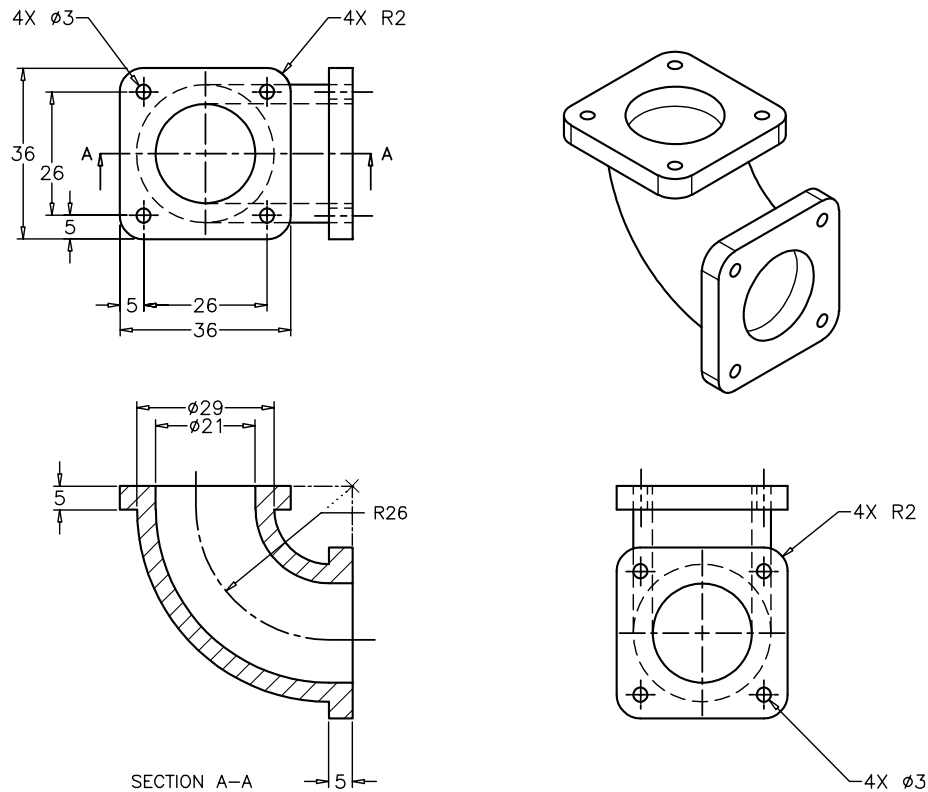


Figure 3-125 Solid model for Example 3

1. Start a new file using the *acad3D.dwt* template.
2. Set the drawing limits of the workspace to 75,75. Next, type **ZOOM** or **Z** at the command prompt and select the **All** option from the options displayed.
3. Orient the view to Left by choosing **Left** in the ViewCube and choose **WCS > New UCS** from the drop-down list below it; you are prompted to specify the origin.
4. Enter **V** at the **Specify origin of UCS or [Face/Named/Object/Previous/View/World/X/Y/Z/ZAxis] <World>** prompt and press ENTER.
5. Right-click on the ViewCube and choose the **Parallel** option.
6. Draw the cross section and path of the sweep feature, as shown in Figure 3-126.

7. Choose the **Region** tool from the **Draw** panel in the **Home** tab and follow the prompt sequence given next to convert the sketch into a region.

Select objects: *Select both the circles.*

Select objects:

2 loop extracted.

2 Region created.

8. Choose the **Solid, Subtract** tool from the **Solid Editing** panel in the **Home** tab and follow the prompt sequence:

Select objects: *Select the region of diameter 29.*

Select objects:

Select solids, surfaces, and regions to subtract.

Select objects: *Select the region of diameter 21.*

Select objects:

9. Change the visual style to Wireframe by selecting the **Wireframe** option from the **Visual Styles** drop-down list in the **View** panel.

10. Choose the **Sweep** tool from **Home > Modeling > Solid Creation** drop-down and follow the prompt sequence given next to sweep the region along the path.

Current wire frame density: ISOLINES=4, Closed profiles creation mode = Solid

Select objects to sweep or [MMode]: *\_MO* Closed profiles creation mode [Solid/Surface]

<Solid>: *\_SO*

Select objects to sweep or [MMode]: *Select the region created in Step 8*

1 found

Select objects to sweep or [MMode]:

Select sweep path or [Alignment/Base point/Scale/Twist]: *Select the arc created in Step 6.*

11. Set the view to **SW Isometric** by choosing the appropriate hotspot in the ViewCube. Also, select the **Realistic** option in the **Visual Styles** drop-down list in the **View** panel. The resulting model should look similar to the one shown in Figure 3-127.

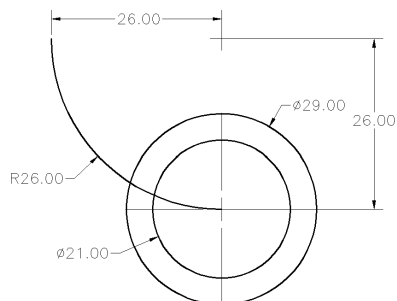


Figure 3-126 Sketch for base pipe feature

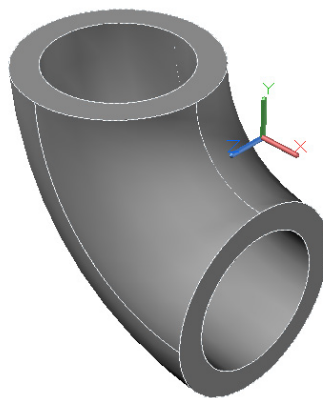
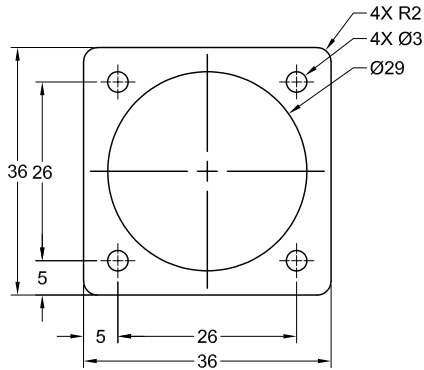
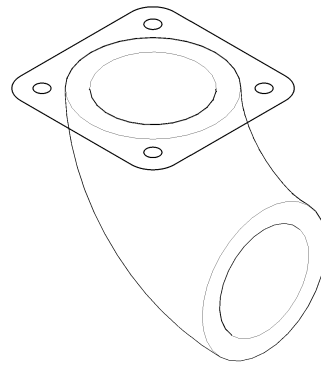


Figure 3-127 Resulting sweep feature

12. Choose the **Top** option from the **3D Navigation** drop-down in the **View** panel and draw the sketch with the dimensions shown in Figure 3-128.
13. Change the view to **SW Isometric**. The model after drawing the sketch and turning off the dimension is shown in Figure 3-129.



**Figure 3-128** Sketch for the area to Press/Pull

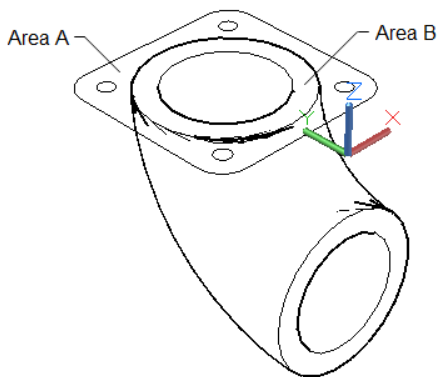


**Figure 3-129** Location of the sketch

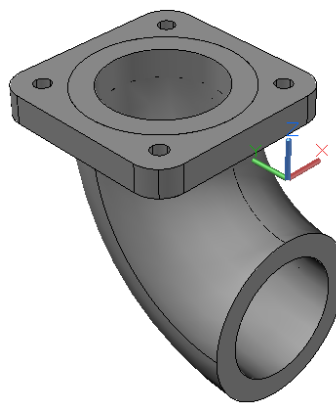
14. Using the **Region** and **Solid, Subtract** tools, create a region shown as Area A in Figure 3-130.
15. Choose the **Extrude** tool from **Home > Modeling > Solid Creation** drop-down and select the region created in previous step and press ENTER. Next, move the mouse in the upward direction, enter the value **5** at the Command prompt, and press ENTER.
16. Choose the **Presspull** tool and pull the area shown as Area B in Figure 3-130 by the same value as specified in Step 15. The resulting model should look similar to the one shown in Figure 3-131.
17. Similarly, create the flange for the other face of the pipe. The resulting model should be similar to the one shown in Figure 3-132.
18. Choose the **Solid Union** tool from the **Solid Editing** panel in the **Home** tab and follow the prompt sequence given next.

Select objects: *Select all objects.*

Select objects:

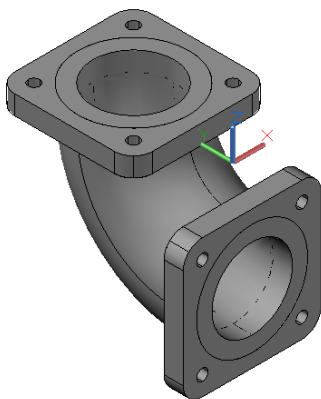


*Figure 3-130 Two areas to presspull*

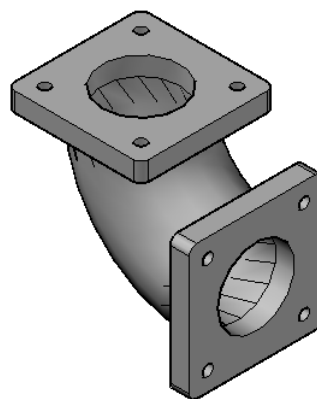


*Figure 3-131 Resulting model after Step 15*

The final solid model should look similar to the one shown in Figure 3-133.



*Figure 3-132 Resulting model after Step 16*



*Figure 3-133 Final model after Union*

## Self-Evaluation Test

Answer the following questions and then compare them to those given at the end of this chapter:

1. The \_\_\_\_\_ tool can be used to add as well as remove material from a model.
2. The \_\_\_\_\_ tool is used to generate a helical curve.
3. The number of paths for a loft feature cannot be more than \_\_\_\_\_.
4. At least \_\_\_\_\_ cross-sections are required to create a loft feature.
5. You can extrude the selected region about a path using the \_\_\_\_\_ option of the **Extrude** tool.

6. Open entities can be converted into regions. (T/F)
7. An ellipse can be converted into a polysolid. (T/F)
8. You can twist a cross-section while sweeping it. (T/F)
9. In AutoCAD, you can create a pyramid of maximum 42 sides. (T/F)
10. The **Cone** tool can be used to create a solid cone with a circular and an elliptical base. (T/F)

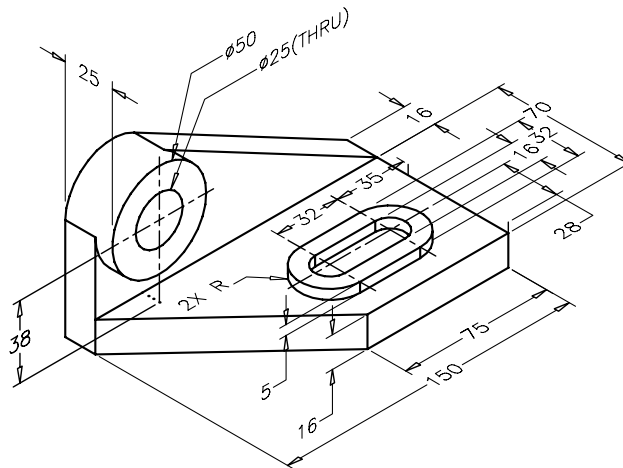
## Review Questions

Answer the following questions:

1. Which of the following values for the taper angle is used to taper the extruded model from the base?
  - (a) Positive
  - (b) Negative
  - (c) Zero
  - (d) None of these
2. Which of the following tools is used to create a cube?
  - (a) **Box**
  - (b) **Cuboid**
  - (c) **Polygon**
  - (d) **Cylinder**
3. Which of the following commands is used to check the interference between selected solid models?
  - (a) **INTERFERE**
  - (b) **INTERSECT**
  - (c) **INTERFERENCE**
  - (d) **CHECK**
4. For which of the following functions is the **Presspull** tool used?
  - (a) Add material
  - (b) Remove material
  - (c) Both add and remove material
  - (d) Neither add nor remove material
5. The \_\_\_\_\_ direction is known as the extrusion direction.
6. The \_\_\_\_\_ tool is used to create an apple-like structure.
7. The \_\_\_\_\_ tool is used to create a revolved solid.
8. Guides for the **Loft** tool should always \_\_\_\_\_ the cross-section.
9. The \_\_\_\_\_ option of the **Revolve** tool is used to select a 2D entity as the revolution axis.
10. You can revolve an open entity. (T/F)

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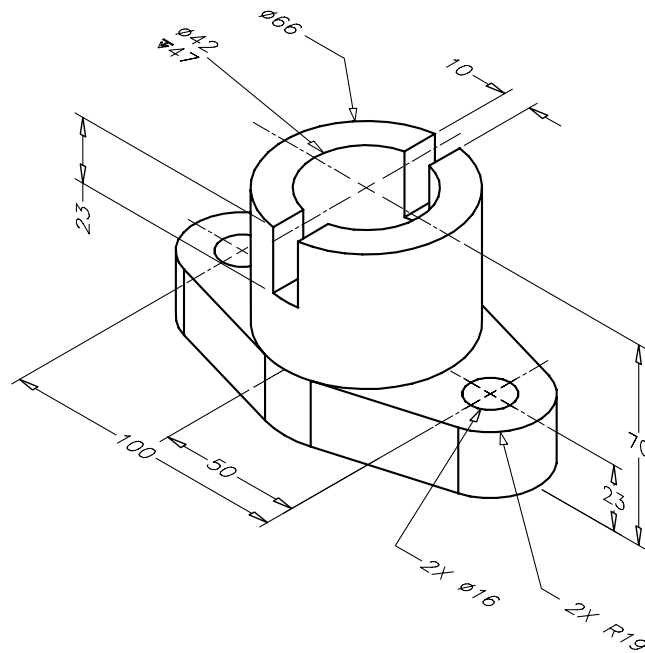
In this exercise, you will create the solid model shown in Figure 3-134. Assume the missing dimensions.



*Figure 3-134 Model for Exercise 1*

**Problem-Solving Exercise 1**

In this exercise, you will create the solid model with dimensions shown in Figure 3-135.



*Figure 3-135 Solid model for Problem-Solving Exercise 1*

**Answers to Self-Evaluation Test**

1. Presspull, 2. Helix, 3. one, 4. two, 5. Path, 6. F, 7. T, 8. T, 9. F, 10. T