AutoCAD® 2009 Tutorial
Second Level: 3D Modeling
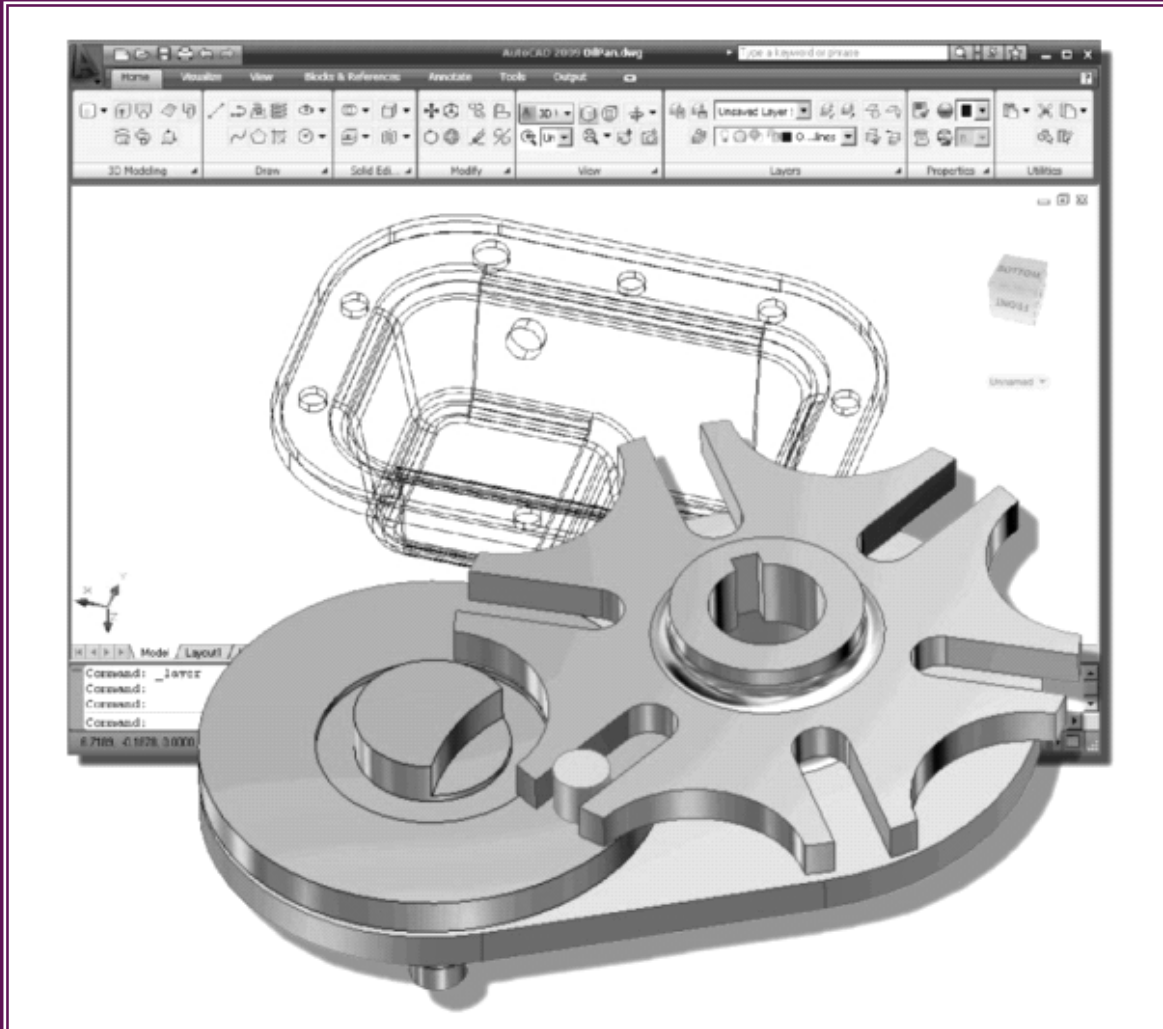
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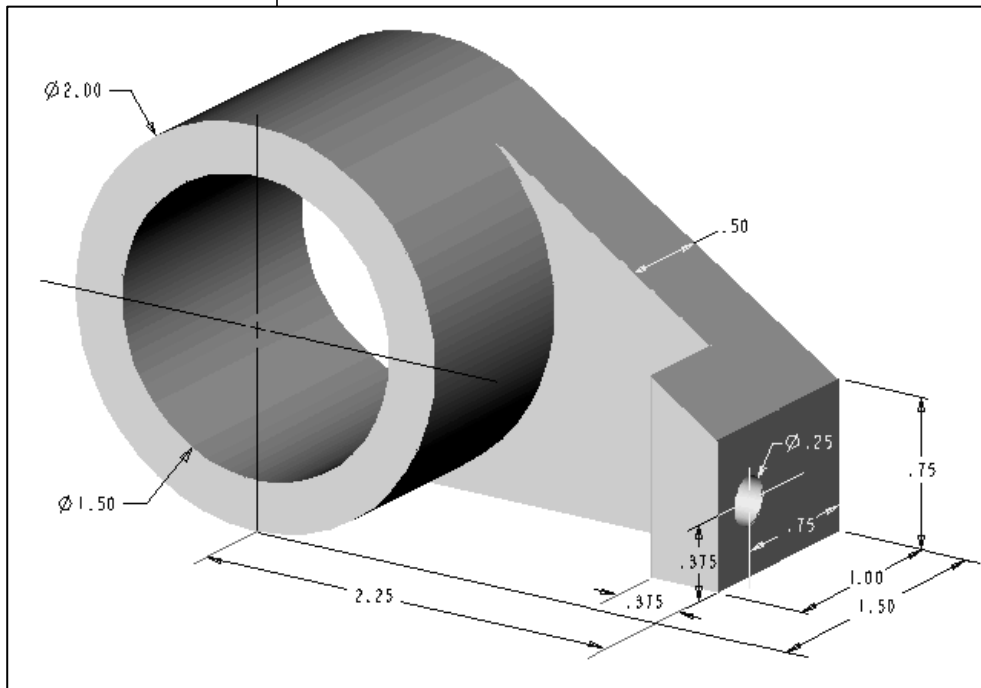
Chapter 5
3D Surface Modeling

Learning Objectives
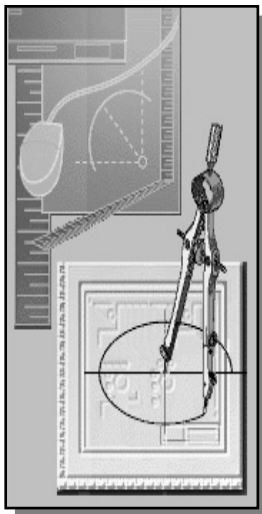
- **Create 3D Surface Models**
- **Understand and Apply the Different Surface Modeling Techniques**
- **Understand the Use of the 2D SOLID Command**
- **Understand the Use of 3D FACE Command**
- **Use the Hidden Edge Option**

Introduction

As illustrated in the previous chapters, there are no surfaces in a wireframe model; it consists only of points, lines and curves that describe the edges of the object. Surface modeling was developed to provide the surface information that is missing in wireframe modeling. Essentially, defining the skin of a design creates a surface model. Although it is possible to create a surface model without using a wireframe model, in most cases it is much easier to create a surface model on top of a wireframe model. In surface modeling, a wireframe model can be used to provide information about the edges and corners so that the desired faces can be easily positioned and placed.

Surface modeling is more sophisticated than wireframe modeling in that surface modelers define not only the edges of 3D objects, but also the surfaces. Surface modeling provides hiding, shading, and rendering capabilities that are not available in wireframe modeling. Surface models do not provide the physical properties that solid models provide, such as mass, weight, center of gravity, and so on.

The AutoCAD surface modeler defines faceted surfaces using a filled polygon. The created faces of surface models are only planar, which means the surface models can only have approximate curved surfaces. It is important to note that the AutoCAD surface modeler does not create true curved surfaces. To differentiate these two types of surfaces, faceted surfaces are called **meshes** in AutoCAD. Because of the use of faceted approximation on true curved surfaces, the computer requirements of most faceted surface modelers are typically much less than that of solid modelers. Faceted surface modeling usually provides reasonably good representations of 3D designs with fast rendering and shading capabilities. Faceted surface models are also useful for creating geometry with unusual surface patterns, such as a 3D topographical model of mountainous terrain.

AutoCAD® 2009 provides three basic methods for creating surfaces – the **2D Solid**, **3D Face** and **Region** commands. The three commands were developed parallel to the historical development of the different types of computer modelers.

- **2D Solid**: The first generation surface command available in AutoCAD. Used mostly to fill an area in the sketch plane of the current UCS. This type of surface is not a true 3D surface.

- **3D Face**: Creates a true 3D planar surface (allowing X, Y and Z coordinates) of three-sided or four-sided shape. This is the type of surface developed primarily for creating faceted surface models.

- **Region**: Creates a 2D surface of arbitrary shape from existing 2D entities. This command creates the most flexible and the most complicated type of surface available in AutoCAD. This command was developed to allow manipulation of 2D surfaces using one of the solid modeling construction techniques, namely, the **Constructive Solid Geometry** method.

Although all three commands can be used to create planar surfaces, the resulting surfaces are not equal. In fact, the three commands are developed for specific tasks in mind. The **2D Solid** command is mostly used in 2D drawings to create 2D filled area and the **Region** command is designed so that general 2D shapes can be easily transformed into solid models. The **3D Face** command is the only one that is designed specifically for surface modeling and therefore it is the most suitable for such tasks. The use of the **2D Solid** and **Region** commands in 3D surface modeling can be somewhat awkward and at times very difficult. Note that the use of the **Region** command will be focused on in the solid modeling chapters of this text.

As one can imagine, sketching each surface manually can be very time consuming and tedious. AutoCAD also provides additional tools for more advanced surface modeling, such as **Tabulated surfaces**, **Ruled surfaces** and **Revolved surfaces**. These tools are basically automated procedures, which can be used to define and create multiple copies of planar surfaces in specific directions. The principles and concepts used by these tools are also used in creating solid models, which are covered in chapter six through chapter eight of this text. You are encouraged to re-examine these commands after you have finished the solid modeling chapters.

In this chapter, the general procedures to create surface models are illustrated. The use of the **2D Solid** and **3D Face** commands are illustrated and differences discussed. We will also demonstrate the use of the more advanced surface modeling tools. Two wireframe models, which were created in the previous chapters, will be converted into surface models.
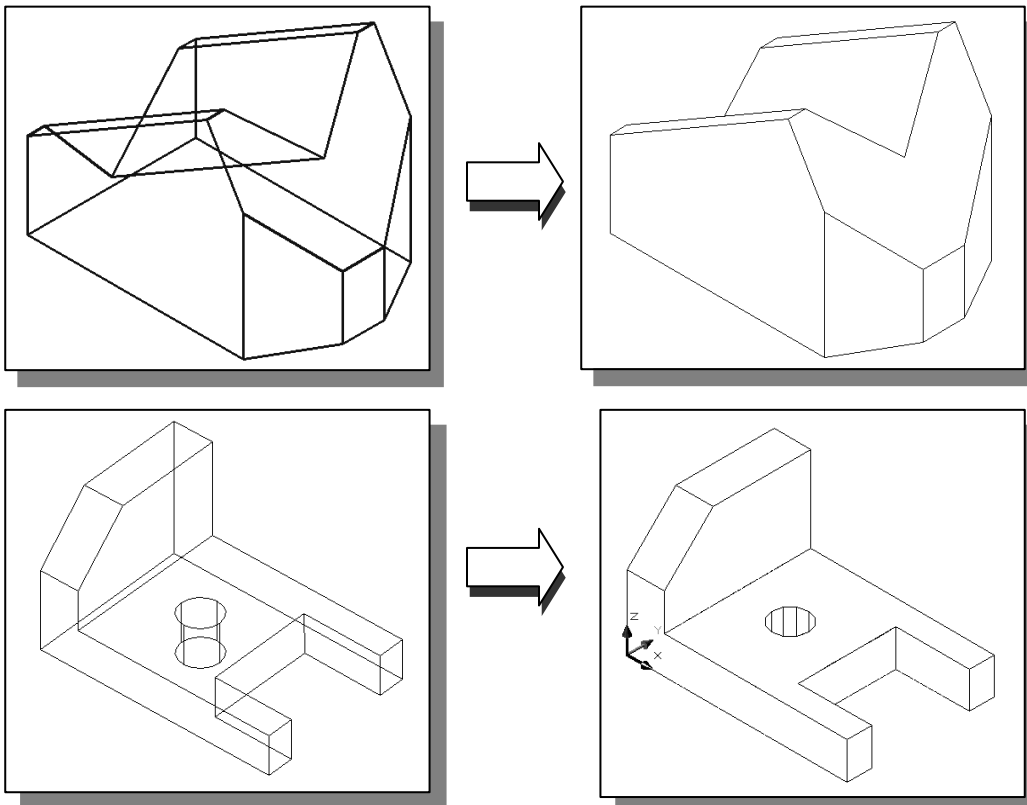
Starting Up AutoCAD® 2009

1. Select the **AutoCAD 2009** option on the *Program* menu or select the **AutoCAD 2009** icon on the *Desktop*.

2. In the *AutoCAD Today* startup dialog box, select the **Open a Drawing** icon with a single click of the left-mouse-button.

3. Click on the ***V-block.dwg*** filename to open the *V-block* wireframe model that was created in the previous chapter. (Use the Browse option to locate the file if it is not displayed.)
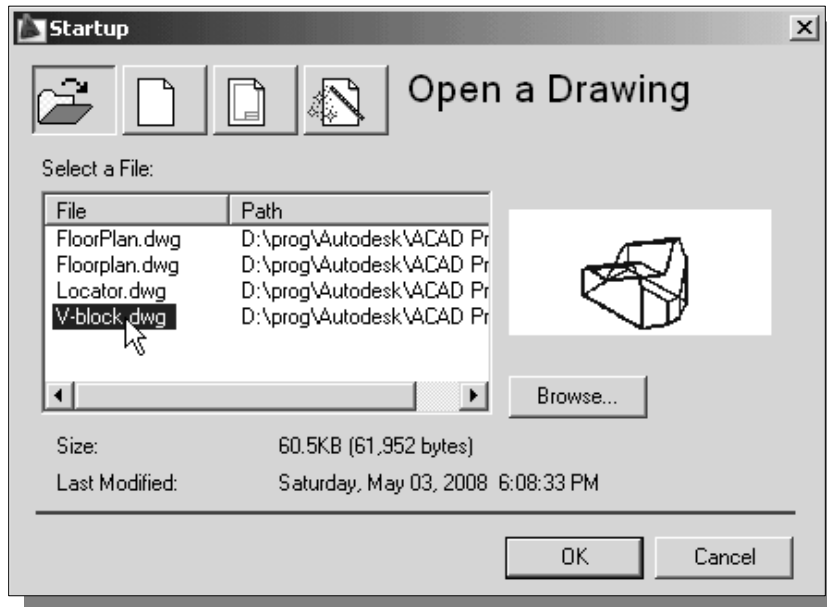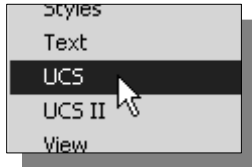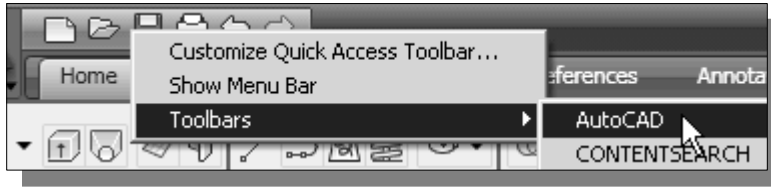

*   The *V-block* wireframe model is retrieved and displayed in the graphics window.
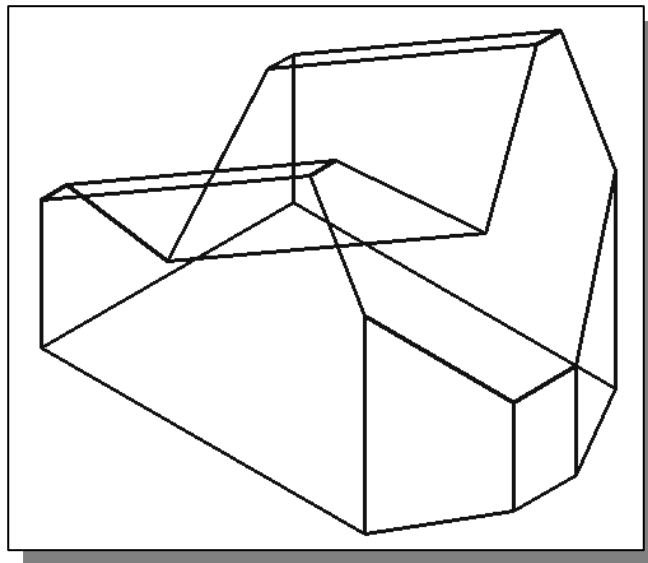
The UCS Toolbar and the Meshes Commands

1. Move the cursor on any icon in the *Standard* toolbar area and **right-mouse-click** once to display a list of options. Select **Toolbars → AutoCAD**.

2. Select **UCS**, with the left-mouse-button, to display the *UCS* toolbar on the screen.

➢ The options available in the *UCS* toolbar allow us to quickly orient and align the UCS.
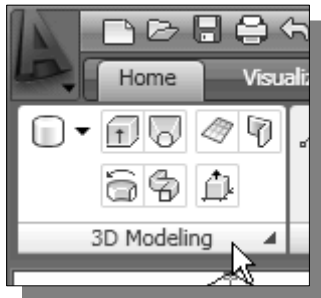
3. Click on the Title area of the *3D Modeling Toolbar* to show the addition commands available

Surface Modeling Commands
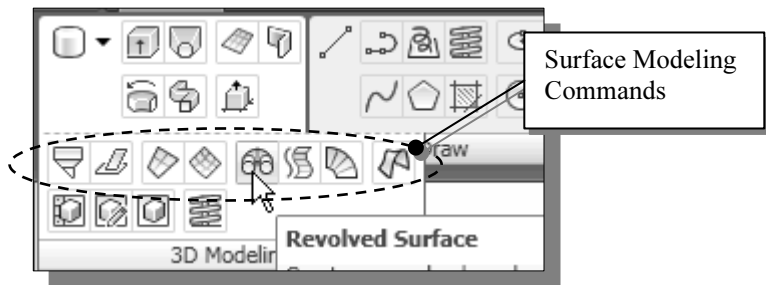
- Note that eight surface modeling commands are available to create Meshes. On your own, move the cursor on top of the different commands and read the brief description of the commands.

Creating a Surface Using the 2D Solid Command

➢ The first generation surface available in AutoCAD is used to fill an area in the sketch plane of the current UCS. It is therefore necessary to properly orient the UCS prior to using the 2D Solid command.
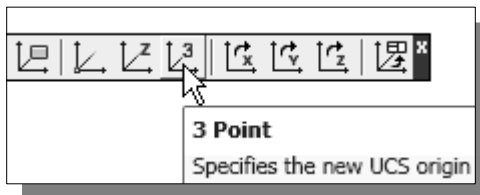
1. Select the **3 Point UCS** icon in the *UCS* toolbar.

3 Point
Specifies the new UCS origin

- The **3 Point UCS** option allows us to specify the new X-axis and Y-axis directions to align the UCS.
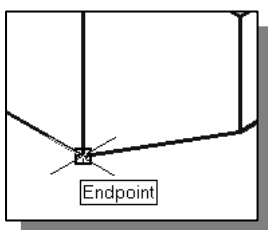
2. In the command prompt area, the message "*Specify new origin point<0,0,0>:*" is displayed. Pick the **lower right corner** of the front face of the wireframe model as shown.
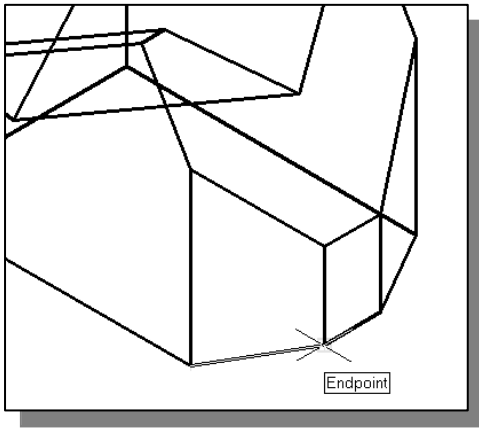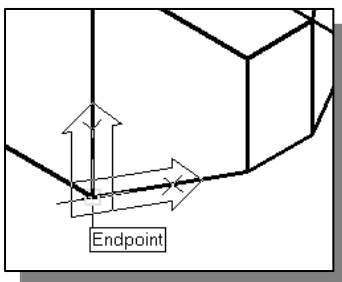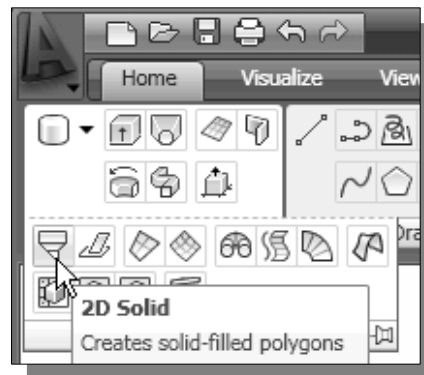
Endpoint

3. In the command prompt area, the message "*Specify point on positive portion of X-axis:*" is displayed. Pick the adjacent corner toward the right side of the model as shown.
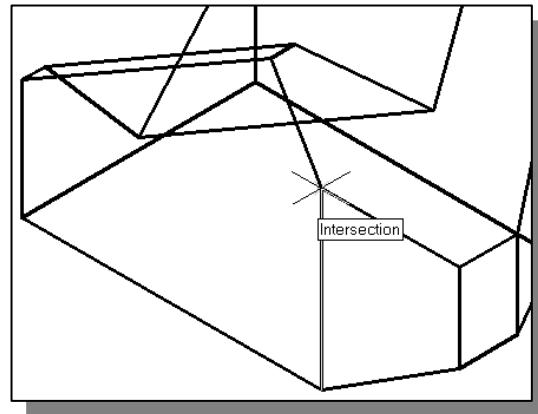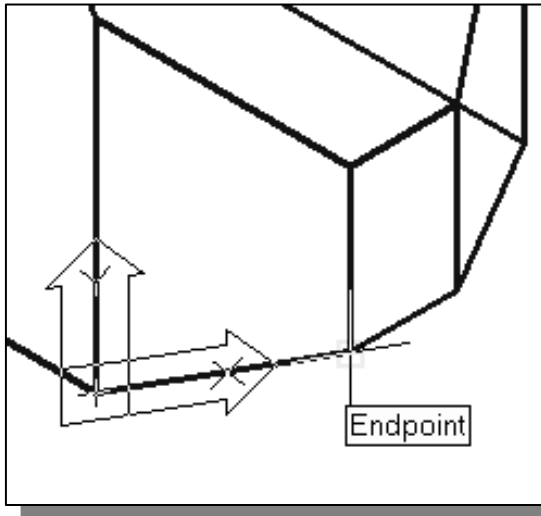
4. In the command prompt area, the message "*Specify point on positive portion of X-axis:*" is displayed. Pick the right corner of the inclined plane as shown.
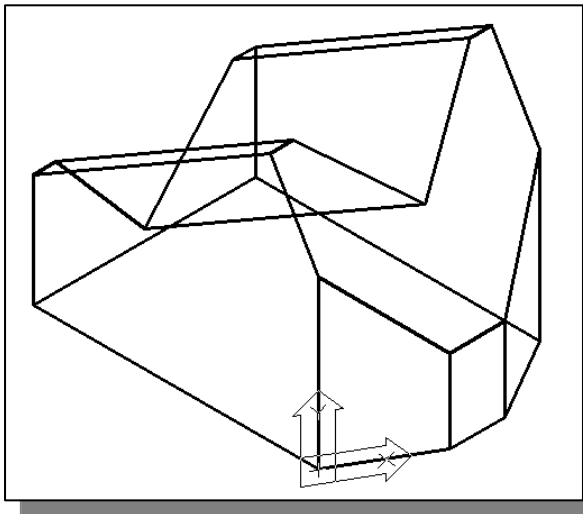
- The new UCS is aligned to the vertical inclined plane as shown.

5. In the *3D Modeling* toolbar, select **2D Solid** as shown.

2D Solid
Creates solid-filled polygons

6. Place the first corner point of the 2D solid at the origin of the new UCS.

Endpoint

7. In the command prompt area, the message "*Specify second point:*" is displayed. Pick the bottom right corner of the inclined plane as shown.
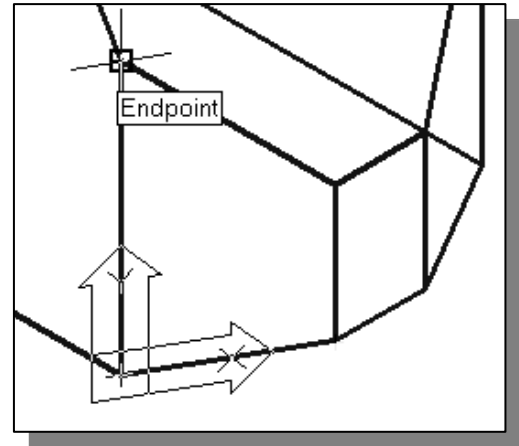
Endpoint

8. In the command prompt area, the message "*Specify third point:*" is displayed. Pick the corner directly above the origin of the UCS as shown.

- The 2D Solid command requires the third point to be specified diagonally opposite to the second point. This seemly strange way of specifying the third corner was established when the 2D Solid command was first introduced back in the mid-1980s. Note that the **3D Face** command, the second-generation surface command in AutoCAD, does not follow this convention.
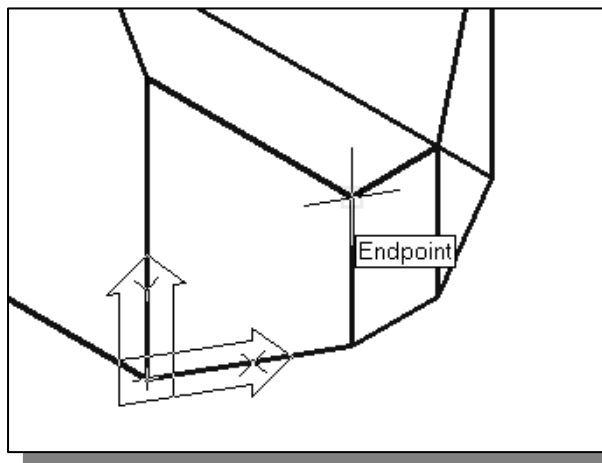
Endpoint

9. In the command prompt area, the message "*Specify fourth point or [Exit]:*" is displayed. Pick the corner directly above the second point we selected as shown in the figure.

10. Inside the graphics window, **right-mouse-click once** to end the 2D Solid command.

- The 2D Solid command allows the creation of three-sided or four-sided filled polygons, which can be used to represent faces of surface models. Note that in the above steps, we could accept the three-sided polygon after defining the third corner.

Using the Visual Styles Toolbar
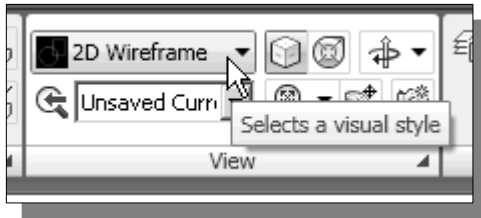
1. Move the cursor to the *View* toolbar panel and **left-click** on the downward triangle to display a list of available options.

   ❖ Five visual styles are available.
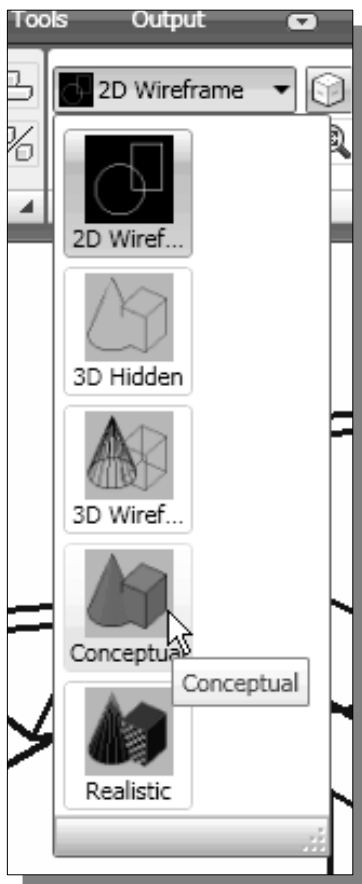
- **2D Wireframe**: Displays the objects using lines and curves to represent the boundaries of objects created. Linetypes and lineweights are visible with this option. Note that this is the default AutoCAD display mode.

- **3D Hidden**: Displays the objects using the 3D wireframe representation with lines that are located behind surfaces and solids removed.

- **3D Wireframe**: Displays the objects using lines and curves to represent the boundaries of objects created. Displays a shaded 3D user coordinate system (UCS) icon. Note that linetypes and lineweights are not visible with this option.

- **Conceptual Visual Style**: Creates a shaded image of polygon faces and solids that uses the Gooch face style, a transition between cool and warm colors rather than dark to light. The effect is less realistic, but it can make the details of the model easier to see.

- **Realistic Visual Style**: Creates a shaded image of polygon faces and solids that gives the objects a smooth and realistic appearance.
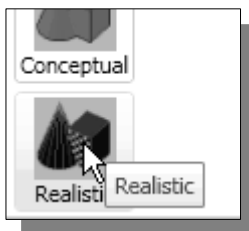
2. Click on the **Realistic Visual Style** icon to display the shaded image of the model.
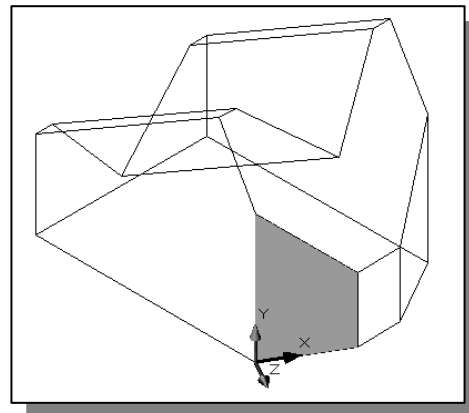
❖ There exists only one surface in our model. The surface was created with the 2D Solid command.
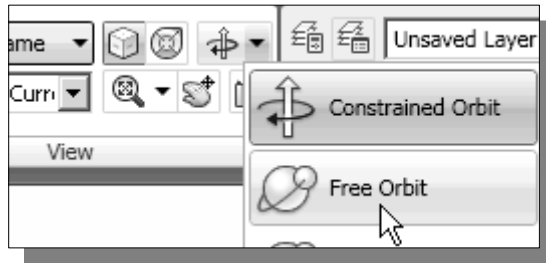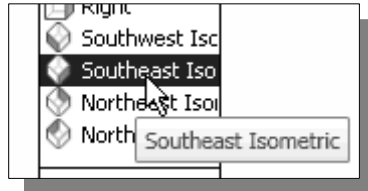
3. Select **Free Orbit** in the *View* toolbar as shown.
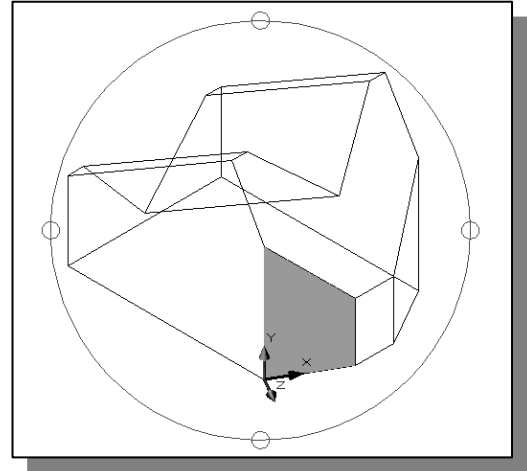
4. Inside the *arcball*, press down the left-mouse-button and drag it to rotate the model freely in 3D space. Observe the display of the shaded surface in contrast to the 3D wireframe edges that are located behind it.
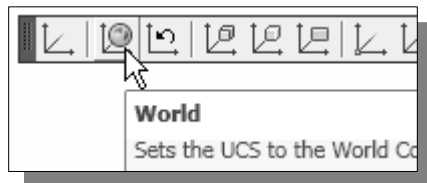
5. In the *UCS* toolbar, select the **World UCS**. This option resets the UCS to align to the world coordinate system.

6. On your own, reset the display to the SE Isometric View before continuing to the next section.

Creating a Surface Using the 3D Face Command

*   The second generation of surface command made available in AutoCAD was the **3D Face** command. The 3D Face command can be used to create true 3D planar surfaces by allowing the X, Y and Z coordinates of the corners to be selected independently of the current UCS. The created polygon can be a three-sided or four-sided shape. This command is the primary construction tool for surface modeling in AutoCAD.
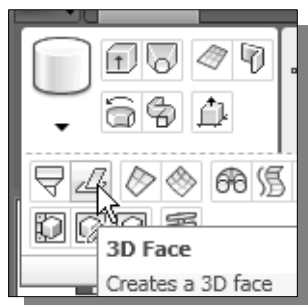
1. In the *3D Modeling* toolbar, select **3D Face** as shown.

2. In the command prompt area, the message "*_3dface Specify first point or [invisible]:*" is displayed. Pick the lower right corner of the vertical inclined face of the model as shown.
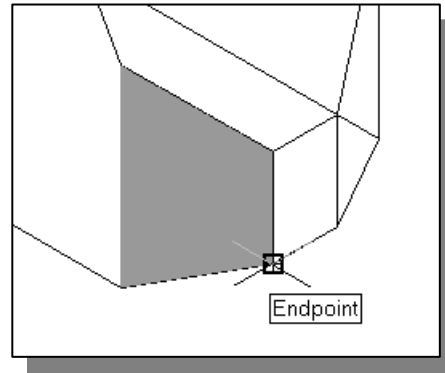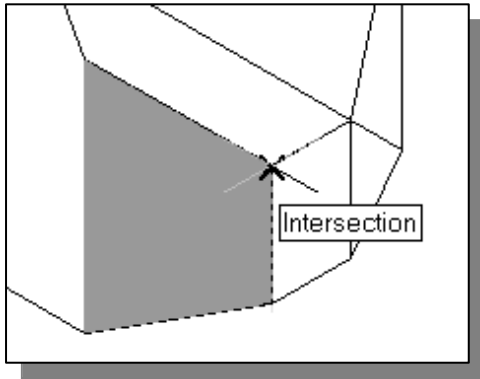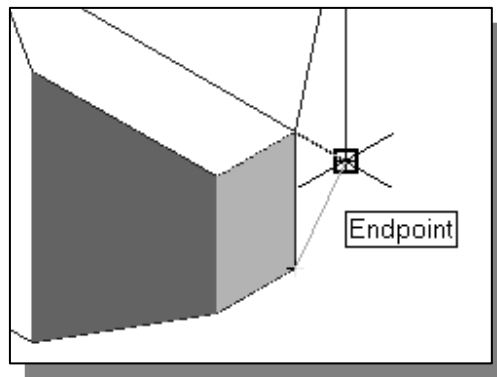
3. In the command prompt area, the message "*Specify second point or [invisible]:*" is displayed. Pick the adjacent corner above the previous selected corner of the vertical inclined face as shown.
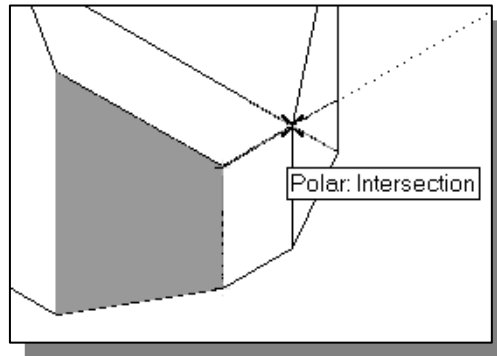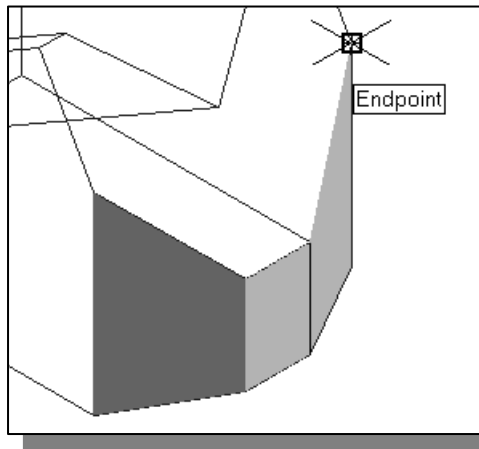
4. In the command prompt area, the message "*Specify third point or [invisible]:*" is displayed. Pick the adjacent corner of the right vertical face of the model as shown.
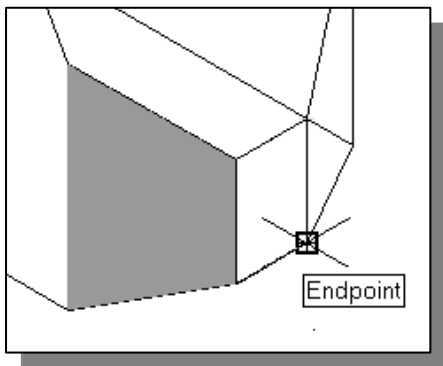
5. In the command prompt area, the message "*Specify fourth point or [invisible] <Create three-sided face>:*" is displayed. Pick the corner below the last selected corner as shown.

6. In the command prompt area, the message "*Specify third point or [invisible] <exit>:*" is displayed. Pick the back corner of the model as shown.

7. In the command prompt area, the message "*Specify fourth point or [invisible] <Create three-sided face>:*" is displayed. Pick the back corner of the model as shown.

- Note that this surface is created independent of the UCS and two corners of the previous face were used to position this face.

8. Inside the graphics window, right-mouse-click to activate the option menu and select **Enter** with the left-mouse-button to end the 3D Face command.
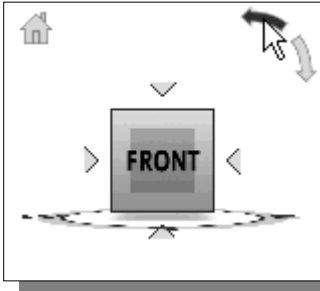
The ViewCube

The *ViewCube* is a 3D navigation tool that appears when the 3D graphics system is enabled. With the *ViewCube*, you can switch between standard and isometric views.
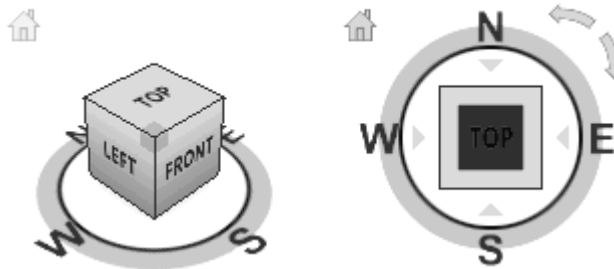
Once the ViewCube is displayed, it is shown in one of the corners of the graphics window over the model in an inactive state. The ViewCube also provides visual feedback about the current viewpoint of the model as view changes occur. When the cursor is positioned over the ViewCube, it becomes active and allows you to switch to one of the available preset views, roll the current view, or change to the Home view of the model.
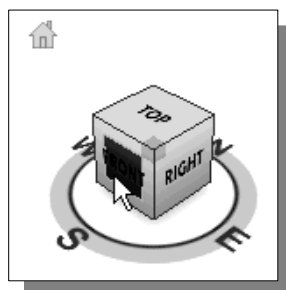
1. Move the cursor over the ViewCube and noticed the different sides of the ViewCube become highlighted and can be activated.

2. Single left-mouse-click when the Front Side is activated as shown. The current view is set to viewing the Front side.
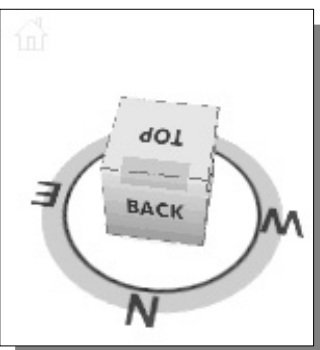
3. Move the cursor over the Counter Clockwise Arrow of the ViewCube and noticed the orbit option become highlighted.

4. Single left-mouse-click to activate the Counter Clockwise option as shown. The current view is orbitd 90 degrees, we are still viewing the Front side.
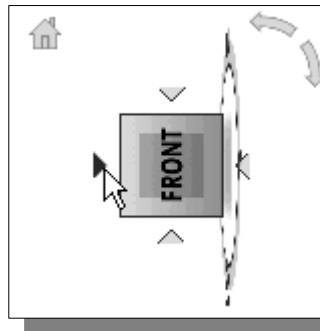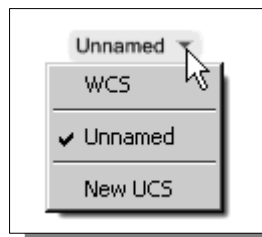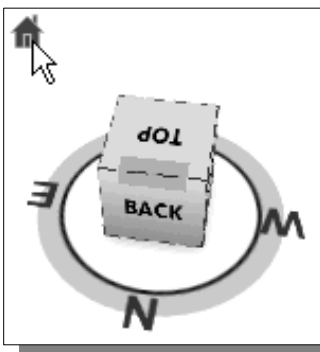
5. Move the cursor over the Left Arrow of the ViewCube and noticed the orbit option become highlighted.

6. Single left-mouse-click to activate the Left Arrow option as shown. The current view is now set to viewing the Top side.
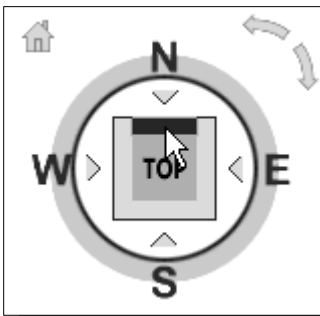
7. Move the cursor over the Top Edge of the ViewCube and noticed the roll option become highlighted.

8. Single left-mouse-click to activate the Roll option as shown. The view will be adjusted to roll 45 degrees.

9. Move the cursor over the *ViewCube* and drag with the left-mouse-button to activate the **Free Rotation** option.

➢ The orientation of the model can also be changed to base on either the UCS or the WCS by clicking on the coordinate setting option below the ViewCube as shown.

10. Move the cursor over the Home icon of the *ViewCube* and noticed the Home View option become highlighted.

11. Single left-mouse-click to activate the **Home View** option as shown. The view will be adjusted back to the default *SW Isometric View*.
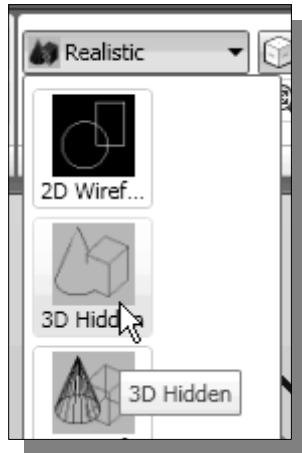
11. In the *Visual Styles* toolbar, click on the **3D Hidden** icon to display the model with hidden lines removed.
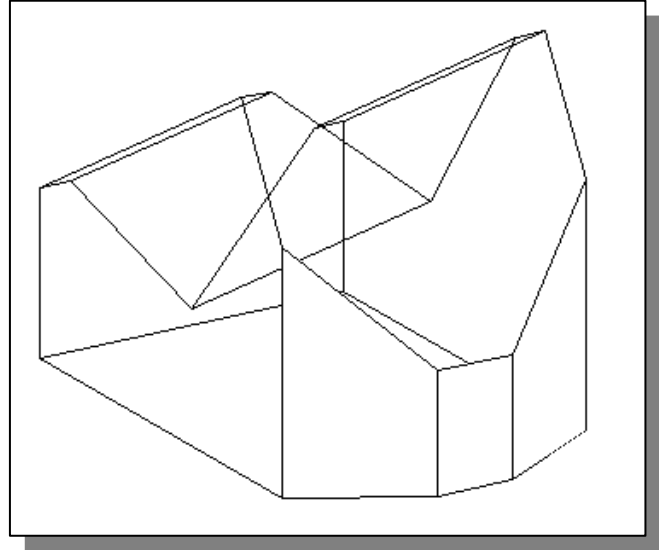
12. On your own, use the **ViewCube** to rotate the model and examine the constructed surface model.
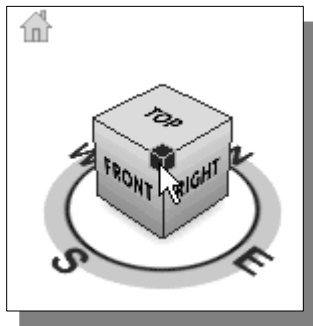
- Reset the display to SE Isometric View before proceed to the next section.

Creating a Surface of Irregular Shape

- The **3D Face** command allows us to create three-sided or four-sided polygons. For surfaces of irregular shape, the Invisible Edge option is available in conjunction with the 3D Face command. Note that the Invisible Edge option cannot be applied to polygons created by the 2D Solid command.
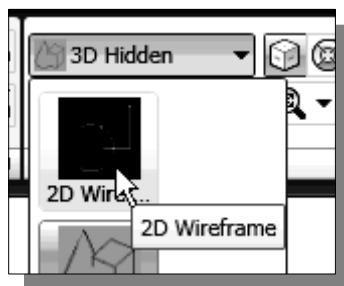
1. Select the **2D Wireframe** in the *Visual Styles* toolbar.

- The 2D Wireframe command resets the display to the default AutoCAD display mode

2. In the *3D Modeling* toolbar, select **3D Face**.
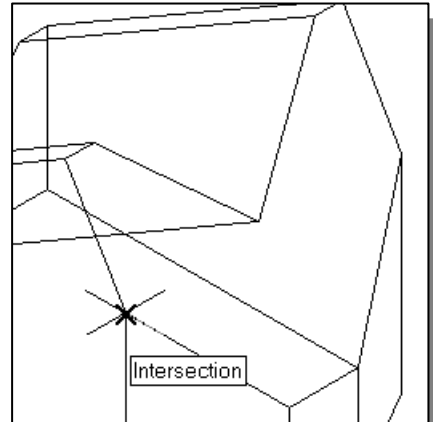
3. In the command prompt area, the message "*_3dface Specify first point or [invisible]:*" is displayed. Pick the top right corner of the model as shown.
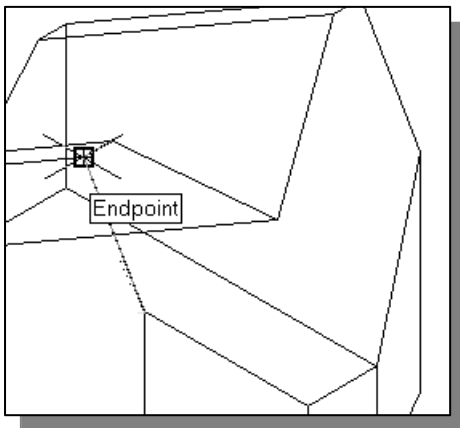
4. In the command prompt area, the message "*Specify second point or [invisible]:*" is displayed. Pick the top front corner of the model as shown.
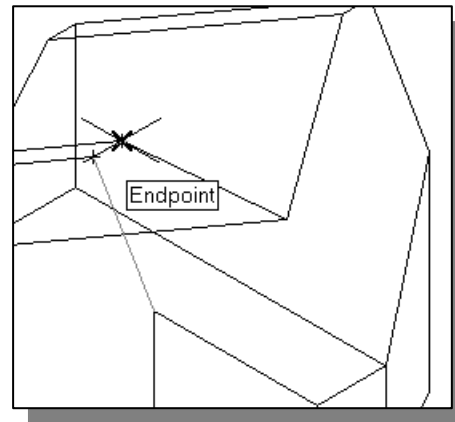
5. In the command prompt area, the message "*Specify third point or [invisible] <exit>:*" is displayed. Pick the top corner of the model adjacent to the previously selected corner as shown.
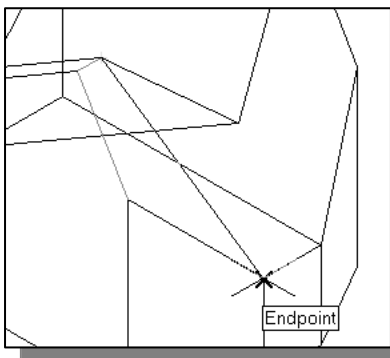
6. In the command prompt area, the message "*Specify fourth point or [invisible] <Create three-sided face>:*" is displayed. Pick the corner below the last selected corner as shown.
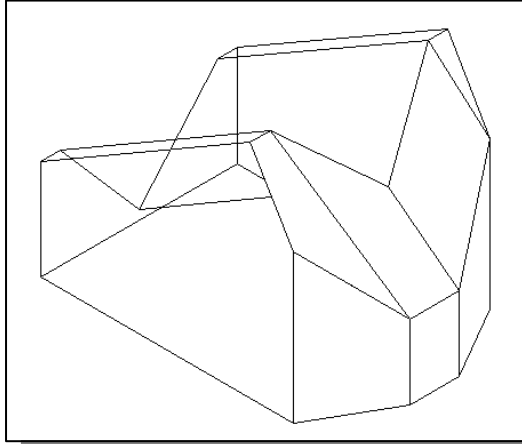
7. On your own, repeat the zigzagging pattern to define polygons until all corners of the inclined surface have been selected and additional polygons are created as shown in the figure. Note that the last polygon we created is a three-sided polygon.
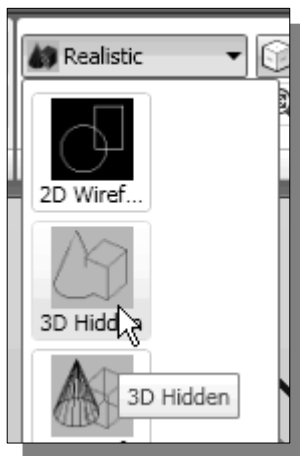
8. In the *Visual Styles* toolbar, click on the **3D Hidden** icon to display the model with hidden lines removed. Note that the edges of the polygons are displayed as shown.
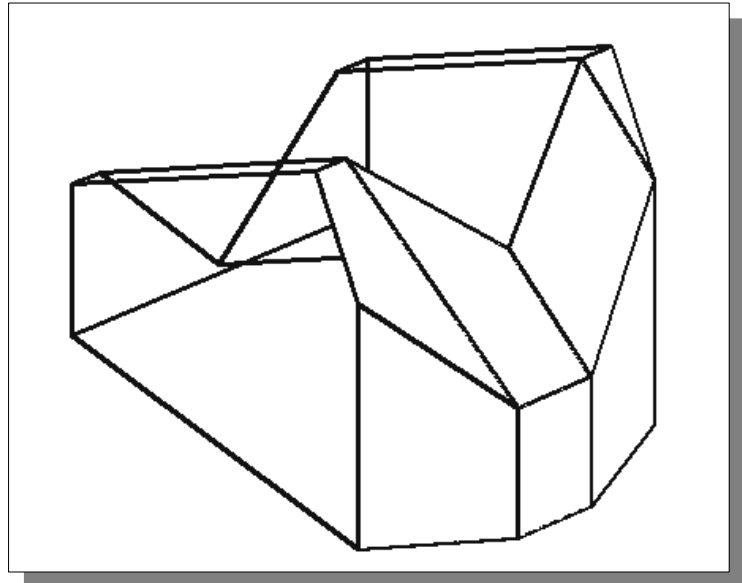

9. On your own, examine the model by selecting the different *Visual Styles*.
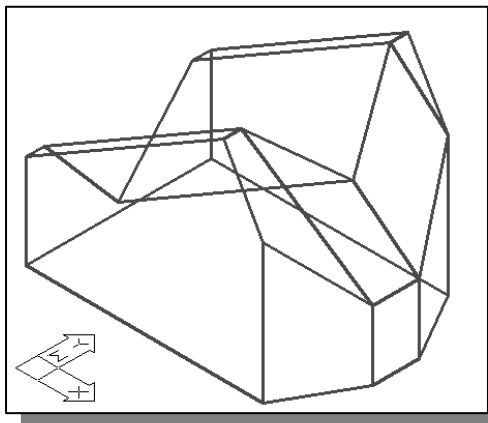
10. Rest the *Visual Styles* toolbar to **2D Wireframe,** the default AutoCAD display mode.

Using the Invisible Edge Option

- The Invisible Edge option is used to turn off the display of selected edges and therefore allow the adjacent polygons, created by the 3D Face command, to appear as being joined together.
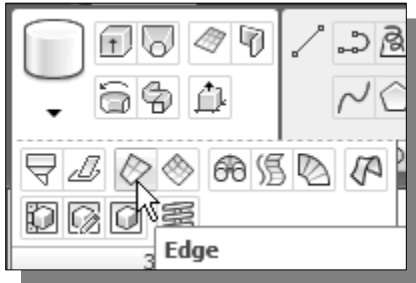
1. In the 3D Modeling toolbar, select **Edge** as shown in the figure.

2. In the command prompt area, the message "*Specify edge of 3dface to toggle visibility or [Display]:*" is displayed. Pick the three edges inside the inclined surface as shown.

3. Inside the graphics window, right-mouse-click to activate the option menu and select **Enter** to end the Edge command.
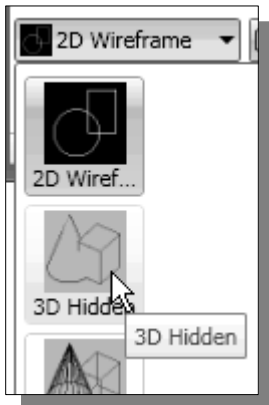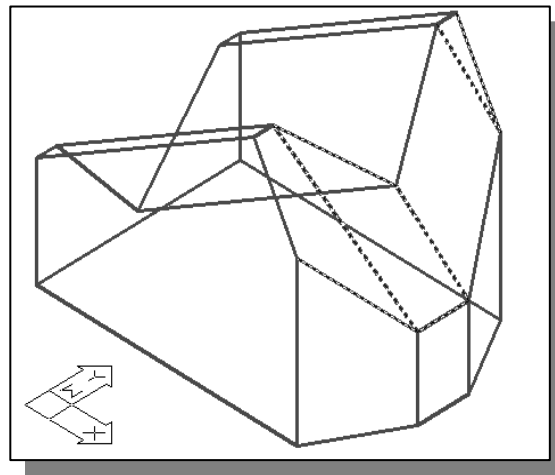
4. Set the *Visual Style* toolbar to **3D Hidden**.

5. On your own, examine the model by selecting the different *Visual Styles*.
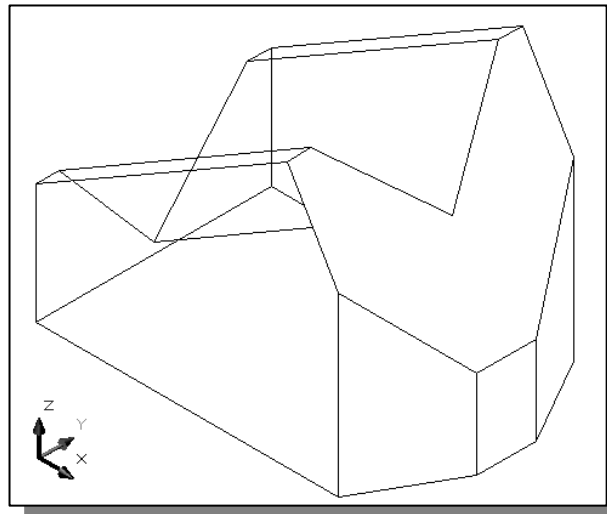
- The selected edges are removed from the display so that the face of the inclined surface of the model appears to be more realistic.

Moving with the Grip Editing Tools
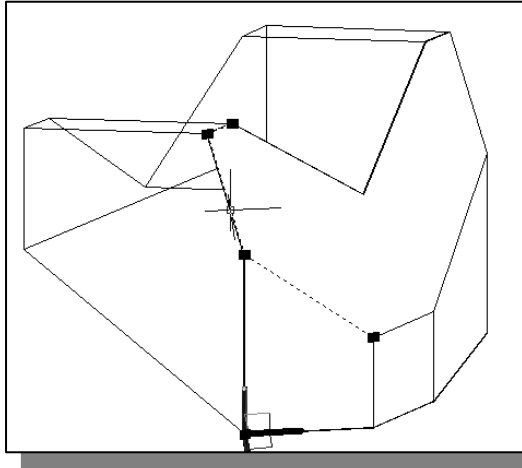
1. Select one of the 3D face we created by clicking on the front edge of the inclined surface as shown.

• Four grip points, the small rectangles displayed at the corners of the highlighted polygon, can be used to adjust the size and shape of the highlighted polygon.


Polar: 0.1889 < 0°
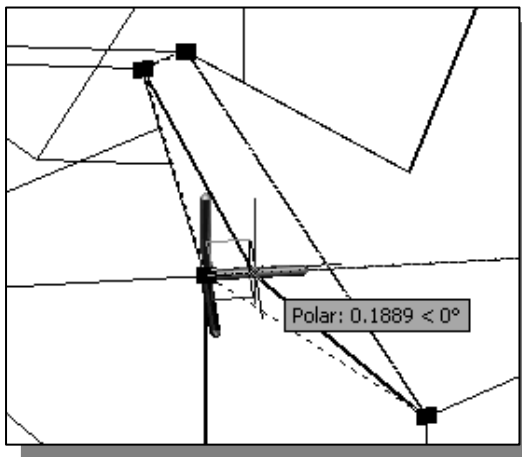
2. Move the cursor on one of the grip points. Notice the grip editing axes is automatically aligned to the grip point.

3. Click on one of the axes and drag with the left-mouse-button to move the grip point. (Clicking on the axis constrain the movement to the selected axis.)

4. Press the **[Esc]** key to deselect the highlighted entities.

➢ On your own, repeat the above steps and complete the surface model of the design.
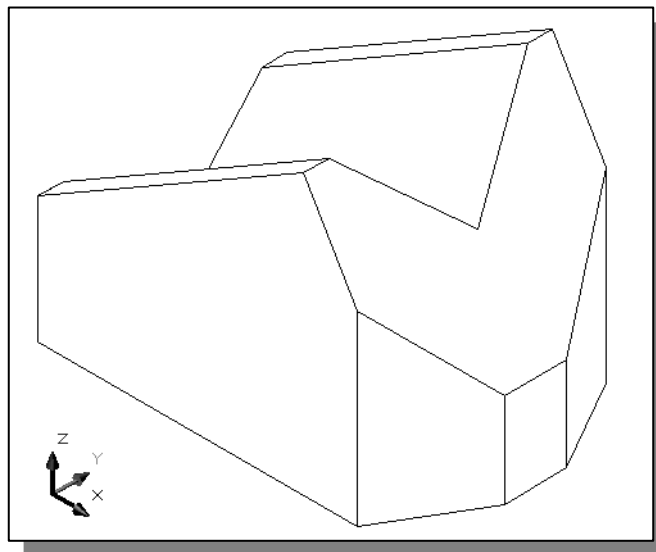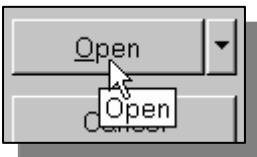
The *Locator* Wireframe Model
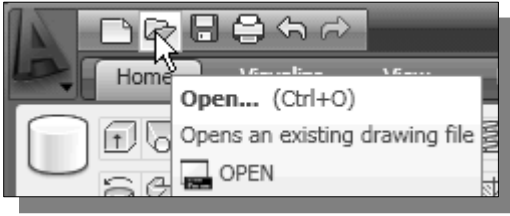
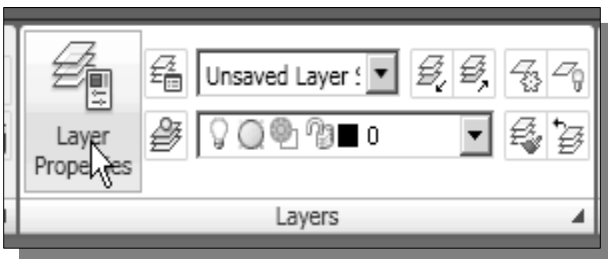1. Click on the **Open** icon in the *Standard* toolbar.

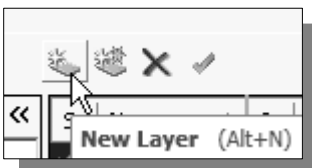2. In the *Select File* window, pick the *Locator* file that was created in Chapter 3.
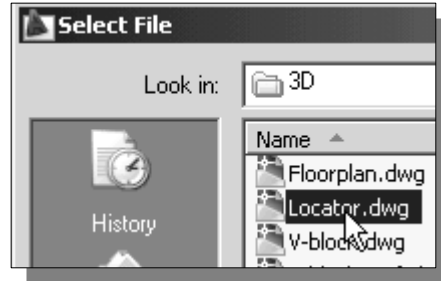
3. Click **Open** to open the model file.
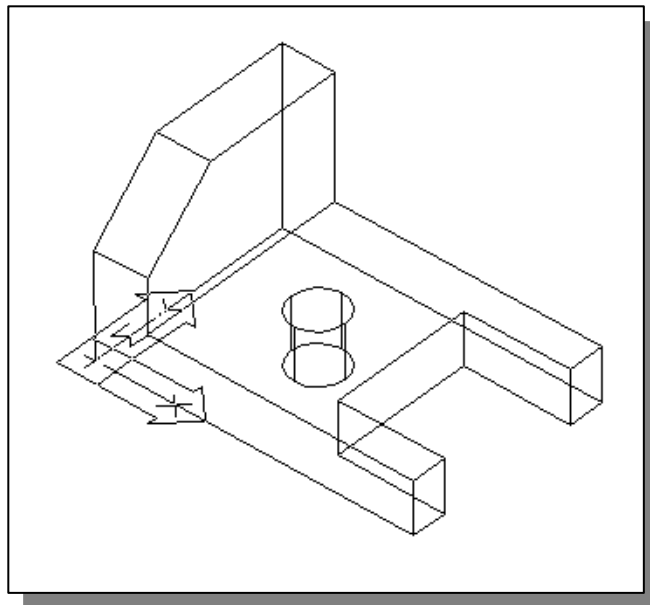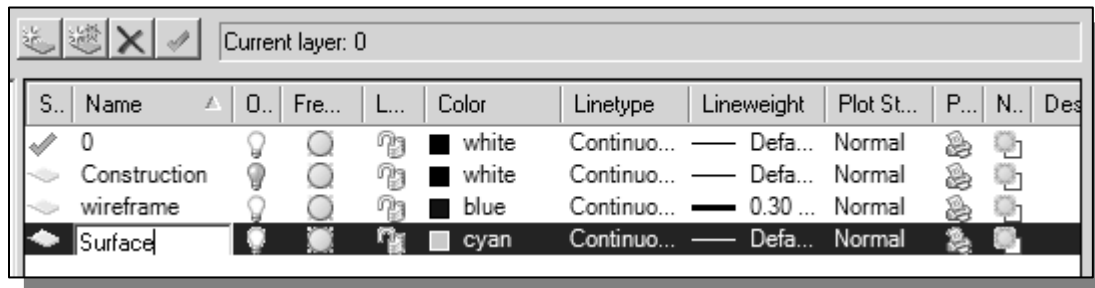
Moving Objects to a Different Layer

1. Click **Layers Properties Manager** in the *Layers* toolbar.

2. Click on the **New** button to create new layers.

3. Create **three new layers** with the following settings:

| *Layer*	*Color*	*LineType*	*LineWeight*
Construction	**White**	**Continuous**	**Default**
Wireframe	**Blue**	**Continuous**	**0.30mm**
Surface	**Cyan**	**Continuous**	**Default**

4. Click on the **Close** button to accept the settings and exit the *Layer Properties Manager* dialog box.
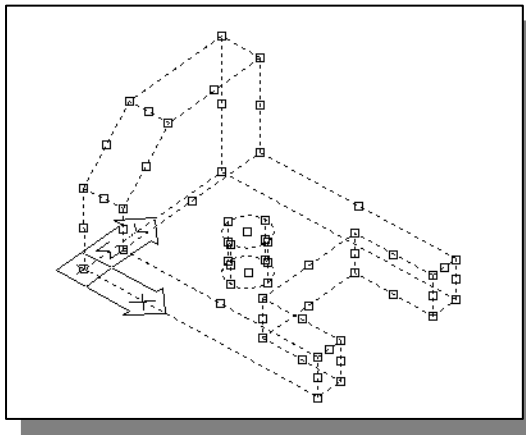
5. Inside the graphics window, pre-select all entities by using the left-mouse-button to create a *selection window* enclosing all entities.

- Note that all selected entities are highlighted.
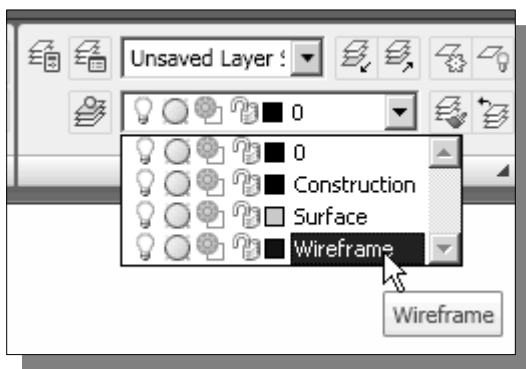
6. On the *Object Properties* toolbar, choose the **Layer Control** box with the left-mouse-button.

- Notice the layer name displayed in the *Layer Control* box is the selected object's assigned layer and layer properties.

7. In the *Layer Control* box, click on the **Wireframe** layer name as shown.

❖ All entities of the *Locator* model are moved to the *Wireframe* layer.

8. Press the [**ESC**] key twice to deselect all highlighted entities.

Advanced Surface Modeling Commands

❖ Several of the advanced surface-modeling commands are displayed in the last group of the *Surfaces Modeling* toolbar. These commands allow us to quickly create and duplicate surfaces in specific manners.
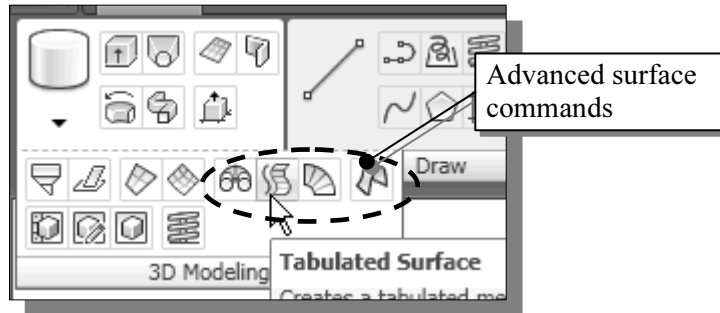

- **Revolved Surface**: Creates a surface mesh by rotating a group of objects about an axis.

- **Tabulated Surface**: Creates a surface mesh representing a general tabulated surface defined by a path curve and a direction vector. The resulting mesh is a series of parallel polygons running along a specified path.

- **Ruled Surface**: Creates a surface mesh between two objects.

- **Edge Surface**: Creates a surface patch mesh from four edges.

SurfTab1 & SurfTab2 system variables: These two variables are used to set the number of increments used by the Ruled Surface and Tabulated Surface commands. The default values are set to six, which means any curve will be approximated with six straight lines.
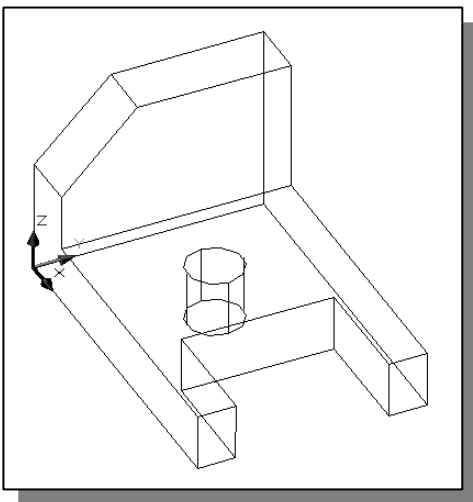

1. On your own, use the **Free Orbit** command and adjust the display of the wireframe model so that the four vertical lines connecting the two circles are visible as shown.

- To illustrate the use of the Ruled Surface and Tabulated Surface commands, we will first split the top circle into two arcs. Note that these surfacing commands allow us to construct a polygon mesh for different situations and regions. The split of the circle is necessary in creating a mapped surface on the top plane of the model.
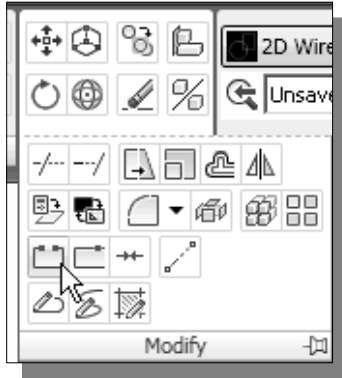
2. Select **Break** in the *Modify* toolbar.

- The Break command can be used to erase parts of objects or split an object in two. Note that we can only erase parts of a circle. We will therefore erase a portion of the circle and then split the circle into two arcs.
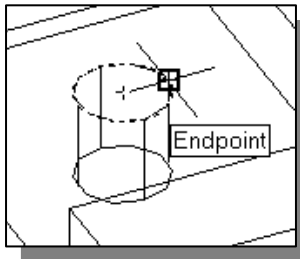
3. Select the top circle as shown. Note that the portion defined by two points will be erased.
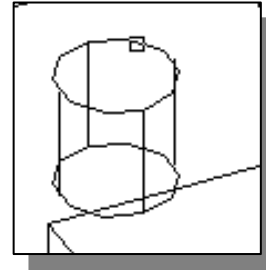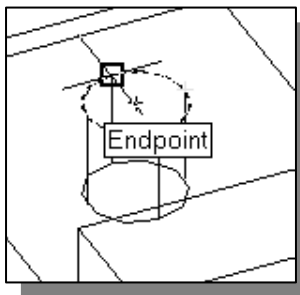
- By default, AutoCAD treats the selection point as the first break point. We can override the first point by choosing **First point** in the option menu.
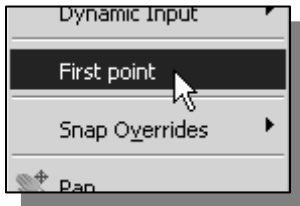
4. In the command prompt area, the message "*Specific second break point or [First point]:*" is displayed. Right-mouse-click once and select **First point** in the option menu.

5. In the command prompt area, the message "*Specific first break point:*" is displayed. Choose the top endpoint of the vertical line as shown.

6. In the command prompt area, the message "*Specific second break point:*" is displayed. Choose the top endpoint of the vertical line as shown.

- One quarter of the circle has been erased. We will next split the arc into two arcs, again using the **Break** command.
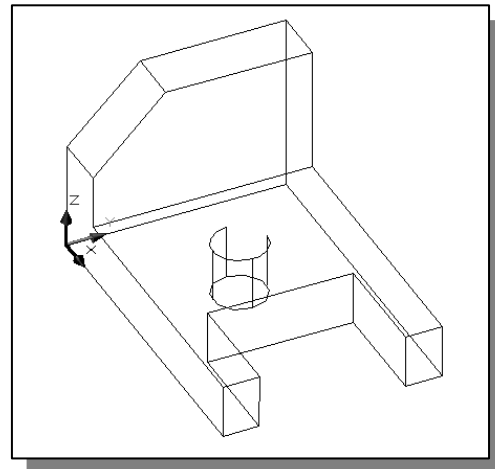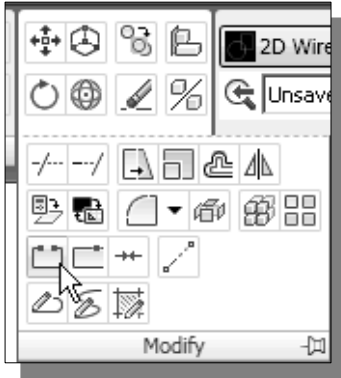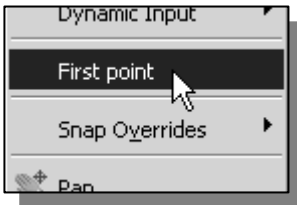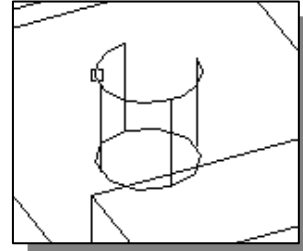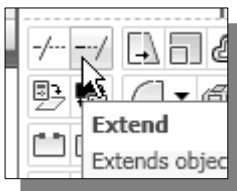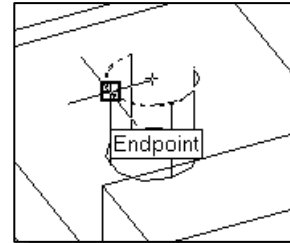
7. Select **Break** in the *Modify* toolbar.

8. Select the top arc as shown.

- By default, AutoCAD treats the selection point as the first break point. We can override the first point by choosing **First point** in the option menu.

9. In the command prompt area, the message "*Specific second break point or [First point]:*" is displayed. Right-mouse-click once and select **First point** in the option menu.

10. In the command prompt area, the message "*Specific first break point:*" is displayed. Choose the top endpoint of the left vertical line as shown.

11. In the command prompt area, the message "*Specific second break point:*" is displayed. To split an object, choose the **same endpoint** that was chosen as the first endpoint.

12. Select **Extend** in the *Modify* toolbar. Note the *Projection* type is set to **View**, as shown in the prompt window.
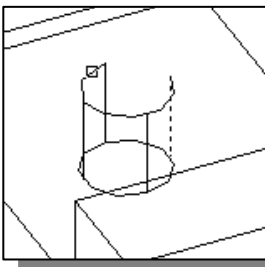
```
Command: _extend
Current settings: Projection=View, Edge=None
Select boundary edges ...
Select objects or <select all>:
```
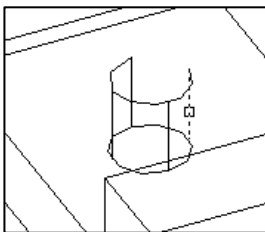
13. Select the right vertical edge to be the extending boundary as shown.

14. Inside the graphics window, right-mouse-click once to accept the selection.

15. Pick the shorter arc near the right endpoint to extend the arc in that direction.

16. Inside the graphics window, right-mouse-click once to display the option menu and select **Enter** to end the Extend command.

Using the Tabulated Surface Option

- In AutoCAD, the **TABSURF** command allows us to construct a polygon mesh representing a general tabulated surface defined by a path curve and a direction vector.
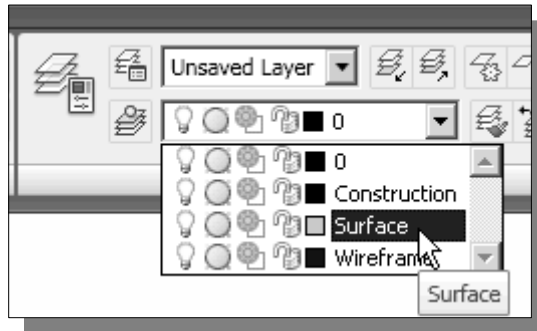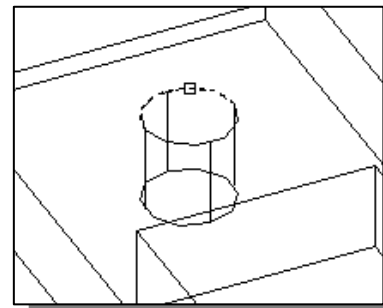
1. Set the *Surface* layer as the *Current Layer* by choosing the layer name in the *Layer Control* box as shown.
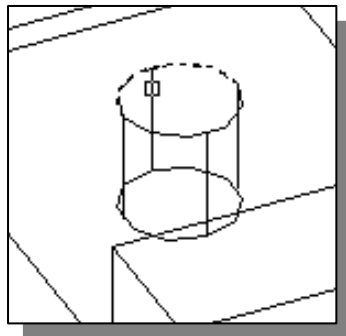
- We will place the surface model on a different layer than the wireframe model.
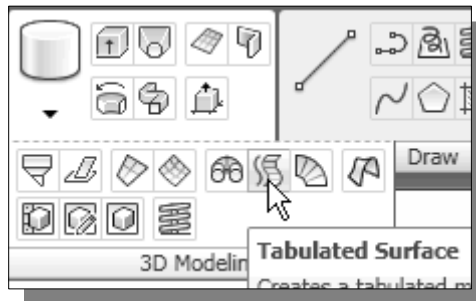
2. Click **Tabulated Surface** in the *3D Modeling* Toolbar.

3. In the command prompt area, the message "*Select object for path curve:*" is displayed. Choose the upper arc as shown.

4. In the command prompt area, the message "*Select object for direction vector:*" is displayed. Choose the vertical line near the top endpoint as shown. Note that the endpoint of the line is used as a reference point to determine the direction of the polygon mesh.

5. On your own, use the **Orbit** and **Visual Styles** commands to examine the constructed polygons.
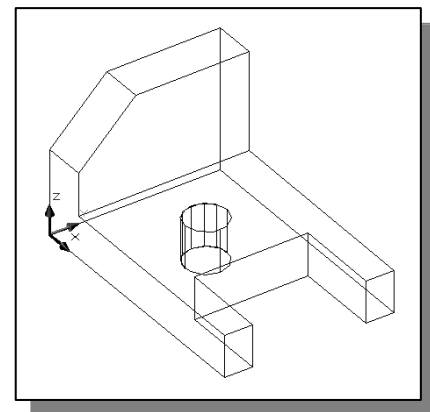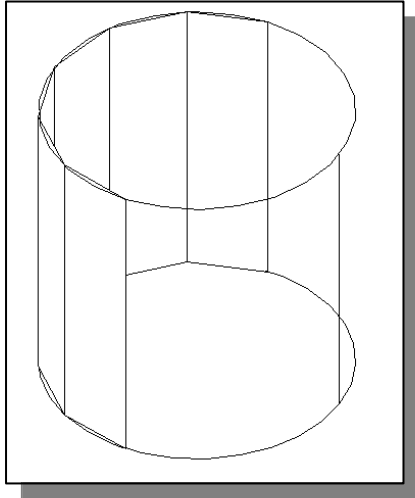
- Exactly six polygons are created and positioned along the selected *path curve*, the upper arc, with the Tabulated Surface command. This is set by the **SurfTab1** variable. We can adjust number of segments to use by typing the word, **surftab1**, at the command prompt.

- ❖ Note that a surface modeler using polygons to approximate true curves is called a *faceted surface modeler*.

Using the Ruled Surface Option

- In AutoCAD, the **RULESURF** command allows us to construct a polygon mesh between two objects. We can use two different objects to define the edges of the ruled surface: lines, points, arcs, circles, ellipses, elliptical arcs, polylines or splines. The two objects to be used as the *rails* of a ruled surface mesh must both be either open or closed. For open curves, AutoCAD starts construction of the ruled surface based on the locations of the specified points on the curves.
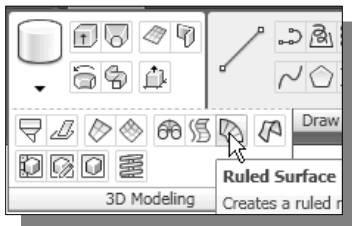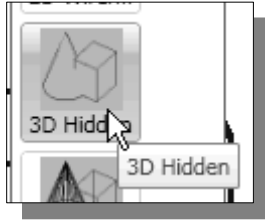
1. Pick **Ruled Surface** in the *Draw* pull-down menu.
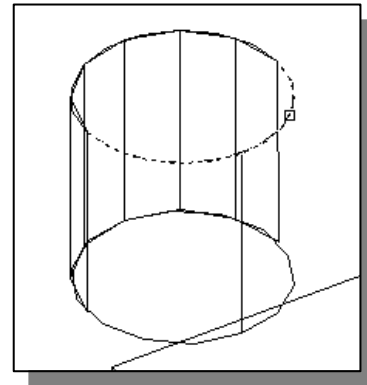
2. In the command prompt area, the message "*Select first defining curve:*" is displayed. Choose the lower arc by clicking on the right side as shown.
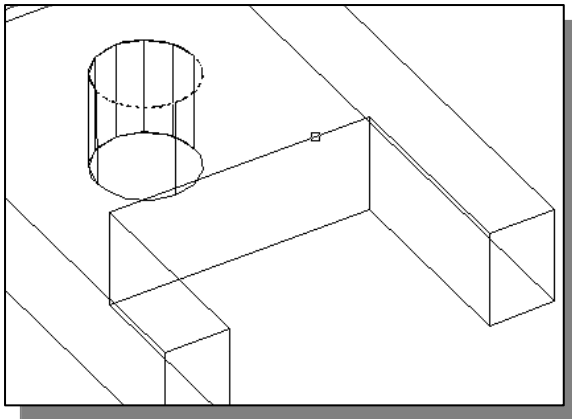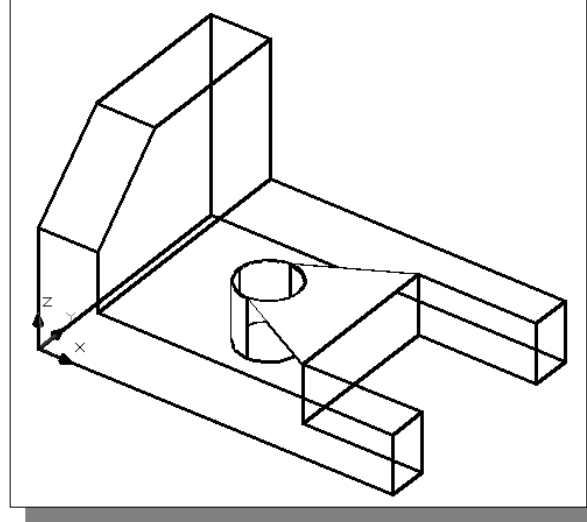
3. In the command prompt area, the message "*Select second defining curve:*" is displayed. Choose the inside straight edge on the right side as shown.

4. In the *Visual Styles* toolbar, click on the **3D Hidden** icon to display the model with hidden lines removed.

- The selected edges are removed from the display so that the face of the ruled surface appears to be more realistic.
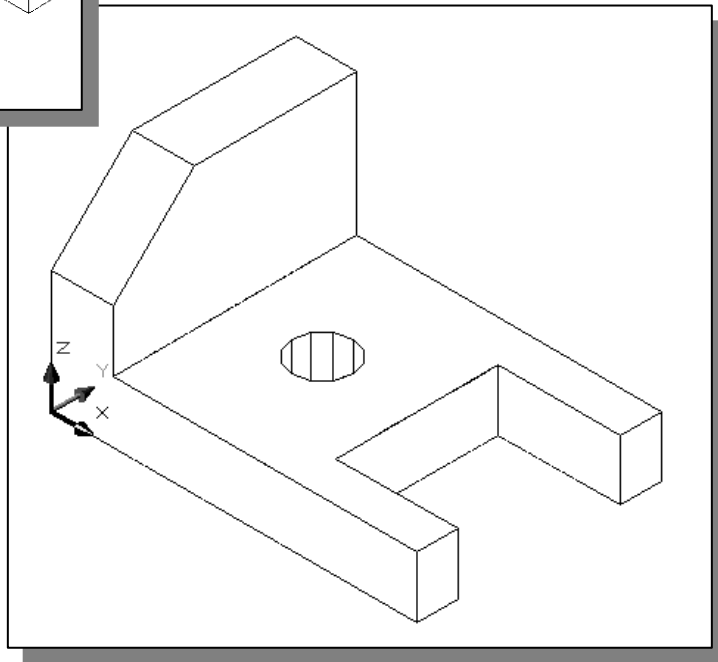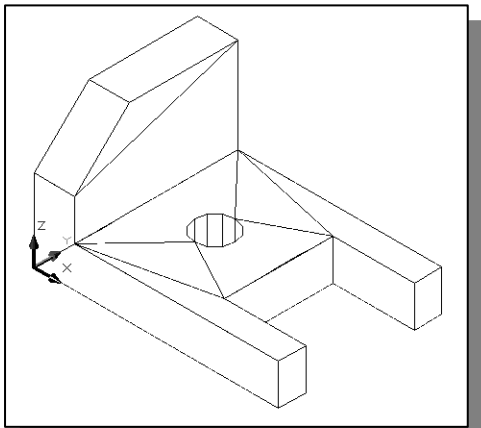
5. On your own, repeat the above steps and create another ruled surface as shown. (Hint: Use the Realtime Zoom function to assist the selection of the arc.)
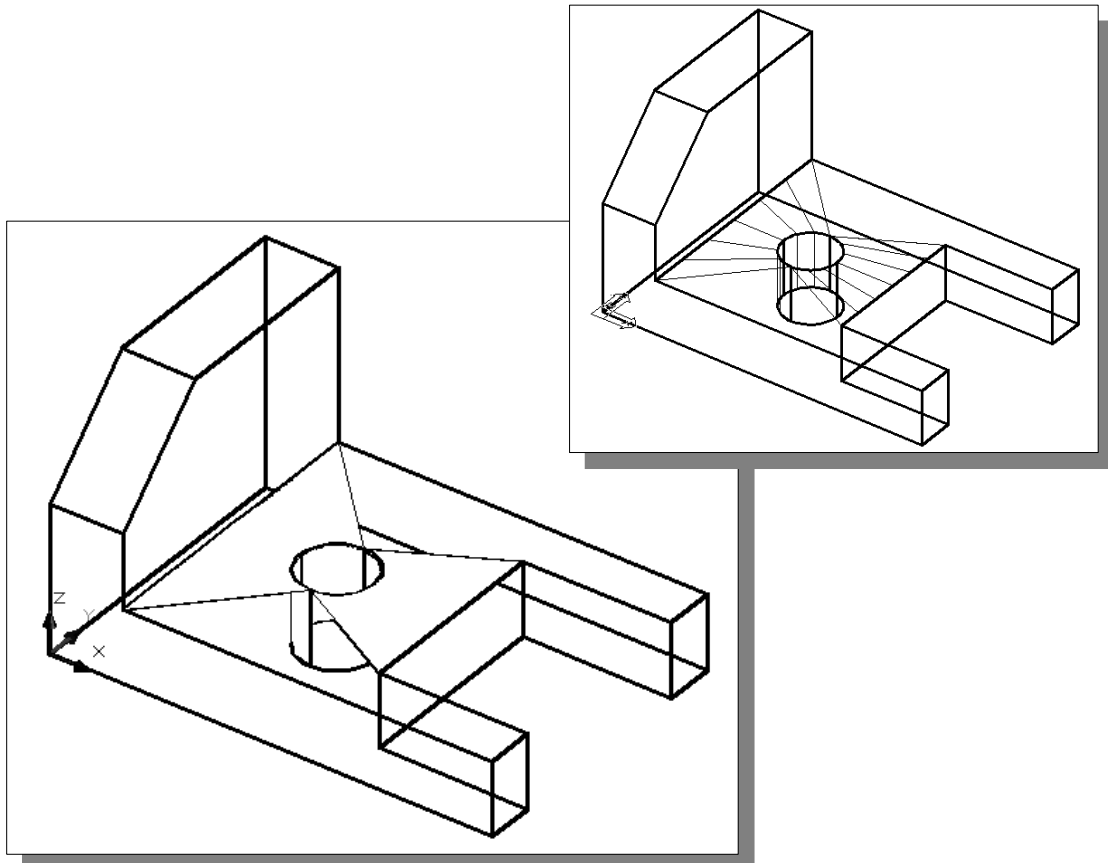
6. In the *3D Modeling* toolbar, select **3D Face**.

- On your own, complete the surface model as shown. (Hint: Use the [**Edge**] command to hide the edges of the created faces.)

Questions:

1. List and describe three differences between *Wireframe models* and *Surface models*.

2. List and describe the three types of surfaces available in AutoCAD.

3. List and describe two different shading options in AutoCAD.

4. What is the difference between the 2D Solid and 3D Face commands in AutoCAD?

5. What is the difference between Tabulated Surface and Ruled Surface in AutoCAD?
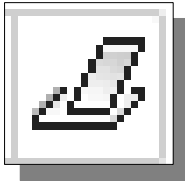
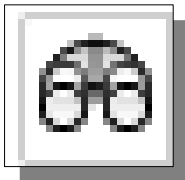6. Identify and describe the following commands:
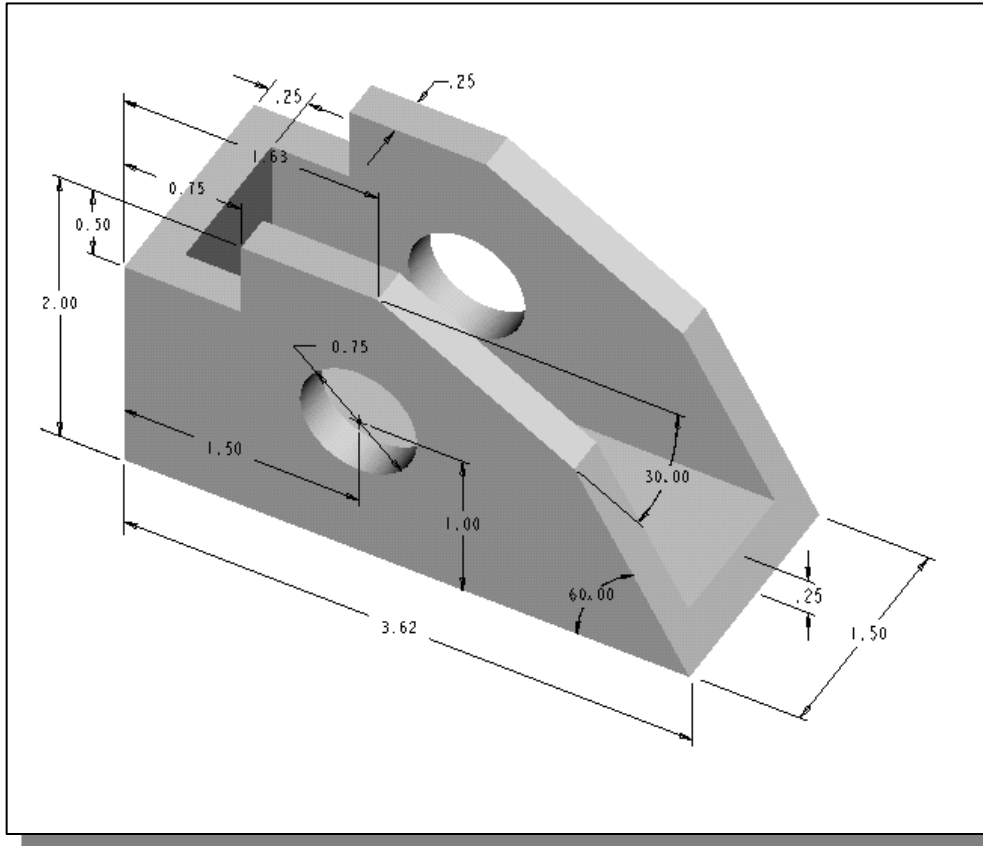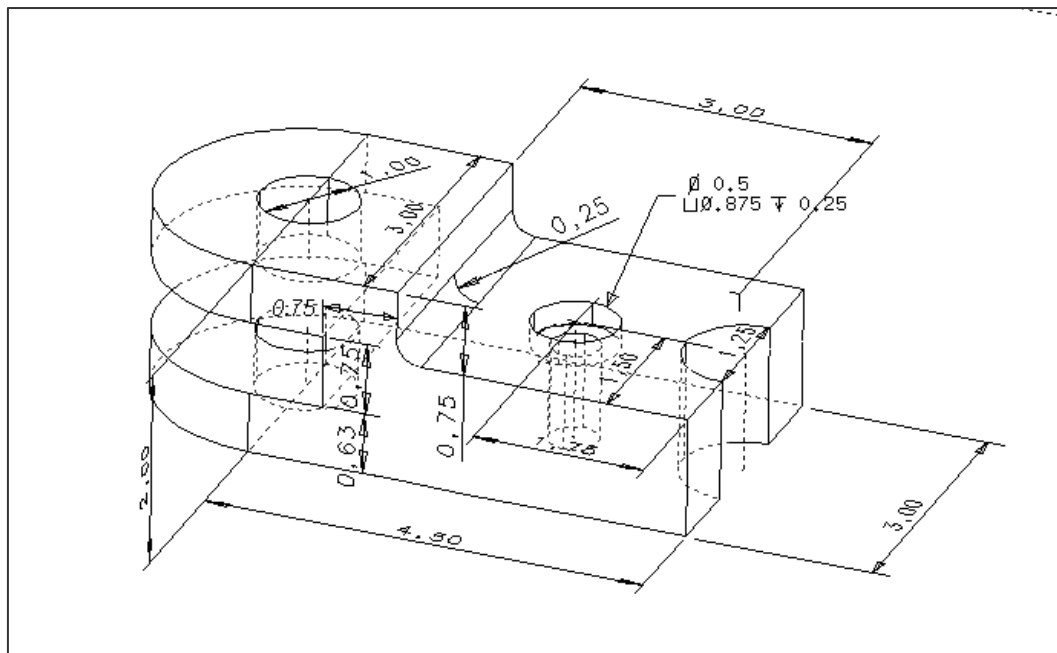
   a)

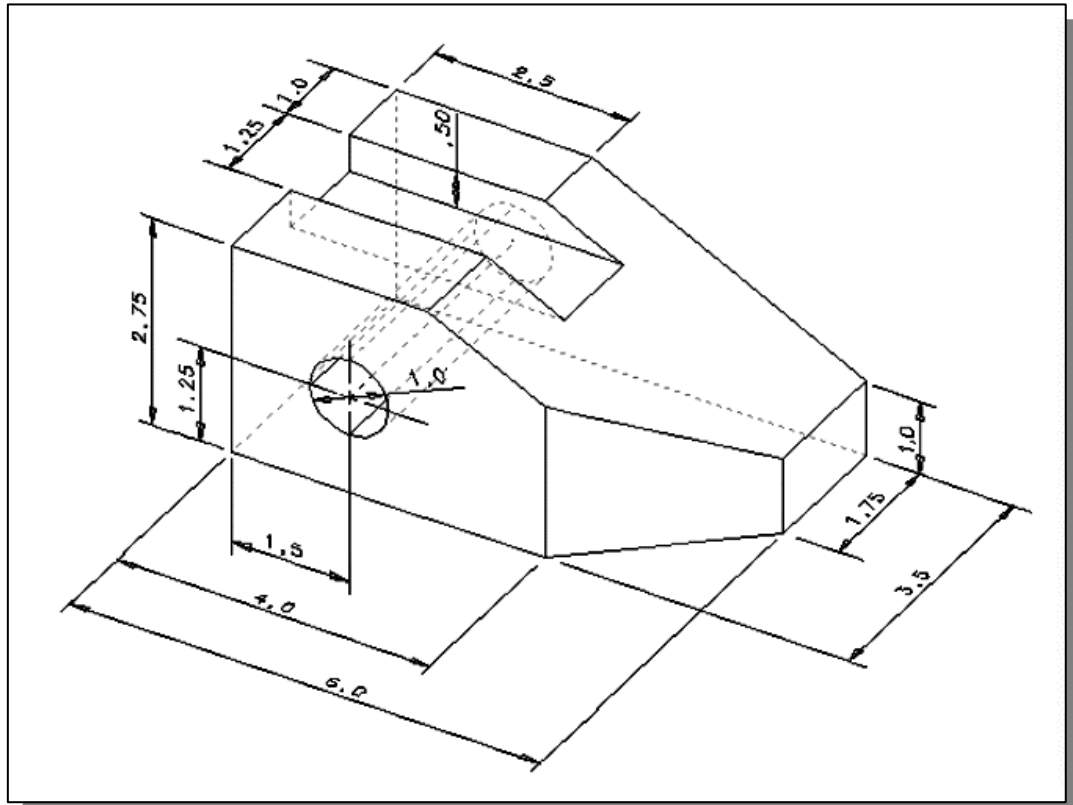
   b)
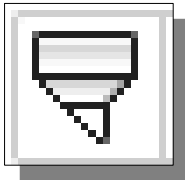
   c)

   d)

Exercises: All dimensions are in inches.

1.

2.

3.

4.