C h a p t e r

5

Solid Problem Four

In this chapter, you will learn the following to World Class standards:

- **Sketch of Solid Problem Four**
- **Starting a 3D part drawing**
- **Drawing a solid cylinder**
- **Union of four solids**
- **Placing an curved edge on a solid using the Fillet Tool**
- **Drawing a solid box**
- **Adding a construction line**
- **Moving a solid within the master solid**
- **Copying and rotating a solid using Grips**
- **Adding circles to be extruded**
- **Subtracting two solids from the master solid**
- **Saving the solid problem**

Sketch of Solid Problem Four

_____

You start the fourth solids problem with a rough sketch showing the dimensions of each detail. This part is symmetrical across the x-axis and y-axis. In this exercise, you will draw 4 concentric cylinders, stacking each one on top of each other, union them, and then subtract two simple boxes to detail the teeth on top of the cylindrical section. There are two areas on top of the larger cylinders which will have a rounded edge. Use the dimensions that are shown in the sketch in Figure 5.1.
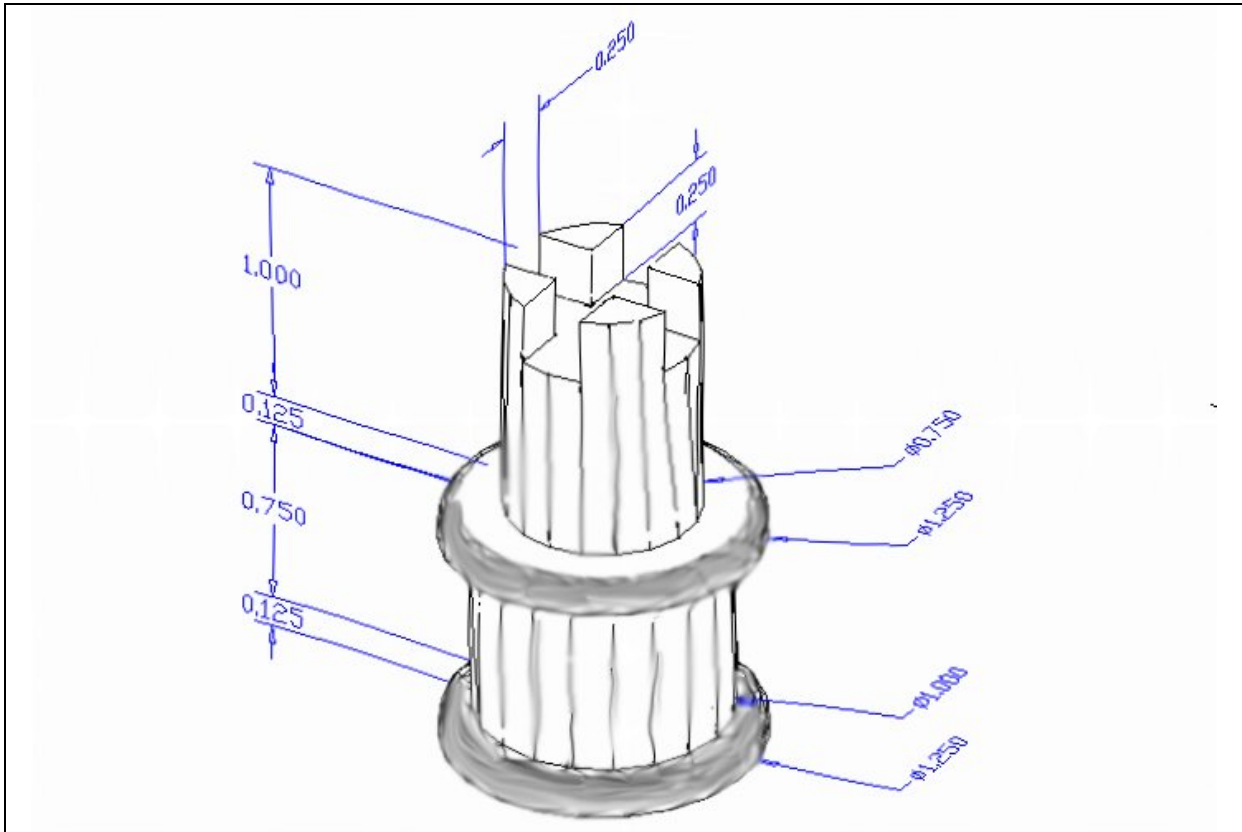

Figure 5.1 – Problem Four sketch

When you receive a sketch from a professional, quickly identify the complex shapes and decide how to begin your drawing. Problem Four has four different cylinders of different diameters and heights, so you will create each one sequentially and then union them together. This problem will address basic solid parts that have different complexities with each additional component built on the previous part.

The stacking technique of creating a master solid is as popular as any and may often be more common when building a XREF assembly of more than one solid. This problem will give you plenty of practice using cylinders. All of the drills in the Fundamentals of 3D Drawing textbook will walk you through such common repetitive maneuvers that you will use often in 3D modeling.

Starting a 3D Part Drawing

_____

You will draw Problem Four using the Mechanical template. First select the New tool on the Quick Access Toolbar. A list of templates is loaded in the "Select template" window. Scroll down the list and select Mechanical.dwt. A new drawing file will open that contains the system variables and layer definitions which you will use later in Paper Space to finish the drawing.
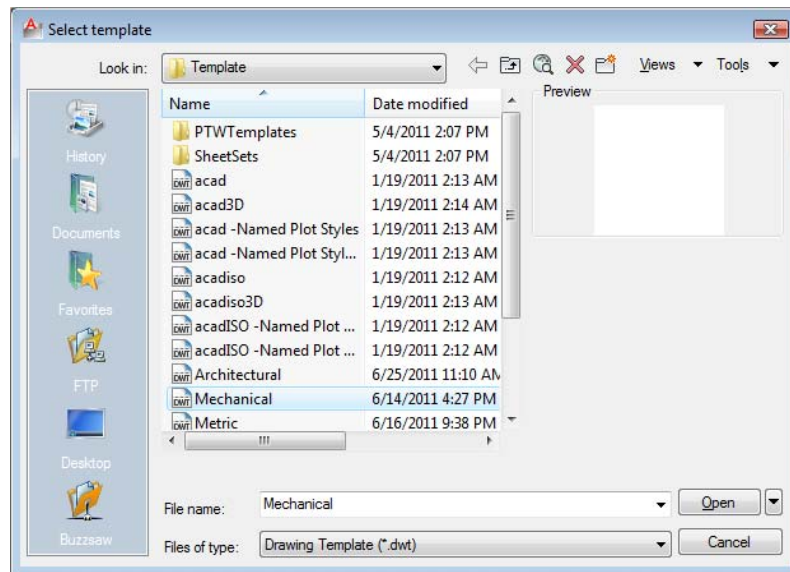

Figure 5.2 – Starting the drawing using the Mechanical template

On the View panel, select the Southwest Isometric View tool which allows you to see the part on the XY plane and the vertical Z-axis will rise upward.

Drawing a Solid Cylinder

_____

In problem three, you used the 2D circle command to create circles that you then extruded into cylinders. In this exercise you will use a 3D solid command to create cylinders with just one tool. Select the Southwest Isometric view from the View panel to get started.

```
Command: _cylinder
Specify center point of base or [3P/2P/Ttr/Elliptical]:
Specify base radius or [Diameter]: D
Specify diameter : 1.25
Specify height or [2Point/Axis endpoint]: 0.125
```

Figure 5.3 – Cylinder command line prompts

Pick the Cylinder command from the Modeling panel tool beneath the drop-down arrow under the Box tool. Specify the center point for the base of the cylinder anywhere in the lower center of the graphical display. Notice that you can type "E" for elliptical to create a cylinder with an oval shape as opposed to a circular one. For this problem you do not need to create an elliptical cylinder, so type "**D"** for diameter and hit **ENTER** to input the sketch's measurement of **1.25**. Hit **ENTER** to advance to the next prompt, which is to "specify the height of the cylinder." Type **0.125** and **ENTER**. The complete command line sequence is shown in Figure 5.3. The first of four cylinders will appear in the graphical display as shown in Figure 5.4.
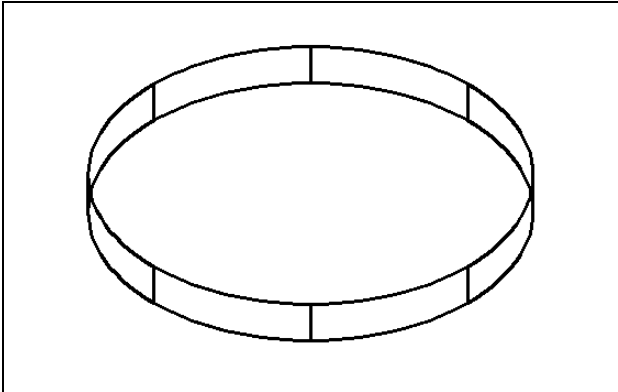

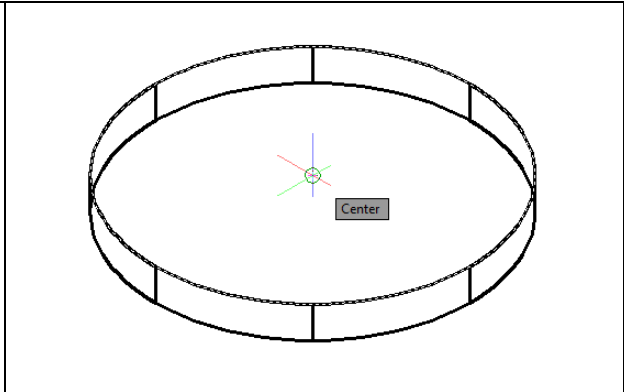**Figure 5.4 – The first cylinder**   **Figure 5.5 – Picking the top center point**

To draw the second cylinder, hit **ENTER** to repeat the command. Specify the center point for the base of the next cylinder by referencing the center Osnap of the top face of the first cylinder; you may need to bring your cursor to the top edge of the cylinder to get the center symbol to appear. Type "**D"** for diameter and **ENTER** to input the measurement from the sketch of **1.00**. Hit **ENTER** to advance to the next prompt, which is "specify the height of the cylinder". Key in **0.75** for the height and hit **ENTER**. The second of four cylinders will appear on the top of the first in the graphical display as shown in Figure 5.6.
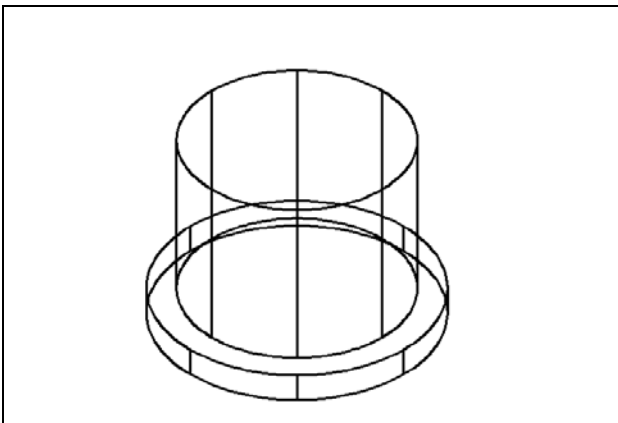

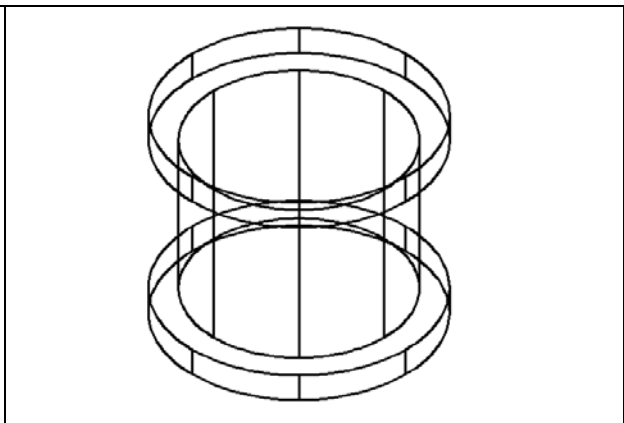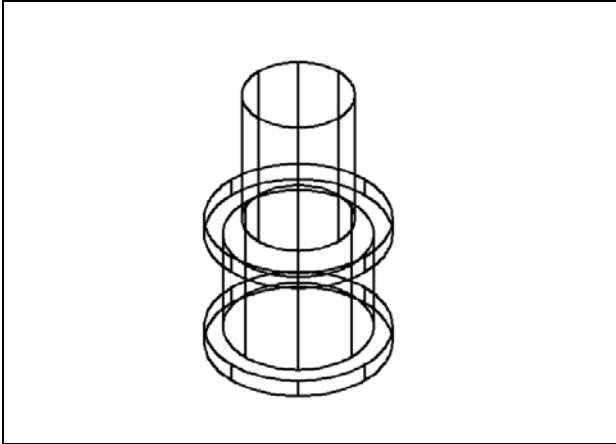**Figure 5.6 – Adding the second cylinder**   **Figure 5.7 – Adding the third cylinder**

Hit **ENTER** to repeat the Cylinder command again. Specify the center point for the base of the cylinder as the top of the second circular solid using the Center Osnap. Type "**D"** for

diameter and **ENTER**, and then input the sketch's measurement of **1.25**. Hit **ENTER** to advance to the next prompt, which is "specify the height of the cylinder". Type **0.125** and **ENTER**. The third of four cylinders will appear on the top of the second in the graphical display as shown in Figure 5.7.


To draw the fourth cylinder, hit **ENTER** to repeat the Cylinder command once more. Specify the center point for the base as the top of the third cylinder using the Center Osnap. Type "**D"** for diameter and hit **ENTER**, and then input the sketch's measurement of **0.75**. Hit **ENTER** to advance to the next prompt, which is "specify the height of the cylinder". Type **1.0** and **ENTER**. The last of four cylinders appears on the top of the third in the graphical display as shown in Figure 5.8.

Figure 5.8 – Adding the fourth cylinder

Union of Four Solids

_____

Now you will use the Boolean command Union to join all four cylinders together into one complex 3D solid.
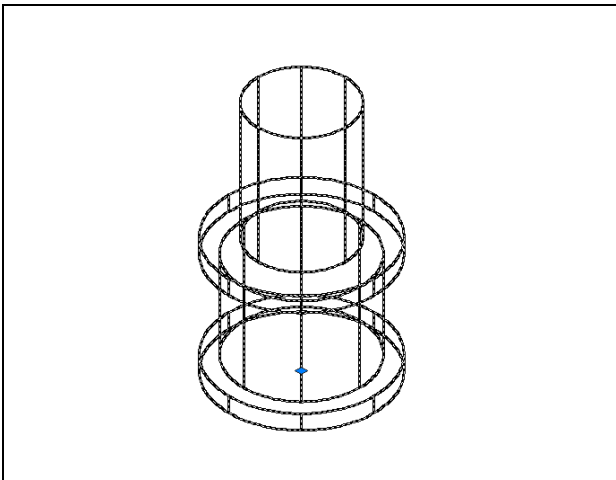
To add all four solids together, select the Union tool on the Solid Editing panel. You will be prompted to "Select objects". Select all four cylinders and the system will respond with "4 found". Hit **ENTER** and the solids will join into one entity as shown in Figure 5.9. You cannot see any difference one the graphical display because the tessellation lines outlining all the cylinders are still physical edges to the single solid. To test your work, select the solid with one pick of the mouse and the entire solid will become highlighted.

Figure 5.9 – The single solid, shown selected

Placing a Curved Edge on a Solid Using the Fillet Tool

_____

To place a fillet or curve on two converging straight lines in the Fundamentals of 2D Drawing, you selected both lines to identify the position of the radius. When placing a three dimensional curve on a solid, you just pick the edge that represents the corner where the two lines meet. In this case, you will put a curvature on two of the top edges of the solid.
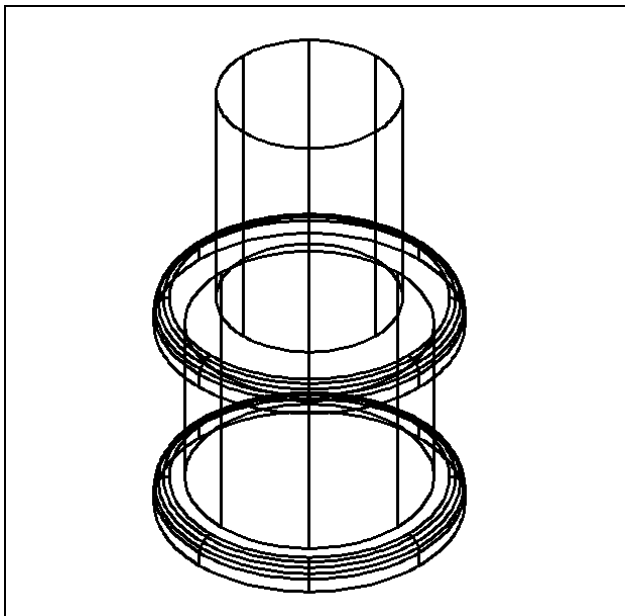
Select the Fillet tool on the Modify panel. Type an "**R**" for radius and then **0.0625** for the measurement. Also, type **"**M**"** because you will be place multiple fillets on the solid. Now pick the top edge of the first cylinder, hit **ENTER**, and the line will become dashed. At the prompt, "**Enter fillet radius or [Expression] <0.06250>:**" just hit **ENTER** again because you have already specified the default radius value. Select the top edge of the other 1.25 cylinder and hit **ENTER**. The hard corners become 0.0625 curvatures as shown in Figure 5.10.

Figure 5.10 – The two filleted edges

Drawing a Solid Box

_____

Like in previous exercises, you will utilize the Length option of the Box command. Type **L** after specifying a corner on the graphical display **to** the left of the master solid and the system will ask three questions. The first prompt is "Specify Length": type a number and hit ENTER to designate the length on the **X axis**. The second prompt is "Specify Width": type a number and hit ENTER to designate the length on the **Y axis**. The third prompt is "Specify Height": type a number and hit ENTER to designate the length on the **Z axis**.
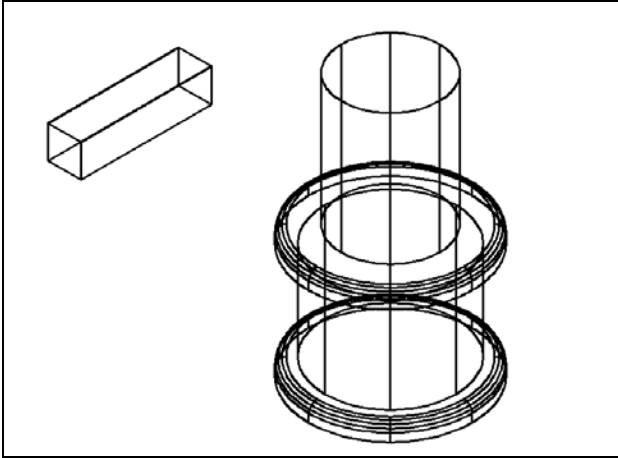
Select the Box tool from the Modeling panel. When you are prompted to specify the corner of the box at the command line, specify any point to the left of the master solid as shown in Figure 5.11. Type L after specifying the starting point and the system will ask you three questions. Type 1.0 and ENTER to "Specify Length". Type 0.25 and ENTER to "Specify Width". Type .25 and ENTER to "Specify Height". The box will appear as shown in Figure 5.11.

Figure 5.11 – Drawing a solid box

Moving a Solid onto the Master Solid

_____

Remember that the Move command is actually a three dimensional function and you can use the tool to relocate any entity to another point (X,Y,Z) in Model Space. In the Fundamentals of 2D Drawing textbook, periodically you drew a construction line to assist in the placement or modification of an entity. In this exercise you will use a construction line to establish the center of the top face of the solid box so that you can reference that point when placing the box on top of the master solid. Do not forget to erase the construction line after moving the part.
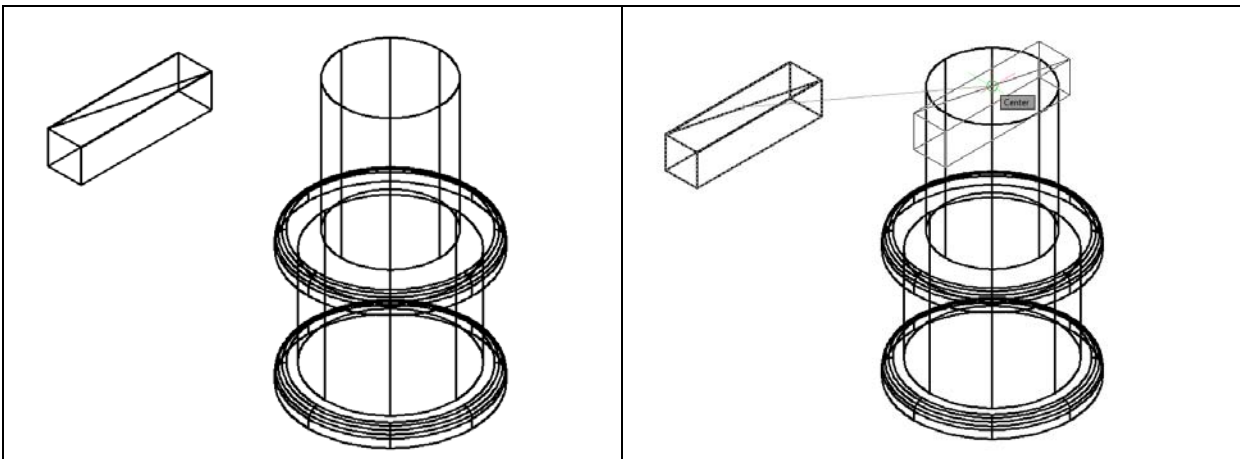

Figure 5.12 – Adding a Construction Line   **Figure 5.13 – Moving the Box and Line**

First select the Line tool on the Draw panel. Using endpoint Osnaps, draw a diagonal line diagonally across the top face of the solid box from one vertex to the other as shown in Figure 5.12. Hit ENTER to exit the Line command.

To move the box, select the Move tool on the Modify panel. When prompted to "Select Objects" pick the solid box and the line, and the command line will respond with "2 found". Hit **ENTER** to go the second part of the command. Pick the Midpoint Osnap of the construction line as your base point. Pick the Center Osnap of the top of the master solid as shown in Figure 5.13 and the solid box and line will move to that location. Finally, remove the construction line by selecting it with your cursor and hitting DELETE.

Copying and Rotating a Solid using Grips

_____

You may be familiar with using grips from some of your 2D training. Now you will use the grips to copy and rotate another solid box on top of the master solid. First, select the solid box and select the grip in the center of the top face of the box. Right click and choose the Copy command from the menu that appears (Figure 5.14). Now copy the box into the same position as the original box. Select the box again, select the center grip, right click, and then select the Rotate command from the menu. Making sure that the Ortho mode is on you can easily rotate the copied box 90 degrees (Figure 5.15).
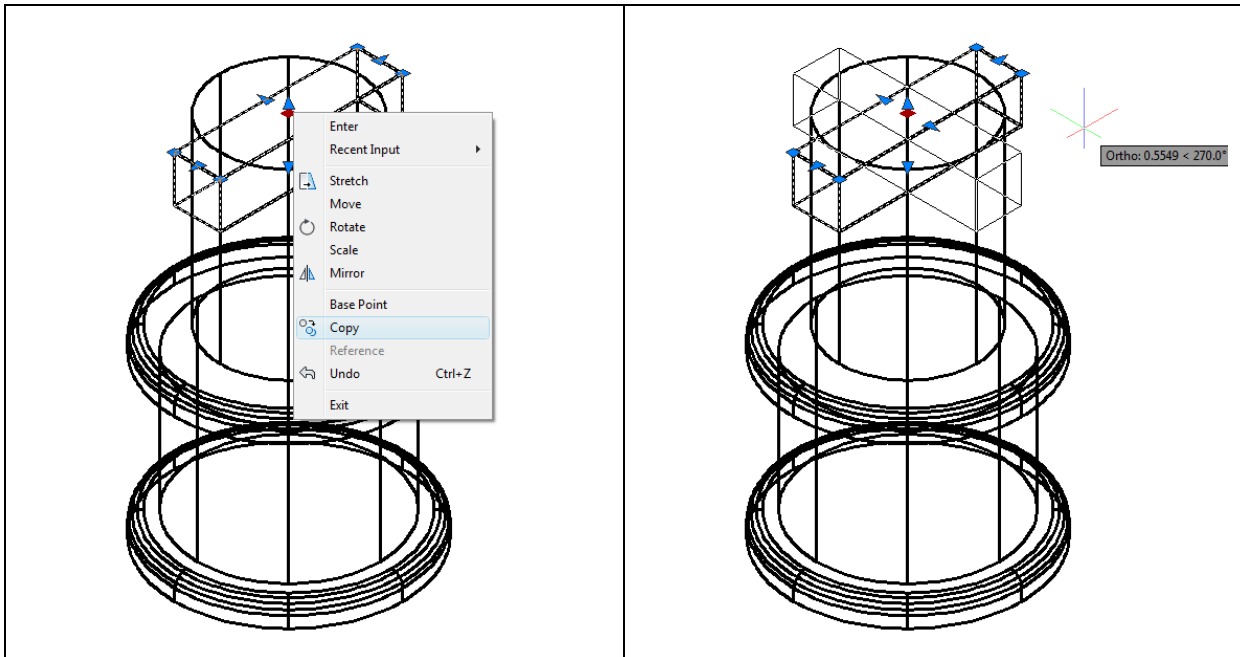
Figure 5.14 – Moving the Box and Line   **Figure 5.15 – Moving the Box and Line**

Subtracting a 3D Solid from Another Solid

_____

To remove the smaller solid boxes from the master solid, select the Subtract tool on the Solid Editing panel.

When prompted to "Select solids and regions to subtract from", select the larger master solid as shown in Figure 5.16 and the system will respond with "1 found". Hit ENTER and when prompted to "Select solids and regions to subtract" select the two solid boxes. The command line will display "2 found". Hit ENTER to remove the shape of the two solid boxes from the master solid as shown in Figure 5.17.
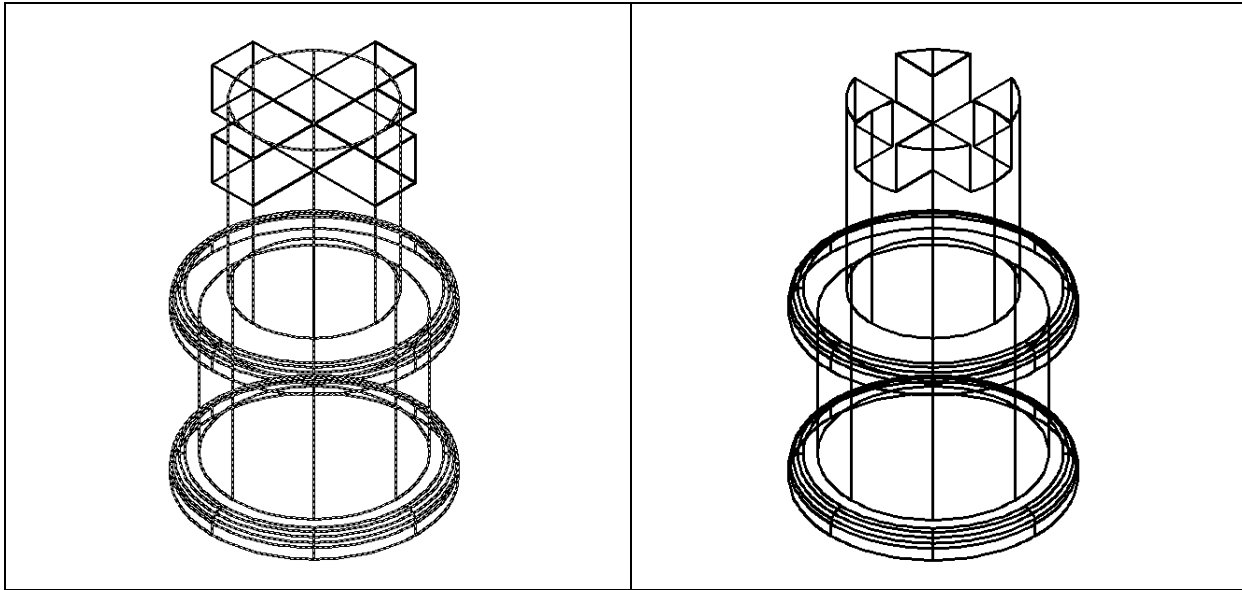

Figure 5.16 – Picking the Master Solid   **Figure 5.17 – Subtracting the Two Boxes**

Improve the View by Hiding Tessellation Lines

_____

In Figure 5.17, you will notice that the tessellation lines representing the solid's outline on the far edge of the part are visible. You would not be able to see this detail through a solid model unless the material was transparent. You can use another Visual Style to view the part in a more realistic manner.

Figure 5.18 – The Conceptual visual style

Moving the Solid to the Origin Point

_____

To move Problem Four to the drawing origin of 0,0,0 on the x, y and z axis, select the Move tool from the Modify panel under the Home tab, select the 3D solid, and hit ENTER. At the prompt "specify base point or displacement," select the center Osnap of the bottom face of the solid, which will become its insertion point into an assembly drawing. At the "second point of displacement," type 0,0,0 and ENTER, or #0,0,0 and ENTER if using Dynamic Input. Problem Four will move to the origin point. Moving a part at the origin is important for when you wish to insert the solid into an External Referenced Assembly drawing (Figure 5.19).
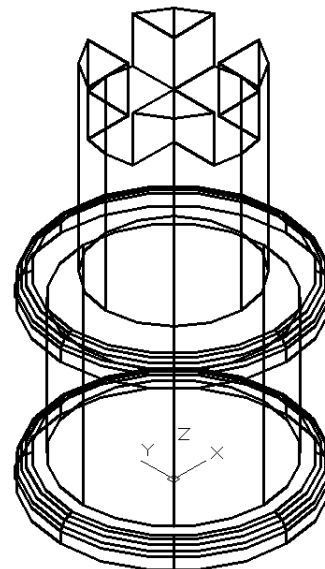
Select the Conceptual Visual Style tool beneath the first drop-down arrow on the View panel. If you wish to return the graphical display to the previous setup showing all tessellation lines, choose the first drop-down box on the View panel and click 2D Wireframe. By choosing the 2D wireframe tool, the solid part and the UCS icon will return to the previous appearance. This command does not alter the mass of the solid or any of the dimensions, but is available for the computer aided designer as a viewing option.

Figure 5.19 – Moving the Finished Solid

Saving the Solid Problem

_____

To save Problem 4 in your Fundamentals of 3D Drawing Folder, select the Save As tool on the Quick Access toolbar. The Save Drawing As window will appear in your graphical display. In the Save In list box, select your drawing folder. At the File Name textbox, type "Problem 4" and hit the Save button to save the drawing (Figure 5.20).
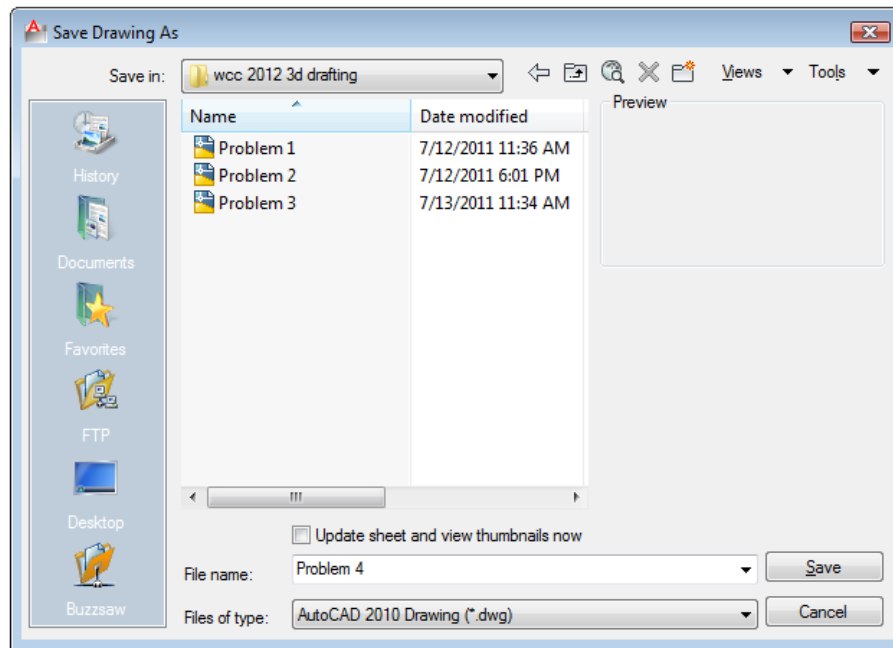

Figure 5.20 – Saving Problem Four

* World Class CAD Challenge 03-04 * - Close this drawing file. Create a New file and draw the four solid cylinders, union, draw a solid box, move and array and subtract the boxes from the master solid. Move the finished solid to the origin of the drawing. Complete the task in less than 5 minutes. Continue this drill four times, each time completing the drawing in less than 5 minutes to maintain your World Class ranking.

* World Class CAD Challenge * - Report your best times to World Class CAD at www.worldclasscad.com to obtain your world class ranking.