Chapter 1

The User Coordinate System

Learning Objectives

After completing this chapter, you will be able to:

- *Understand the concept of World Coordinate System (WCS)*
- *Understand the concept of User Coordinate System (UCS)*
- *Control the display of UCS icon*
- *Change the current UCS icon type*
- *Use the UCS command*
- *Dynamically move and align the UCS*
- *Understand different options for changing UCS using the UCS tool*
- *Change UCS using the Dynamic UCS button*
- *Manage UCS through the UCS dialog box*
- *Understand different system variables related to the UCS and the UCS icon*

Key Terms

- *UCS Icon*
- *UCS*
- *UCS Manager*

THE USER COORDINATE SYSTEM (UCS)

When you start a new drawing in AutoCAD, the world coordinate system (WCS) is established by default. The objects you draw uses the WCS to locate itself in the drawing space. In WCS, the *X*, *Y*, and *Z* coordinates of any point are measured with respect to the fixed origin (0,0,0). By default this origin is located at the lower left corner of the screen, by nature this coordinate system is fixed and can not be moved. Generally 2D drawings, wireframe models, and surface models can be created in WCS but in the case of solid models it is not possible to keep the origin and the orientation of the *X, Y,* and *Z* axes at the same place every time. The reason for this is that in case you want to create a feature on the top face of an existing model you will need to shift the working plane to the top face of the model. This can be done by using the Elevation option of the **ELEV** command, refer to Figure 1-1. But, on using the **ELEV** command, it is not possible to create a feature on the faces other than the top and bottom faces of an existing model.

This problem can be solved by using the user coordinate system (UCS). Using the **UCS** command, you can relocate and reorient the origin and *X*, *Y*, and *Z* axes and establish your own coordinate system, depending on your requirement. The UCS is mostly used in 3D drawings, where you may need to specify points that vary from each other along the *X*, *Y*, and *Z* axes. It is also useful for relocating the origin or rotating the *X* and *Y* axes in 2D work, such as ordinate dimensioning, drawing auxiliary views, or controlling the hatch alignment. The UCS and its icon can be modified using the **UCSICON** and **UCS** commands. After reorienting the UCS, you can create a feature on any of the face of an existing model, refer to Figure 1-2.

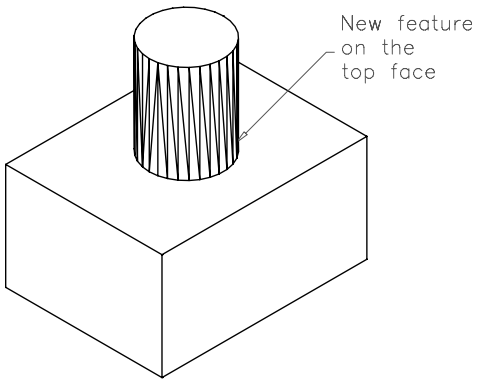


Figure 1-1 *Creating a new feature on the top face*

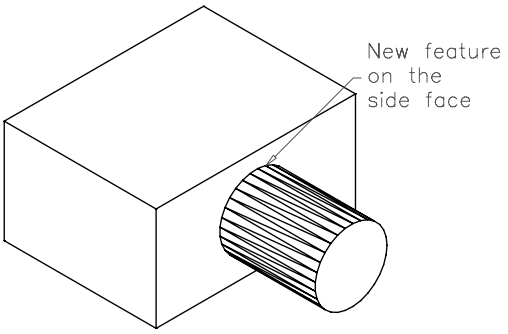


Figure 1-2 *Creating a new feature on the side face*

CONTROLLING THE VISIBILITY OF THE UCS ICON

Ribbon: View > Viewport Tools > UCS Icon
Menu Bar: View > Display > UCS Icon > On **Command:** UCSICON

The **UCS Icon** tool is used to control the visibility and location of the UCS icon, which is a geometric representation of the directions of the current *X*, *Y*, and *Z* axes. AutoCAD displays different UCS icons in model space and paper space, as shown in Figures 1-3 and 1-4. By default, the UCS icon is displayed near the bottom left corner of the drawing area. You can change the location and visibility of this icon using the **UCSICON** command. The prompt sequence for the **UCSICON** command is given next.

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Enter an option [ON/OFF/All/Noorigin/ORigin/Selectable/Properties] <ON>: *You can specify any option or press ENTER to accept the default option.*

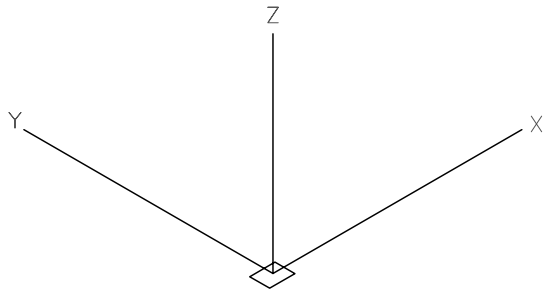


Figure 1-3 *The UCS icon in the Model space*



Figure 1-4 *The UCS icon in the Paper space*

ON

This option is used to display the UCS icon on the screen. You can also display the UCS icon by choosing the **Show UCS Icon** tool from the **Show UCS** drop-down list of **Coordinates** panel in the **Home** tab.

OFF

This option is used to make the UCS icon invisible from the screen. When you choose this option, the UCS icon will no longer be displayed on the screen. You can again turn on the display using the **ON** option of the **UCSICON** command. Alternatively, choose the **Hide UCS Icon** tool from the **Show UCS** drop-down list of **Coordinates** panel in the **Home** tab to make the UCS icon invisible.

All

This option is used to apply changes to the UCS icon in all active viewports. If this option is not used, the changes will be applied only to the current viewport.

Noorigin

This option is used to display the UCS icon at the lower left corner of the viewport, irrespective of the actual location of the origin of the current UCS.

ORigin

This option is used to place the UCS icon at the origin of the current UCS. You can also choose the **Show UCS Icon at Origin** tool from the **Show UCS** drop-down list of the **Coordinates** panel in the **Home** tab. Alternatively, type **UCSICON** at the command prompt and press enter. Next, select the **ORigin** option from the options displayed.



Note

*You can switch into different workspaces using the **Workspace** Switching drop-down list available at the right in the **Status Bar**.*

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Selectable

This option allows you to control the selection of UCS. By default, UCS is selectable.

Properties

When you select this option, the **UCS Icon** dialog box will be displayed, as shown in Figure 1-5. You can also display this dialog box by choosing the **UCS Icon, Properties** tool from the **Coordinates** panel in the **Home** tab. Alternatively, place the cursor over the UCS Icon in the drawing area and right-click; a shortcut menu will be displayed. Choose **UCS Icon Settings > Properties** from the shortcut menu; the **UCS Icon** dialog box will be displayed. The options in this dialog box are discussed next.

UCS icon style Area

The options in this area are discussed next.

3D: This button is selected by default. As a result, the 3D UCS icon will be displayed in the model space.

2D: If this radio button is selected, the 2D UCS icon will be displayed instead of the 3D UCS icon, refer to Figure 1-6.

Line width. This drop-down list is used to specify the line width of the 3D UCS icon. The default value for the line width is 1. Note that this drop-down list will not be activated if the **2D** radio button is selected.

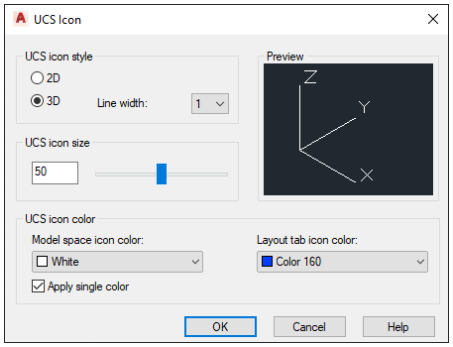


Figure 1-5 *The* ***UCS Icon*** *dialog box*

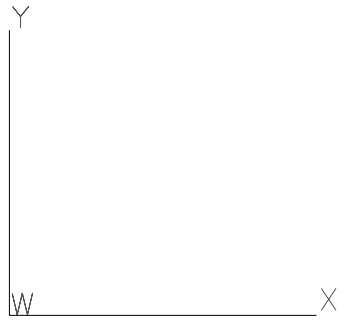


Figure 1-6 *2D UCS icon at the World position*

UCS icon size Area

The edit box and slider bar provided in this area are used to control the size of the UCS icon. You can enter values from ranging 5 to 95 in the edit box or by adjusting the sliding bar. The size of the UCS icon is proportional to the viewport size as the value entered is the percentage of the viewport size.

UCS icon color Area

The **UCS icon color** area has two drop-down lists, **Model space icon color** and **Layout tab icon color**. The options in these drop-down lists are used to change the color of the UCS icon. By default, the color in the **Model space icon color** drop-down list is white and in the **Layout tab**

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icon color drop-down list is Color 160. You can assign any color to the UCS icon. By default, there are seven colors in first and eight colors in second drop-down list. However, you can also select a color from the **Select Color** dialog box which will be displayed after you select the **Select Color** option from the **Model space icon color** drop-down list or the **Layout tab icon color** drop-down list.

DEFINING THE NEW UCS

Ribbon: Visualize > Coordinates > UCS **Toolbar:** UCS
Menu Bar: Tools > New UCS **Command:** UCS



The **UCS** tool is used to set a new coordinate system by shifting the working plane (*XY* plane) to the desired location. For certain views of the drawing, it is better to have the origin of measurements at some other point on or relative to your drawing objects. This makes locating the features and dimensioning the objects easier. The change in the UCS can be viewed by the change in the position and orientation of the UCS icon, which is placed by default at the lower left corner of the drawing window. The origin and orientation of a coordinate system can be redefined by using the **UCS** command. Alternatively, choose the **UCS** tool from the **Coordinates** panel of the **Visualize** tab. The prompt sequence after choosing this tool is given next:

Current ucs name: *WORLD*
Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis] <World>: *Select an option*.

If the **UCSFOLLOW** system variable is set to 0, any change in the UCS will not affect the drawing view.

If you choose the default option of the **UCS** tool, you can establish a new coordinate system by specifying a new origin point, a point on the positive side of the new *X* axis, and a point on the positive side of the new *Y* axis. The direction of the *Z* axis is determined by applying the right-hand rule, about which you will learn in the next chapter. This option changes the orientation of the UCS to any angled surface. The prompt sequence that will follow is given next.

Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis] <World>: *Specify the origin point of the new UCS.*
Specify point on X-axis or <accept>: *Specify a point on the positive portion of the X axis.*
Specify point on the XY plane or <accept>: *Specify a point on the positive portion of the Y axis to define the orientation of the UCS completely.*

In AutoCAD, you can directly manipulate the UCS as per your requirement. This implies that you can easily move the origin of UCS, align the UCS with objects, or rotate it around X, Y, and Z axis without invoking the UCS command. You can also move the UCS and place it at the desired location without using any command. To do so, select the UCS; the grips are displayed on it. Place the cursor on the rectangular grip displayed at the intersection of three axes of UCS; a shortcut menu will be displayed, as shown in Figure 1-7.

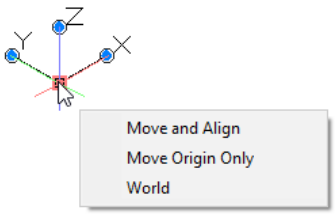


Figure 1-7 *UCS shortcut menu*

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Choose the **Move and Align** option from the shortcut menu; the UCS will be displayed attached to the cursor. You can move the UCS to any point but you can align it only with the face of a 3D object, surface, or mesh. To align the UCS, move it to any point on the face of a 3D object, surface, or mesh; the face gets highlighted and the UCS automatically aligns with the orientation of that face, surface, or mesh, as shown in Figure 1-8.

In case of a curved surface, the UCS will get aligned in such a way that the Z-axis becomes normal to the surface at the specified point. After aligning the UCS to the selected face, you can change the direction of X axis, Y axis, or Z axis dynamically. You can also use the shortcut menu displayed on placing the cursor on the X, Y, or Z grip.

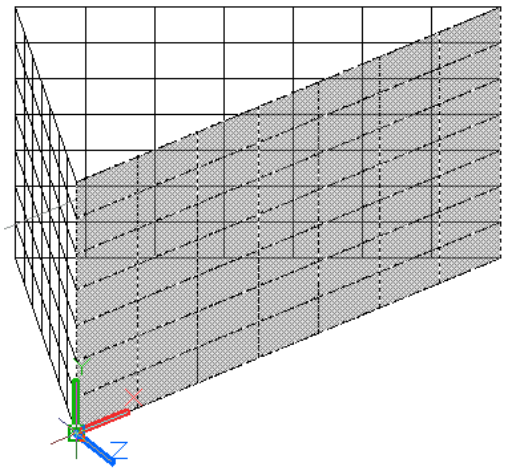


Figure 1-8 *UCS aligned to the highlighted face*

If you choose **World** from the UCS shortcut menu, then the UCS will move and align to the World Coordinate System. The World Coordinate System is discussed next.

Note

Depending upon the type of UCS required, you can choose the corresponding tools available in the ***Coordinates*** *panel of the* ***Home*** *tab.*

A null response to the point on the *X* or *Y* axis prompt will lead to a coordinate system, in which the *X* or *Y* axis of the new UCS is parallel to that of the previous UCS.

W (World) Option

Using this option, you can set the current UCS back to the WCS, which is the default coordinate system. When the UCS is placed at the world position, a small rectangle is displayed at the point where all the three axes meet in the UCS icon, refer to Figure 1-9 (a). If the UCS is moved from its default position, this rectangle is no longer displayed, indicating that the UCS is not at the world position, as shown in Figure 1-9(b).

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Note

If 2D UCS icon is selected instead of 3D UCS icon and if the UCS is not at the world position; the W icon will not be displayed.

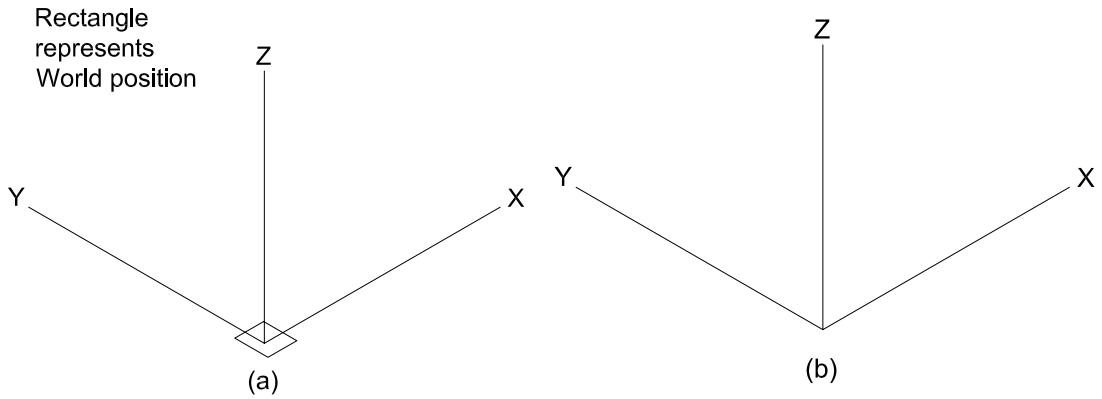


Figure 1-9 *UCS at the world position and UCS not at the world position*

F (Face) Option

This option is used to align a new UCS with the selected face of a solid object. You can invoke this option by choosing the **Face** tool from the Align UCS drop-down list in the **Coordinates** panel, as shown in Figure 1-10. The prompt sequence that will follow when you choose this tool is given next.

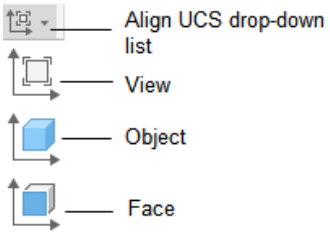


Figure 1-10 *The **Face** tool in the Align UCS drop-down list*

Select face of solid, surface, or mesh: *Select the face to align the UCS.*
Enter an option [Next/Xflip/Yflip] <accept>: *Select an option or accept the selected face to align.*

The **Next** option is used to locate the new UCS on the adjacent face or the back face of the selected edge. **Xflip** rotates the new UCS by 180 degrees about the *X* axis and **Yflip** rotates it about the *Y* axis. Pressing ENTER at the **Enter an option [Next/Xflip/Yflip] <accept>** prompt accepts the location of the new UCS as specified.

OB (OBject) Option

With the **OB** (**OBject**) option of the **UCS** tool, you can establish a new coordinate system by selecting an object in the drawing. However, some of the objects such as 3D polyline, 3D mesh, viewport object, or xline cannot be used for defining a UCS. The positive *Z* axis of the new UCS is in the same direction as the positive *Z* axis of the object selected. If the *X* and *Z* axes are given, the new *Y* axis is determined by the right-hand rule. You can also invoke this option by choosing the **Object** tool from the Align UCS drop-down list in the **Coordinates** panel. The prompt sequence that will follow when you choose this tool is given next.

Select object to align UCS: *Select the object to align the UCS.*

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In Figure 1-11, the UCS is relocated using the **OBject** option and is aligned to the circle. The origin and the *X* axis of the new UCS are determined by using the following rules:

Arc

When you select an arc, its center becomes the origin for the new UCS. The *X* axis passes through the endpoint of the arc that is closest to the point selected on the object.

Circle/Cylinder/Ellipse

When you select a circle, cylinder, or an ellipse, its center becomes the origin of the new UCS, and the *X* axis passes through the point selected on the object, refer to Figure 1-12.

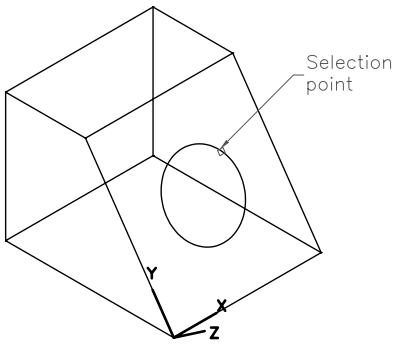


Figure 1-11 *Relocating the UCS using a circle*

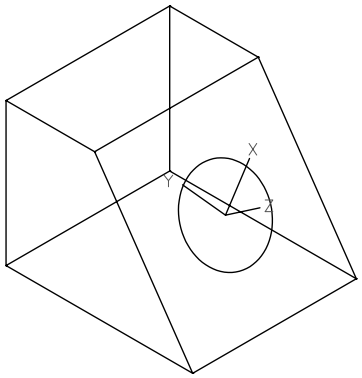


Figure 1-12 *UCS at a new location*

Line/Mline/Ray/Leader

When you select a line, mline, ray, or a leader, the endpoint nearest to the point selected on it becomes the origin of the new UCS. The *X* axis is defined so that the line lies on the *XY* plane of the new UCS. Therefore, in the new UCS, the *Y* coordinate of the second endpoint of the line is 0.



Note

The linear edges of solid models or regions are considered as individual lines when selected to align a UCS.

Spline

When you select a spline, the endpoint that is nearest to the point selected on the spline becomes the origin of the new UCS. An imaginary line will be drawn between the two endpoints of the spline and the *X* axis will be aligned along this imaginary line.

Dimension

When you select a dimension, the middle point of the dimension text becomes the origin of the new UCS. The *X* axis direction is identical to the direction of the *X* axis of the UCS that existed when the dimension was drawn.

Point

The position of the point is the origin of the new UCS. The directions of the *X*, *Y*, and *Z* axes will be same as those of the previous UCS.

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Solid

When you select a solid, the first point selected on the solid becomes the origin of the new UCS. The *X* axis of the new UCS lies along the line between the first and second points of the solid.

2D Polyline

When you select a polyline, the end point nearest to the point selected on the polyline becomes the origin of the new UCS. The *X* axis extends from the start point to the next vertex.

3D Face

When you select a 3D face, its first point becomes the origin of the new UCS. The *X* axis is determined by using the first two points, and the positive side of the *Y* axis is determined by the first and fourth points for a flat rectangular face. For a flat planar face, the X axis will always be parallel to the edge through which the UCS is moved on the face. The *Z* axis is determined by applying the right-hand rule.

Shape/Text/Block/Attribute/Attribute Definition

When you select a shape, text, block, attribute, or a attribute definition, its insertion point becomes the origin of the new UCS. The new X axis is defined by the rotation of the object around its positive Z axis. Therefore, the object you select will have a rotation angle of zero in the new UCS.



Tip

Except for 3D faces, the XY plane of the new UCS will be parallel to the XY plane of the object when it was drawn. However, X and Y axes may be rotated.

V (View) Option



The **V** (**View**) option of the **UCS** tool is used to define a new UCS whose *XY* plane is parallel to the current viewing plane. The current viewing plane, in this case, is the screen of the monitor. Therefore, a new UCS is defined that is parallel to the screen of the monitor. The origin of the UCS defined in this option remains unaltered. This option is used mostly to view a drawing from an oblique viewing direction or to write text for the objects on the screen. You can also invoke this option by choosing the **View** tool from the **Align UCS** drop-down list in the **Coordinates** panel. As soon as you choose this tool, a new UCS is defined parallel to the screen of the monitor.

X/Y/Z

With these options, you can rotate the current UCS around the desired axis. You can specify the angle by entering the angle value at the required prompt or by selecting two points on the screen with the help of a pointing device. You can specify a positive or a negative angle. The new angle is taken relative to the *X* axis of the existing UCS. The **UCSAXISANG** system variable stores the default angle by which the UCS is rotated around the specified axis, by using the **X**/ **Y**/ **Z** options of the **UCS** tool. The right-hand thumb rule is used to determine the positive direction of rotation of the selected axis. You can also invoke the corresponding option by choosing the

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X/Y/Z button from the Rotate UCS drop-down in the **Coordinates** panel, as shown in Figure 1-13. However, in AutoCAD, you can rotate the UCS dynamically using the grips and shortcut menu.

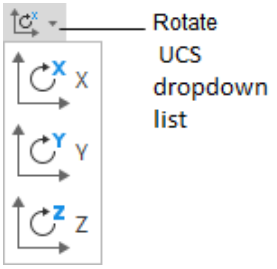


*Figure 1-13 Tools in the **Rotate UCS** drop-down list*

X



In Figure 1-14, the UCS is rotated using the **X** option by specifying an angle about the X axis at the command prompt. The first model shows the UCS setting before the UCS was relocated and the second model shows the relocated UCS.

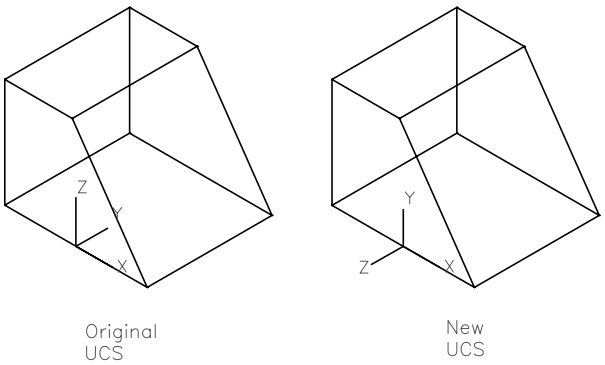


Figure 1-14 Rotating the UCS about the X axis

You can also choose the X tool from the Rotate UCS drop-down list in the **Coordinates** panel. The prompt sequence that will follow when you choose the **X** tool is given next.

Specify rotation angle about X axis <90>: *Specify the rotation angle.*

Alternatively, you can dynamically rotate the UCS about the X axis by following the steps given below:

1. Click on the UCS in the drawing area to select it.
2. Move the cursor to the grip of the Y or Z axis; a shortcut menu will be displayed, as shown in Figure 1-15.
3. Choose the **Rotate Around X Axis** option from the shortcut menu and then rotate the UCS dynamically. You can also enter the desired rotation angle in the edit box attached to the cursor.

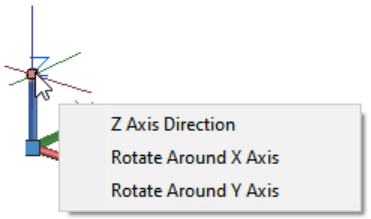


Figure 1-15 Shortcut menu for UCS rotation

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Y



In Figure 1-16, the UCS is rotated using the **Y** option by specifying an angle about the Y axis. The first model shows the UCS setting before the UCS was relocated and the second model shows the relocated UCS. The prompt sequence that will follow when you choose the **Y** tool from the Rotate UCS drop-down list is given next.

Specify rotation angle about Y axis <90>: *Specify the angle.*

Alternatively, you can dynamically rotate the UCS about the Y axis by following the steps given below:

1. Click on the UCS in the drawing area to select it.
2. Move the cursor to the grip of the X or Z axis.
3. Choose the **Rotate Around Y Axis** option from the shortcut menu and rotate the UCS dynamically or specify the desired angle.

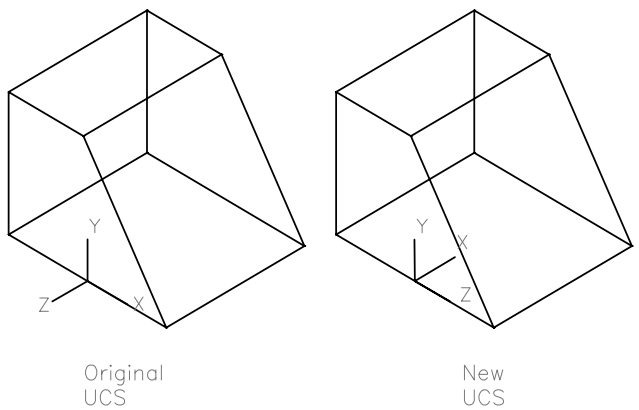


Figure 1-16 *Rotating the UCS about the Y axis*

Z



In Figure 1-17, the UCS is rotated using the **Z** option by specifying an angle about the *Z* axis. The first model shows the UCS setting before the UCS was rotated and the second model shows the rotated UCS. The prompt sequence that will follow when you choose the **Z** tool from the **Rotate UCS** drop-down is given next.

Specify rotation angle about Z axis <90>: *Specify the angle.*

Alternatively, you can dynamically rotate the UCS about the Z axis by following the steps given below:

1. Click on the UCS in the drawing area to select it.
2. Move the cursor to the grip of the X or Y axis.
3. Choose the **Rotate Around Z Axis** option from the shortcut menu and rotate the UCS dynamically or specify the desired rotation angle.

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Note

You can rotate the UCS about any axis also by using the options in the shortcut menu displayed on right-clicking on the UCS. To do so, move the cursor on the ***Rotate Axis*** *sub-menu in the shortcut menu and then choose the required option.*

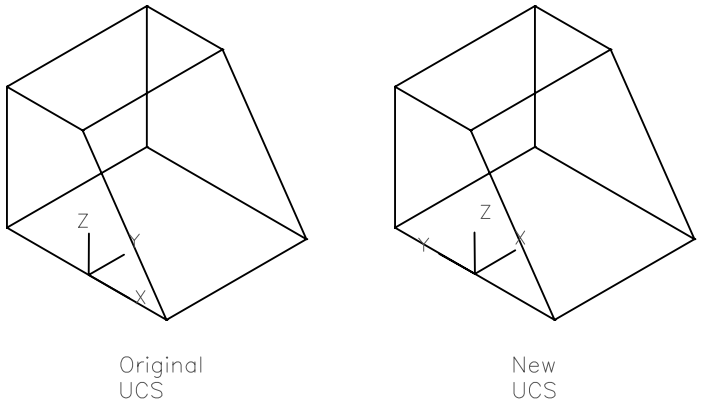


Figure 1-17 *Rotating the UCS about the Z axis*

ZA (ZAxis) Option



This option is used to change the coordinate system by selecting the origin point of the *XY* plane and a point on the positive *Z* axis. After you specify a point on the *Z* axis, AutoCAD determines the *X* and *Y* axes of the new coordinate system accordingly. The prompt sequence that will follow when you choose the **Z Axis Vector** tool from the **Coordinates** panel is given next.

Specify new origin point or [Object] <0,0,0>: *Specify the origin point, as shown in Figure 1-18.*
Specify point on positive portion of Z-axis <default>: **@ 0,-1,0**

Now, the front face of the model will become the new work plane, refer to Figure 1-19 and all the new objects will be oriented accordingly. If you give a null response to the **Specify point on positive portion of Z-axis <current>** prompt, the *Z* axis of the new coordinate system will be parallel to (in the same direction as) the *Z* axis of the previous coordinate system. Null responses to the origin point and the point on the positive *Z* axis establish a new coordinate system in which the direction of the *Z* axis is identical to that of the previous coordinate system; however, the *X* and *Y* axes may be rotated around the *Z* axis. The positive *Z* axis direction is also known as the extrusion direction.

When the **Object** option is selected at the **Specify new origin point or [Object] <0,0,0>** prompt, then you will be prompted to select an object. Select an open object and the UCS will be placed at the end point nearest to the point of the object selection, with its Z-axis along the tangent direction at that end point and pointing away from the object.

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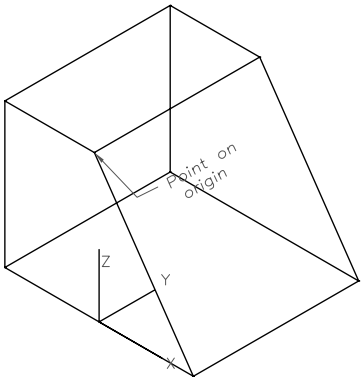


Figure 1-18 *Specifying a point on the origin*

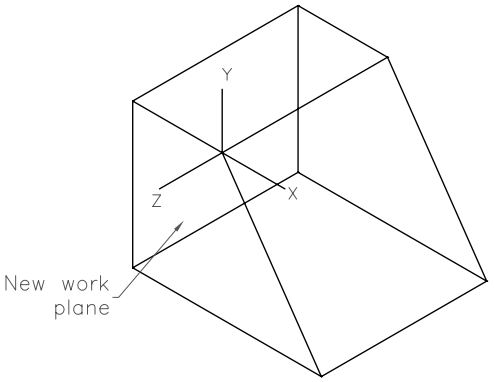


Figure 1-19 *Relocating the UCS using the* ***ZA*** *option*

Previous Option

The **Previous** option is used to restore the current UCS settings to the previous UCS settings. AutoCAD saves the last ten UCS settings. You can go back to the previous ten UCS settings in the current space using the **Previous** option. If the value of **TILEMODE** is 0, the last ten coordinate systems in paper space and in model space are saved. You can also invoke this option by choosing the **UCS, Previous** tool from the **Coordinates** panel. When you choose this tool, the previous UCS settings are automatically restored.

NAmed Option

This option is used to name and save the current UCS settings, restore a previously saved UCS setting, view a previously saved UCS list, and delete the saved UCS from the list. The prompt sequence for this option is given next.

Command: **UCS**
Current ucs name: *WORLD*
Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis]
<World>: **NA**
Enter an option [Restore/Save/Delete/?]: *Enter an option.*

Depending on your requirement, you can select any one of the following options:

Restore Option

The **Restore** option of the **UCS** command is used to restore a previously saved named UCS. Once it is restored, it becomes the current UCS. However, the viewing direction of the saved UCS is not restored. You can also restore a named UCS by selecting it from the **UCS** dialog box that appears when you invoke the **UCS, Named UCS** tool from the **Coordinates** panel. As this option does not have a button to restore the Named UCS, you need to choose this option by using the **UCS** command at the Command prompt. The prompt sequence that will follow when you invoke the **UCS** command is given next.

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Enter an option [Restore/Save/Delete/?]: ***R***
Enter name of UCS to restore or [?]: *Specify the name of UCS.*

You can specify the name of the UCS to be restored or list the UCSs that can be restored by entering **?** at the previous prompt. The prompt sequence that will be followed is given next.

Enter UCS name(s) to list <*>: *Specify the name of the UCS to list or give a null response to list all available UCSs.*

If you give a null response at the previously mentioned prompt, then the AutoCAD text window will be opened listing all the available UCSs.

Save Option

With this option, you can name and save the current UCS settings. The following points should be kept in mind while naming the UCS:

1. The name can be up to 255 characters long.
2. The name can contain letters, digits, blank spaces and the special characters $ (dollar), - (hyphen), and _ (underscore).

As this option does not have a tool, you can invoke this option using the Command prompt. The prompt sequence that will follow after entering the **UCS** command is given next.

Current ucs name: *WORLD*
Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis]<WORLD>: **NA**
Enter an option [Restore/Save/Delete/?]: **S**
Enter name to save current UCS or [?]: *Specify a name to the UCS.*

Enter a valid name for the UCS at this prompt. AutoCAD saves it as a UCS. You can also list the previously saved UCSs by entering **?** at this prompt. The next prompt sequence is:

Enter UCS name(s) to list <*>:

Enter the name of the UCS to list or give a null response to list all the available UCSs.

Delete Option

The **Delete** option is used to delete the selected UCS from the list of saved coordinate systems. As this option does not have a button, you can invoke this option using the Command prompt. The prompt sequence that will follow after entering the **UCS** command is given next.

Current ucs name: *WORLD*
Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis]: **NA**
Enter an option [Restore/Save/Delete/?]: **D**
Enter UCS name(s) to delete <none>: *Specify the name of the UCS to delete.*

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The UCS name you enter at this prompt is deleted. You can delete more than one UCS by entering the UCS names separated with commas.

? Option

By invoking this option, you can list the name of the specified UCS. This option gives you the name, origin, and *X*, *Y*, and *Z* axes of all the coordinate systems relative to the existing UCS. If the current UCS has no name, it is listed as WORLD or UNNAMED. The choice between these two names depends on whether the current UCS is the same as the WCS. The prompt sequence that will be displayed when you invoke this option using the Command prompt is given next.

Current ucs name: *WORLD*
Specify origin of UCS or [Face/NAmed/OBject/Previous/View/World/X/Y/Z/ZAxis]
<WORLD>: **NA**
Enter an option [Restore/Save/Delete/?]: **?**
Enter UCS name(s) to list <*>:

Apply Option



The **Apply** option applies the current UCS settings to a specified viewport or to all the active viewports in a drawing session. If the **UCSVP** system variable is set to 1, each viewport saves its UCS settings. The **Apply** option is not displayed at the Command prompt as an option for the **UCS** command. Therefore, you have to choose the **Apply** button from the **UCS** toolbar. The prompt sequence that will follow when you choose this button is given next.

Pick viewport to apply current UCS or [All]<current>: *Pick inside the viewport or enter **A** to apply the current UCS settings to all viewports.*

Origin Option



This option is used to define a new UCS by changing the origin of the current UCS, without changing the directions of the X, Y, Z axes, refer to Figures 1-20 and 1-21. The new point defined becomes the origin point (0,0,0) for all the coordinate entries, until the origin is changed again. You can specify the coordinates of the new origin or click on the screen using the pointing device. The **Origin** option is not displayed at the Command prompt as an option for the **UCS** command. Therefore, you have to choose the **Origin** button from the **UCS** toolbar. Alternatively, choose the **Origin** tool from the **Coordinates** panel to specify the coordinates of the new origin. The prompt sequence that will follow when you choose this tool is given next.

Specify new origin point <0,0,0>: *Specify the origin point, as shown in Figure 1-20.*



Tip

If you do not provide the Z coordinate for the origin, the current Z coordinate value will be assigned to the UCS.

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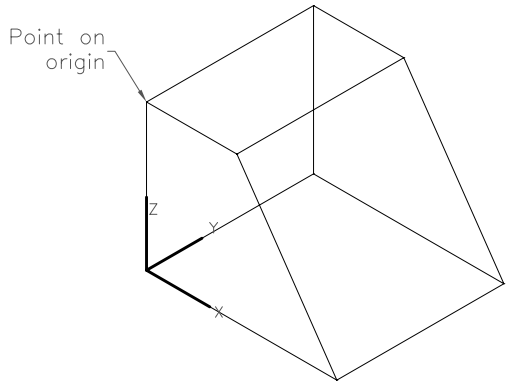


Figure 1-20 *Defining a new origin for the UCS*

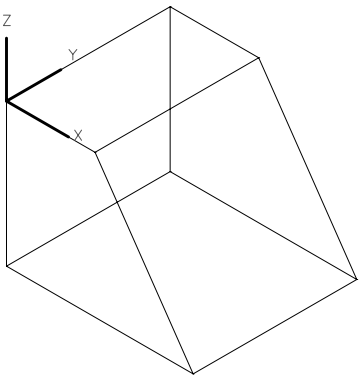


Figure 1-21 *Relocating the UCS for the new origin*

3-Point Option

The **3-Point** option is the default option of the **UCS** command. With this option, you can establish a new coordinate system by specifying a new origin point, a point on the positive side of the new *X* axis, and a point on the positive side of the new *Y* axis, refer to Figure 1-22. The direction of the *Z* axis is determined by applying the right-hand rule about which you will learn in the next chapter. This option can also be used to align the UCS at any angled surface. The prompt sequence that will follow when you choose the **3-Point** tool from the **Coordinates** panel is given next.

Specify new origin point <0,0,0>: *Specify the origin point of the new UCS.*
Specify point on positive portion of X-axis <default>: *Specify a point on the positive portion of the X axis.*
Specify point on positive-Y portion of the UCS XY plane<default>: *Specify a point on the positive portion of the Y axis.*

A null response to the **Specify new origin point <0,0,0>** prompt will lead to a coordinate system in which the origin of the new UCS is identical to that of the previous UCS. Similarly, null responses to the point on the *X* or *Y* axis prompt will lead to a coordinate system in which the *X* or *Y* axis of the new UCS is parallel to that of the previous UCS. In Figure 1-23, the UCS has been relocated by specifying three points (the origin point, a point on the positive portion of the *X* axis, and a point on the positive portion of the *Y* axis).

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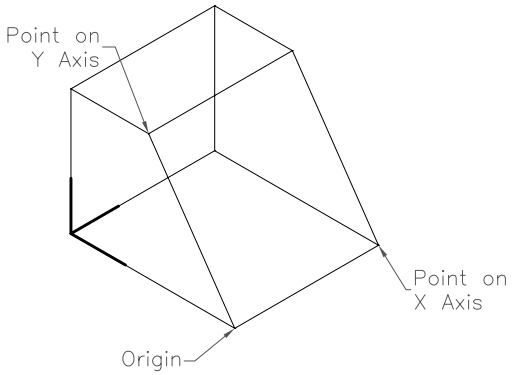


Figure 1-22 *Relocating the UCS using the* ***3-Point*** *option*

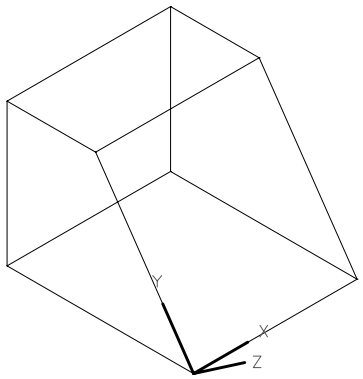


Figure 1-23 *UCS at a new position*

Example 1 *3-Point*

In this example, you will draw a tapered rectangular block. After drawing it, you will align the UCS with the inclined face of the block by using the dynamic alignment. Next, you will draw a circle on the inclined face. The dimensions for the block and the circle are shown in Figure 1-24.

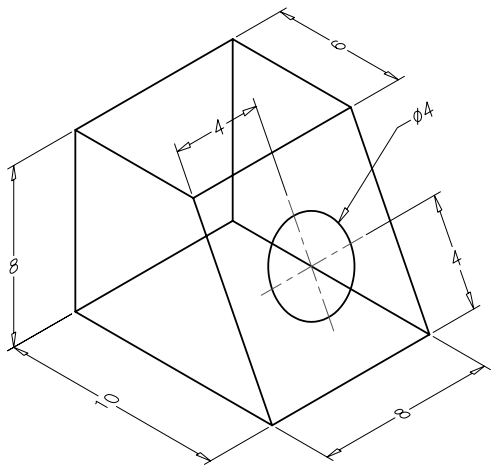


Figure 1-24 *Model for Example 1*

The steps to do this example are given next.

- Draw the edges of the bottom face of the tapered block.
- Specify a new origin.
- Draw the edges of the top face of the tapered block.
- Draw the remaining edges of the block.

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- Align the UCS to the inclined face.
- Draw the circle on the inclined face.

These steps are discussed next.

1. Start a new drawing and choose the **Line** tool. The prompt sequence is given next.

Specify first point: **1,1**
Specify next point or [Undo]: **@10,0**
Specify next point or [Undo]: **@0,8**
Specify next point or [Close/Undo]: **@-10,0**
Specify next point or [Close/Undo]: **C**

2. As the top face of the model is at a distance of 8 units from the bottom face in the positive *Z* direction, you need to define a UCS at a distance of 8 units to create the top face. To do so, select the UCS and then move the cursor to the rectangular grip displayed at the intersection of the three axes; a shortcut menu will be displayed. Choose the **Move Origin Only** option; AutoCAD will prompt you to specify a new origin point. The prompt sequence is as follows:

Specify origin point : **0,0,8**

3. Choose the **Line** tool from the **Draw** panel. The prompt sequence is as follows:

Specify first point: **1,1**
Specify next point or [Undo]: **@6,0**
Specify next point or [Undo]: **@0,8**
Specify next point or [Close/Undo]: **@-6,0**
Specify next point or [Close/Undo]: **C**

4. When you open a new drawing, you view the model from the top view by default. Therefore, when viewing from the top, the three edges of the top side overlap with the corresponding bottom edges. As a result, you will not be able to see all the edges. However, you can change the viewpoint to clearly view the model in 3D. Choose **SE Isometric** from the **View Controls** list in the **In-Canvas Viewport Controls** to orient the view to the SE isometric view. Now, you can see the 3D view of the objects, refer to Figure 1-25.

5. Join the remaining edges of the model using the **Line** tool.The model after joining all edges should look similar to the one shown in Figure 1-26.

Now, dynamic alignment of UCS can be done with a surface, a mesh, and a solid face but the inclined portion is a wire frame. So, you need to convert the wire frame into a surface by using the **Region** tool.

6. Invoke the **Region** tool from the **Draw** panel in the **Home** tab; AutoCAD will prompt you to select objects for generating a region. Next, select the four edges bounding the inclined face and press ENTER; a region will be generated.

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7. Next, select the UCS and place the cursor on the rectangular grip; a shortcut menu will be displayed. Choose the **Move and Align** option from the shortcut menu; you will be prompted to select a face, surface, or mesh.

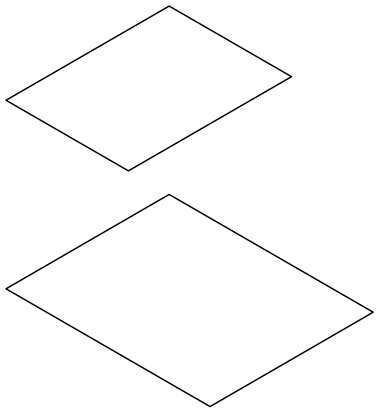


Figure 1-25 *3D view of the objects*

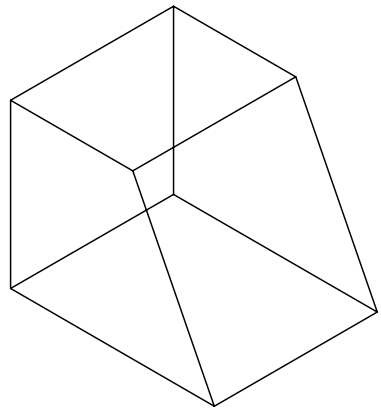


Figure 1-26 *Model after joining all the edges*

8. Select the inclined face by moving through the edge to which you want the X axis to be parallel or you can align the axes by dynamically rotating them. In this case, the X axis is parallel to P1P2 line, refer to Figure 1-27.

9. Choose the **Center, Radius** tool from the **Circle** drop-down in the **Draw** panel and draw the circle on the inclined face.

The final model should look similar to the one shown in Figure 1-28.

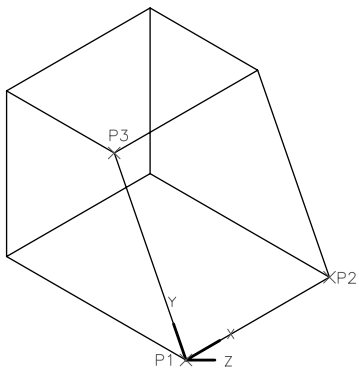


Figure 1-27 *Model after aligning the UCS on the inclined face*

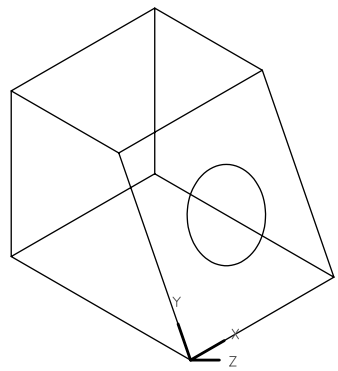


Figure 1-28 *Final model for Example 1*

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MANAGING THE UCS THROUGH THE DIALOG BOX

Ribbon: Visualize > Coordinates > UCS, Named UCS **Command:** UCSMAN
Menu Bar: Tools > Named UCS



In AutoCAD, you can save and restore the UCS by using the **UCS, Named UCS** tool from the **Coordinates** panel. On choosing this tool, the **UCS** dialog box will be displayed, as shown in Figure 1-29. This dialog box is used to restore the saved and orthographic UCSs, specify the UCS icon settings, and rename UCSs. This dialog box has three tabs: **Named UCSs**, **Orthographic UCSs**, and **Settings**. These tabs are discussed next.

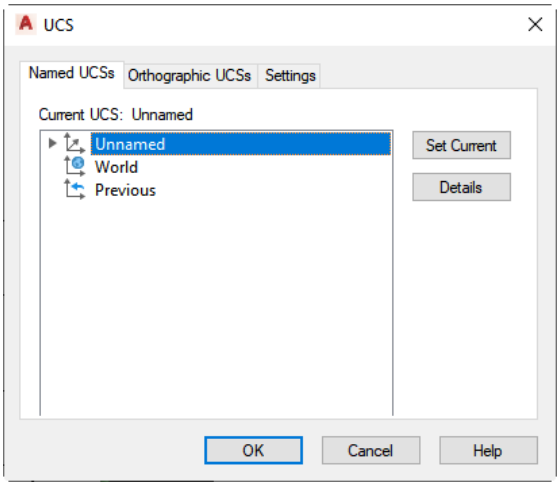


***Figure 1-29** The **Named UCSs** tab of the **UCS** dialog box*

Named UCSs Tab

The list of all coordinate systems defined (saved) on your system is displayed in the list box of the **Named UCSs** tab. The first entry in this list is **World**, which means WCS. The next entry will be **Previous**, if you have defined any other coordinate systems in the current editing session. Selecting the **Previous** entry and then choosing the **OK** button repeatedly allows you to go backward through the coordinate systems defined in the current editing session. If you have created a new UCS as the current coordinate system and not named it, then **Unnamed** will be the first entry in the list. Double-click on the name and rename it. Else, the unnamed UCS will disappear on selecting other UCS. If there are a number of viewports and unnamed settings, only the current viewport UCS name will be displayed in the list. The current coordinate system is indicated by a small pointer icon to the left of the coordinate system's name. The name of the current UCS is also displayed next to **Current UCS** on top of this list box. To make other coordinate system current, select its name in the list, choose the **Set Current** button, and choose the **OK** button. Alternatively, select the required UCS from the **Named UCS Combo Control** drop-down list available in the **Coordinates** panel of the **Visualize** tab. To delete a coordinate system created previously, select its name, and then right-click to display a shortcut menu. Choose the **Delete** option to delete the selected UCS name. To rename a coordinate system, select its name and then right-click to display a shortcut menu and choose **Rename**. Now, enter the new name. You can also double-click on the name you need to modify, and then change the name. The other options in the shortcut menu are **Set Current** and **Details**.

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Tip

All the changes and updating of the UCS information in the drawing are carried out only after you choose the ***OK*** *button.*

If you want to check the current coordinate system's origin and *X*, *Y*, and *Z* axis values, select a UCS from the list and then choose the **Details** button; the **UCS Details** dialog box containing that information is displayed, refer to Figure 1-30. Alternatively, right click on the name of the specific UCS in the list box and then choose the **Details** option from the shortcut menu.

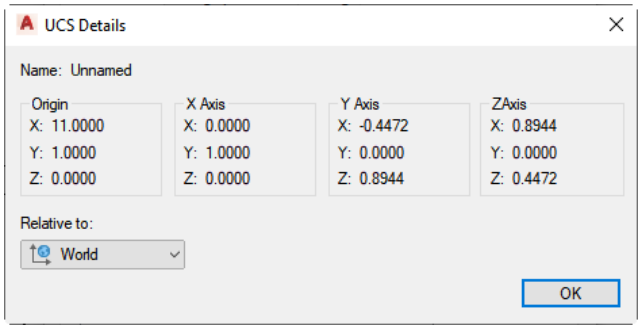


Figure 1-30 *The* ***UCS Details*** *dialog box*

Orthographic UCSs Tab

Different orthographic views are listed in the **Orthographic UCSs** tab, as shown in Figure 1-31. You can select any one of the six orthographic views of the WCS or the user defined coordinate system using the **UCS** dialog box. To define an orthographic coordinate system relative to a UCS, select it from the **Relative to** drop-down list. Next, select the orthographic view from the list of preset orthographic views, and then choose the **Set Current** button; the UCS icon is placed at the corresponding view. You can also right-click on the specific orthographic UCS name in the list and choose **Set Current** from the shortcut menu. The name of the current UCS is displayed above the list of orthographic view. If the current settings have not been saved and named, the **Current UCS** name displayed is **Unnamed**.

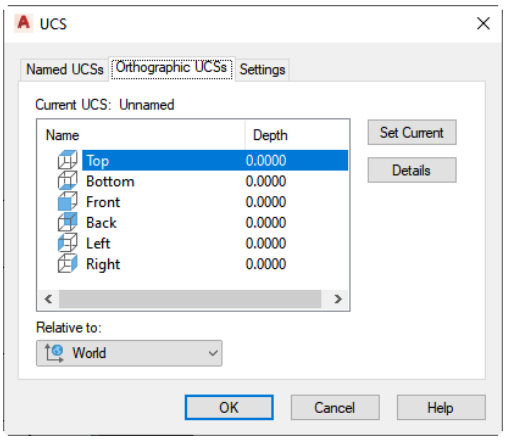


Figure 1-31 *The* ***Orthographic UCSs*** *tab of the* ***UCS*** *dialog box*

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The **Depth** field in the list box of this dialog box displays the distance between the *XY* plane of the selected orthographic UCS setting and the parallel plane passing through the origin of the UCS base setting. The **UCSBASE** system variable stores the name of the UCS, which is considered as the base setting; that is, it defines the origin and orientation. You can enter or modify the values of depth by double-clicking on the depth value of the selected UCS in the list box.

On doing so, the **Orthographic UCS depth** dialog box will be displayed, where you can enter new depth values, refer to Figure 1-32. You can also right-click on a specific orthographic UCS in the list box to display a shortcut menu. Choose **Depth** to display the **Orthographic UCS depth** dialog box. Enter a value in the edit box. If you need to pick a position from the drawing area, choose the **Select new origin** button available next to the edit box; the dialog box will disappear allowing you to specify a new origin or depth on the screen.

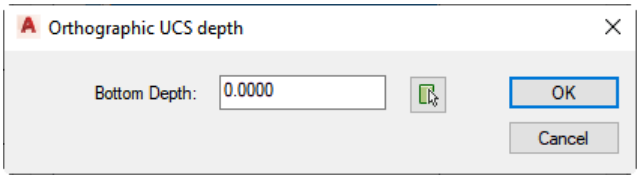


Figure 1-32 *The* ***Orthographic UCS depth*** *dialog box*

Choosing the **Details** button displays the **UCS Details** dialog box with the origin and the *X*, *Y*, *Z* coordinate values of the selected UCS. You can also choose **Details** from the shortcut menu that is displayed on right-clicking on a UCS in the list box. The shortcut menu also has the **Reset** option. Choosing **Reset** from the shortcut menu restores the selected UCS to its default settings. Also, the depth value, if assigned, becomes zero.

Settings Tab

The **Settings** tab of the **UCS** dialog box, refer to Figure 1-33, is used to display and modify the UCS and UCS icon settings of a specified viewport. If you choose the inclined arrow on the **Coordinates** panel, the **UCS** dialog box will be displayed with the **Settings** tab chosen. The options in this dialog box are discussed next.

UCS Icon settings Area

Selecting the **On** check box displays the UCS icon in the current viewport. This process is similar to using the **UCSICON** command and enables you to set the display of the UCS icon to on or off. If you select the **Display at UCS origin point** check box, the UCS icon is displayed at the origin point of the coordinate system in use in the current viewport. If the origin point is not visible in the current viewport, or if the check box is cleared, the UCS icon is displayed in the lower left corner of the viewport. Selecting the **Apply to all active viewports** check box applies the current UCS icon settings to all the active viewports in the current drawing.

UCS settings Area

This area of the **Settings** tab in the **UCS** dialog box specifies the UCS settings for the current viewport. Selecting the **Save UCS with viewport** check box saves the UCS with the viewport. This setting is stored in the **UCSVP** system variable. If you clear this check box, the **UCSVP** variable will be set to 0 and the UCS of the viewport will reflect the UCS of the current viewport. When you select the **Update view to Plan when UCS is changed** check box, the plan view is restored

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after the UCS in the viewport is changed. When the selected UCS is restored, the plan view is also restored. The value is stored in the **UCSFOLLOW** system variable.

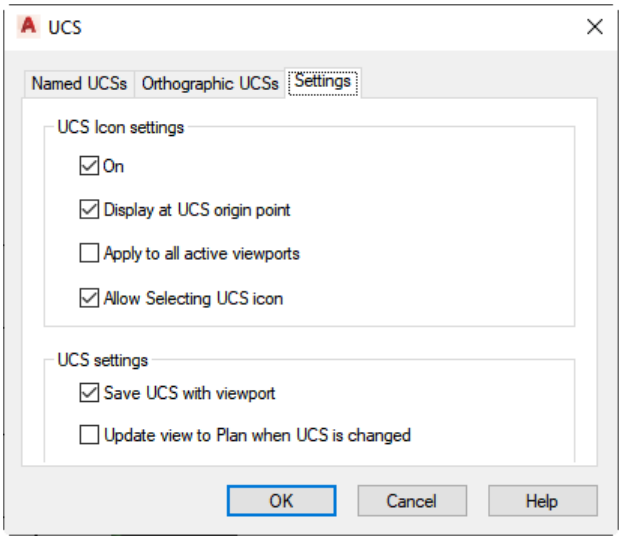


Figure 1-33 *The* ***Settings*** *tab of the* ***UCS*** *dialog box*

SYSTEM VARIABLES

The coordinate value of the origin of the current UCS is held in the **UCSORG** system variable. The *X* and *Y* axis directions of the current UCS are held in the **UCSXDIR** and **UCSYDIR** system variables, respectively. The name of the current UCS is held in the **UCSNAME** variable. All these variables are read-only. If the current UCS is identical to the WCS, the **WORLDUCS** system variable is set to 1; otherwise, it holds the value 0. The current UCS icon setting can be examined and manipulated with the help of the **UCSICON** command. This command defines the UCS icon setting of the current viewport. If more than one viewport is active, each one can have a different value for the **UCSICON** variable. If you are in paper space, the **UCSICON** variable will contain the setting for the UCS icon of the paper space. The **UCSFOLLOW** system variable controls the automatic display of a plan view when you switch from one UCS to another. If **UCSFOLLOW** is set to 1 and you switch from one UCS to another, a plan view is automatically displayed. The **UCSAXISANG** variable stores the default angle value for the *X*, *Y*, or *Z* axis around which the UCS is rotated using the ***X***, ***Y***, ***Z*** options of the **UCS** command. The **UCSBASE** variable stores the name of the UCS that acts as the base; that is, it defines the origin and orientation of the orthographic UCS setting. The **UCSVP** variable decides whether the UCS settings are stored with the viewport or not.

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Self-Evaluation Test

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

1. By default, the _____ is established as the coordinate system in the AutoCAD environment.

2. The _____ coordinate system can be moved to and rotated about any desired location.

3. Once a saved UCS is restored, it becomes the _____ UCS.

4. You can change the 3D UCS icon to a 2D UCS icon using the _____ radio button of the **UCS Icon** dialog box.

5. The _____ point of the 3D face defines the origin of the new UCS.

6. In dynamic alignment of UCS for a flat planar face, the _____ will always be parallel to the edge through which the UCS is moved on the face.

7. You can move the World Coordinate System from its original position. (T/F)

8. The **View** tool in the **Align UCS** drop-down of the **Coordinates** panel of the **Visualize** tab is used to define a new UCS whose *XY* plane is parallel to the current viewing plane. (T/F)

9. An ellipse cannot be used as an object for defining a new UCS. (T/F)

10. While moving the UCS, if you do not specify the *Z* coordinate of the new point, the previous *Z* coordinate will be taken for the new value. (T/F)

Review Questions

Answer the following questions:

1. Which of the following options is used to restore the previous UCS settings?

   (a) **ZAxis** (b) **Restore**
   (c) **Previous** (d) **Save**

2. Which of the following options is used to list names of all the saved UCSs?

   (a) **ZAxis** (b) **Restore**
   (c) **?** (d) **Save**

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3. Which of the following system variables is used to control the automatic display of the plan view when you switch to the new UCS?

   (a) **UCSORG** (b) **UCSFOLLOW**
   (c) **UCS** (d) **UCSBASE**

4. Which of the following system variables is used to store the coordinates of the origin of the current UCS?

   (a) **UCSICON** (b) **UCSORG**
   (c) **UCSVP** (d) **UCSFOLLOW**

5. Which of the following tools is used to manage the UCS using a dialog box?

   (a) **UCS Icon, Properties** (b) **UCS, Named UCS**
   (c) **UCS** (d) **UCS, World**

6. The _____ variable is used to control the *X* axis direction of the current UCS.

7. The _____ direction is known as the extrusion direction.

8. The lineweight of the UCS icon can be changed using the _____ option of the **UCS Icon** dialog box.

9. The _____ option of the **UCS** command is used to change the origin of the current UCS.

10. The _____ variable is used to control the *Y* axis direction of the current UCS.

11. The _____ variable is used to store the default angle value by which the UCS will be rotated.

12. You can change the line width of the UCS icon. (T/F)

13. The size of the UCS icon can vary between 5 and 100. (T/F)

14. The name of the current UCS is stored in the **UCSNAME** variable. (T/F)

15. The selection of the UCS can be controlled by using the options in the **Settings** tab of the **UCS** dialog box. (T/F)

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Exercises 1 through 4

Draw the objects shown in Figures 1-34 through 1-37. Use the **UCS** tools to align the UCS icon and then draw the objects.

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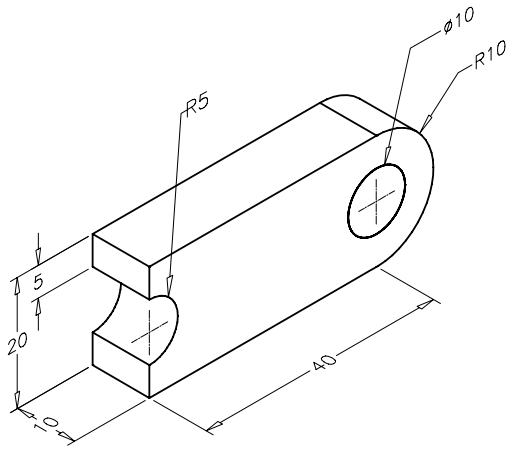


Figure 1-34 *Drawing for Exercise 1*

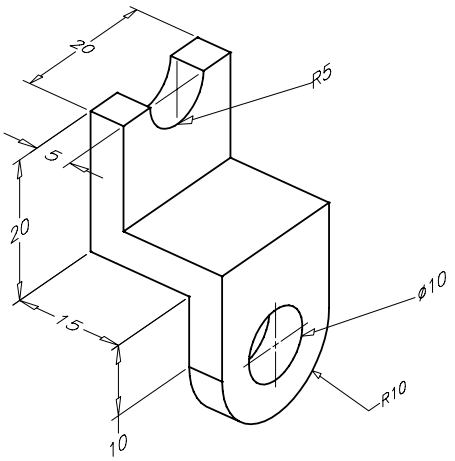


Figure 1-35 *Drawing for Exercise 2*

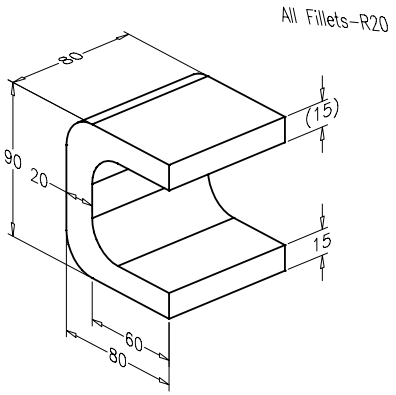


Figure 1-36 *Drawing for Exercise 3*

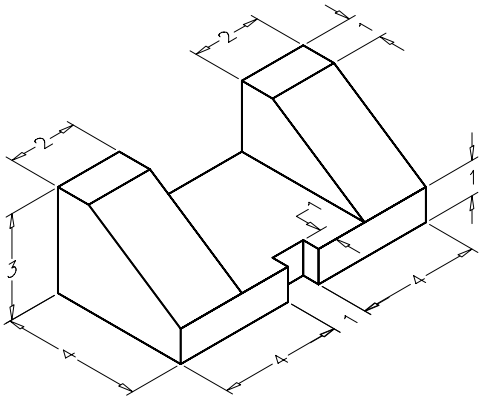


Figure 1-37 *Drawing for Exercise 4*

Exercise 5

Create the drawing shown in Figure 1-38. Align the UCS icon and then draw the objects. Note that in this drawing the left side of the transition should make a 90-degree angle with the bottom.

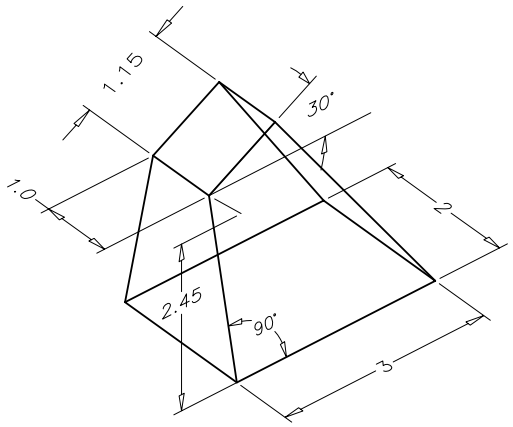


Figure 1-38 *Model for Exercise 5*

Exercise 6

Create the drawing shown in Figure 1-39. Position the UCS icon and then draw the objects. Note that in this drawing, the center of the top polygon is offset at 0.75 units from the center of the bottom polygon.

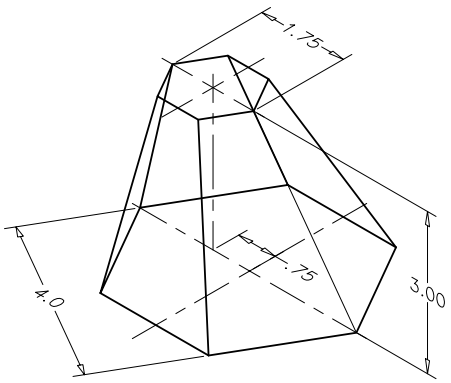


Figure 1-39 *Model for Exercise 6*

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Exercises 7 and 8

In these exercises, you will create the drawing shown in Figures 1-40 and 1-41. Figure 1-42 shows the front view of the model for Exercise 8.

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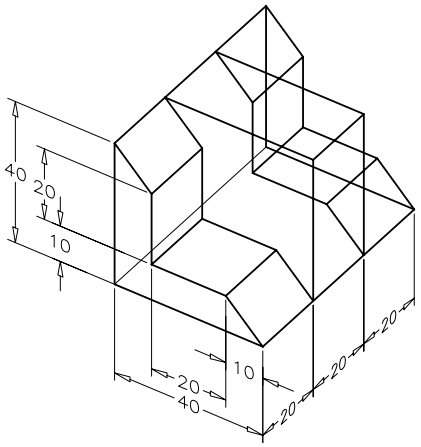


Figure 1-40 *Model for Exercise 7*

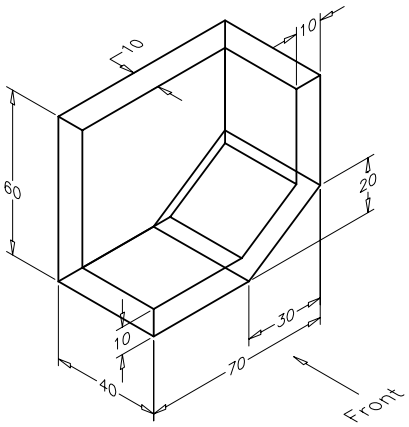


Figure 1-41 *Model for Exercise 8*

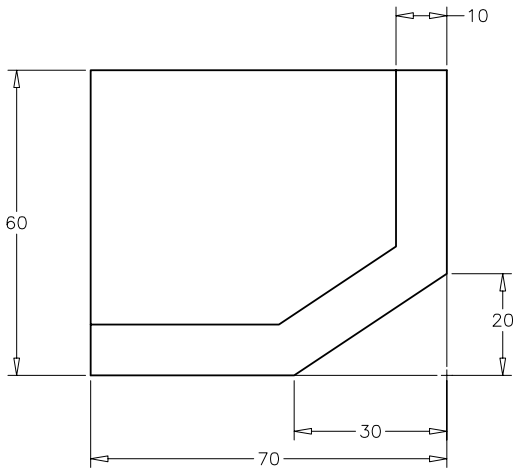


Figure 1-42 *Front view of the Model for exercise 8*

Answers to Self-Evaluation Test

1. World Coordinate System, **2.** user, **3.** current, **4.** 2D, **5.** first, **6.** X axis, **7.** F, **8.** T, **9.** F, **10.** T