Chapter

5

Solid Problem Four

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

1. Sketch of Solid Problem Four
2. Starting a 3D Part Drawing
3. Drawing a Solid Cylinder
4. Combining Four Solids with Union
5. Placing an Curved Edge on a Solid Using the Fillet Tool
6. Drawing a Solid Box
7. Adding a Construction Line
8. Moving a Solid within the Master Solid
9. Creating an Array of a 3D Solid Using the Array Command
10. Adding Circles to be Extruded
11. Subtracting Two Solids from the Master Solid
12. Saving the Solid Problem

Sketch of Solid Problem Four

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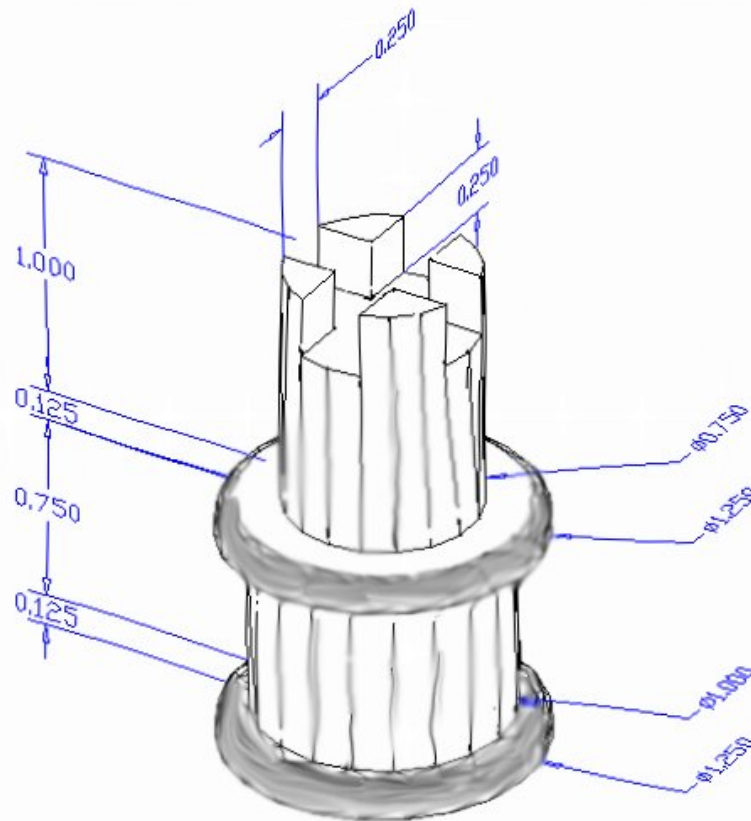

Figure 5.1 – Problem Four Sketch

When you receive a sketch from a professional, you need to practice to quickly identify the different shapes and decide how to proceed with the solid exercise. You can see rather quickly that Problem Four has four different cylinders of different diameters and heights, so separate and create each sequentially before combining them with Union. This problem will help you address basic solid parts with different complexities; each additional component is built on the previous part.

The stacking technique is as popular as any and may often be even more common when building a XREF assembly of more than one solid. This problem will give plenty of practice using cylinders. All ten drills in the Fundamentals of 3D Drawing textbook will give you those repetitive maneuvers which will make you a successful in 3D modeling.

Starting a 3D Part Drawing
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In Problem Four, you will begin the 3D drawing by selecting the New tool on the Standard Toolbar. Select the "Start from Scratch" (first button) at the top of the Start window. Choose to use English units as your Default Settings and hit OK (Figure 5.2). 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.
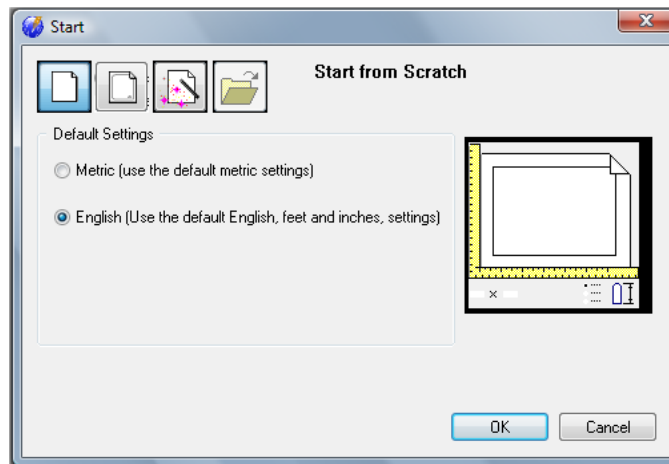

Figure 5.2 – Starting the Drawing Using the Mechanical Template

On the View toolbar, select the Southwest Isometric View tool to allow you to see the part on the XY plane with the vertical Z-axis rising upward.

Drawing a Solid Cylinder
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In problem three, you used the circle and extrude method to obtain a cylinder in a solid problem. In this exercise there will be fewer steps to building the master solid because you will draw four different cylinders on top of each other, not extruding.

```
Command : _CYLINDER
Elliptical/<Center of base of cylinder> <0,0,0>:
Diameter/<Radius of cylinder>: D
Diameter of cylinder: 1.25
Center of second end/<Height of cylinder>: 0.125
```

Figure 5.3 – The Cylinder Text from the Command Line

Pick the Cylinder tool on the Solids toolbar. Specify the center point for the base of the cylinder anywhere in the lower part of the graphical display. Notice that you can pick "E" for elliptical to create a cylinder with an oval section versus a cylindrical one. You will reserve that option for another time, so type "**D"** for diameter and hit **ENTER** to input the sketch's measurement of **1.25**. Hit **ENTER** again to continue to the next prompt, "Center of second end/<Height of cylinder>:." Key in **0.125** for the elevation of the cylinder and hit **ENTER**. The complete command line sequence is shown in Figure 5.3. The first of the four cylinders appears in the graphical display as shown in Figure 5.4.
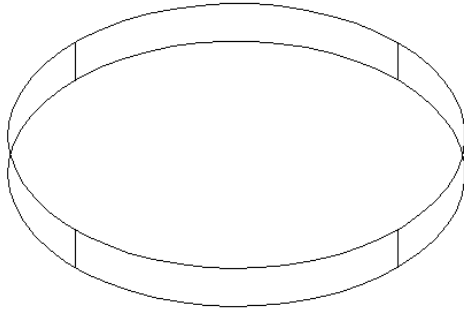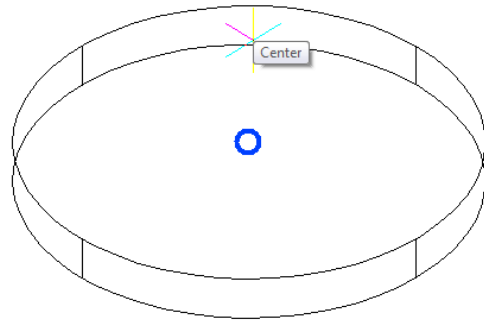
Figure 5.4 – The First Cylinder **Figure 5.5 – Picking the Center of the Top**

To draw the second cylinder, hit **ENTER** to repeat the command. Specify the center point for the base of the cylinder by using the center Esnap on top of the first cylinder (Figure 5.5) Type "**D"** for diameter and hit **ENTER** to input the sketch's measurement of **1.00**. Hit **ENTER** to go to the next prompt, which is to specify the "Center of second end/<Height of cylinder>:.". Key in **0.75** for the height of the solid 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.
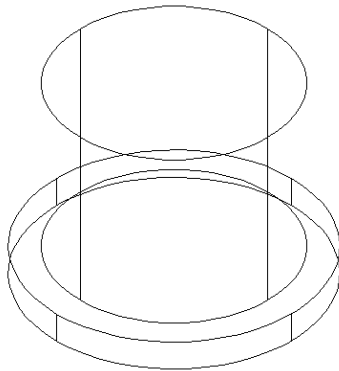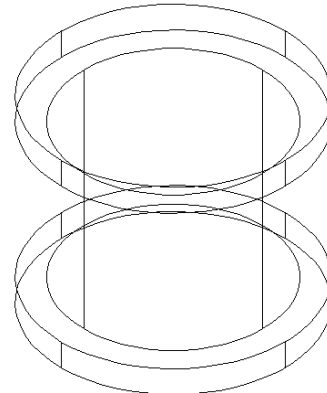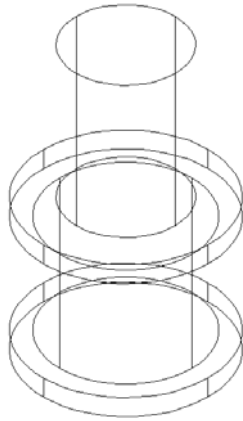

Figure 5.6 – Adding the Second Cylinder **Figure 5.7 – Adding the Third Cylinder**

To draw the third cylinder, hit **ENTER** to repeat the command. Specify the center point for the base of the cylinder by using the center Esnap on top of the second cylinder. Type "**D"** for diameter and hit **ENTER** to input the sketch's measurement of **1.25**. Hit **ENTER** to go to the next prompt, which is to specify the "Center of second end/<Height of cylinder>:.". Key in **0.125** for the height of the solid and hit **ENTER**. The third of four cylinders will appear on the top of the stack in the graphical display as shown in Figure 5.7.

To draw the fourth cylinder, hit **ENTER** to repeat the Cylinder command. Specify the center point for the base of the cylinder as the the top of the third circular solid using the Center Osnap. Type "**D**" for diameter and hit **ENTER** to input the sketch's measurement of **0.75**. Hit **ENTER** to advance to the next prompt, which asks for the "Center of second end/<Height of cylinder>:." Key in **1.0** for the elevation of the solid and hit **ENTER**. The last of four cylinders will appear on the top of the third in the graphical display as shown in Figure 5.8.

Figure 5.8 – Adding the Fourth Cylinder

Combining Four Solids with Union

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For the next step in this problem, you need to use the Union Boolean command. With the Union command, you will join multiple solids into one.
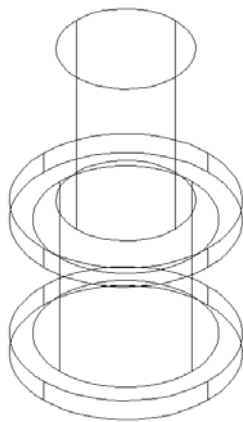
To add the four cylinders together, select the Union tool on the Solids Editing toolbar. You will be prompted to "**Select ACIS objects to union:**." Select all four cylindrical shapes and the system will respond with "**Entities in set: 4**." Hit ENTER to combine the solids into one entity as shown in Figure 5.9. You won't see any difference in the tessellation lines outlining all the cylinders because the edges still represent the detail of the solid. To test your work, select the solid with one pick of the mouse and the entire solid should become highlighted.

Figure 5.9 – Union All Four Solids

Placing an Curved Edge on a Solid Using the Fillet Tool

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To place a fillet or curve on two converging straight lines in 2D drawing, you need to select both lines to identify the position of the radius. When placing a three-dimensional curve on a solid, you pick the straight line of the edge you wish to round. When placing a three dimensional curve on a solid in problem three, you picked the straight edge of the corner. In this case, you will put a curvature on the edge of a cylinder.
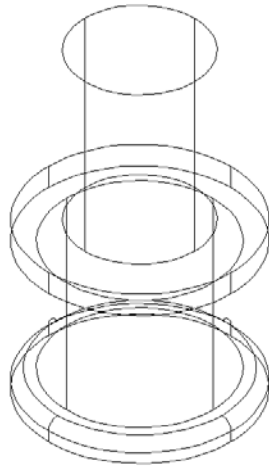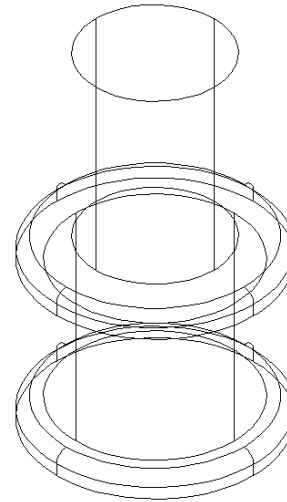
Figure 5.10 – The First Fillet   **Figure 5.11 – The Second Fillet**

Select the Fillet tool on the Modify toolbar. Type an "**R**" for radius and then enter **0.0625** for the measurement. Now pick the top loop of on the first cylinder and hit **ENTER**; the line will become dotted. At the prompt, "**Select an edge: Chain/Radius:,**" hit **ENTER** again since you will not be linking the curved surface with any other edge causing a continuous rounded periphery. On the second **ENTER**, the sharp corner becomes a 0.0625 curvature as shown in Figure 5.10. Repeat the process for the top side of the third cylinder and you will have similar fillets.

Drawing a Solid Box

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The technique you will use in this exercise will utilize the Length option of the Box command. Type **L** after specifying a corner on the graphical display and the system will ask three questions. The first prompt asks for the "Length of side of box:" that will designate the **X** coordinate. The second prompt is "Width of box:" that will designate the **Y** coordinate. The third prompt is "Height of box or [2Points]:" that will designate the **Z** coordinate.
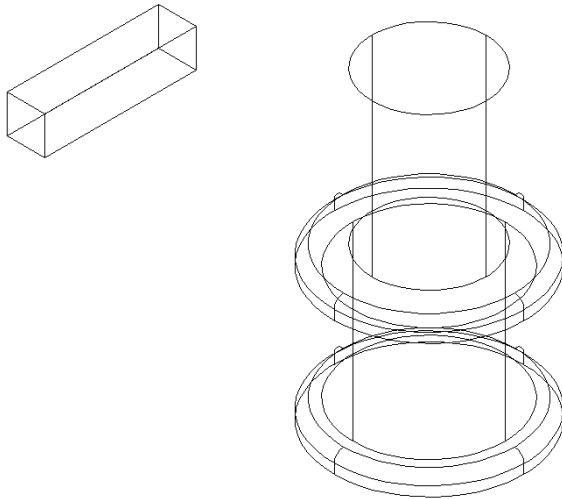
Select the Box tool on the Solids toolbar. At the command line, a prompt asks you to specify the corner of the solid for this box. Specify any point to the left of the solid as shown in Figure 5.11. Then type **L** after specifying the starting point and the system will ask you three questions. The first prompt is asks for the "Length of side of box:" so type **1.0** and **ENTER** for the X coordinate. The second prompt asks for the "Width of box:" so type **0.25** for the Y coordinate and hit **ENTER**. The third prompt asks you to "Specify Height of box or [2Points]:" so type **0.25** and **ENTER** for the Z coordinate. The box will appear as shown in Figure 5.11.

Figure 5.11 – Drawing a Solid Box

Moving a Solid onto the Master Solid

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Remember, 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 your 2D training, periodically you would draw a construction line to assist in the placement of an entity. In this exercise, you will use a construction line to establish the top-middle of the solid box, allowing you to place the three dimensional shape on top of the master component. After moving the part, do not forget to erase the construction line later after you perform the Array, which comes next.
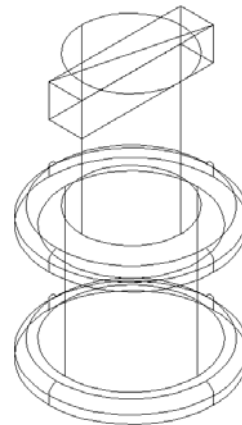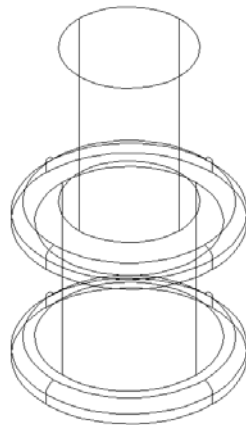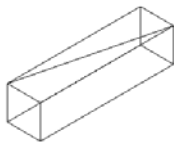

Figure 5.12 – Adding a Construction Line   **Figure 5.13 – Moving the Box and Line**

First select the Line tool on the Draw toolbar. Using the Endpoint Osnap, draw a diagonal line across the top of the solid box from one vertex to the other as shown in Figure 5.13. Hit ENTER to exit the Line command.

To move the box, select the Move tool on the Modify toolbar. When prompted to "Select entities to move:," pick the solid box and line and the command line will respond with "Entities in set: 2." Hit **ENTER** to go to the second part of the command. Next you need to choose a "Vector/<Base point>:" on the graphical display. Pick the Midpoint Esnap of the construction line you've just drawn on top of the box as the base point. The "Displacement point:" is the center point of the top face of the cylinder. Pick the second point using the Center Esnap and the solid box and line will move as shown in Figure 5.13. Remember again to erase the construction line before moving on.

Creating an Array of a 3D Solid Using the Array Command

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On the View toolbar, select the Top View tool to allow you to see the part on the XY plane. To copy and rotate the solid box in the XY plane, you will be using the standard Array command.
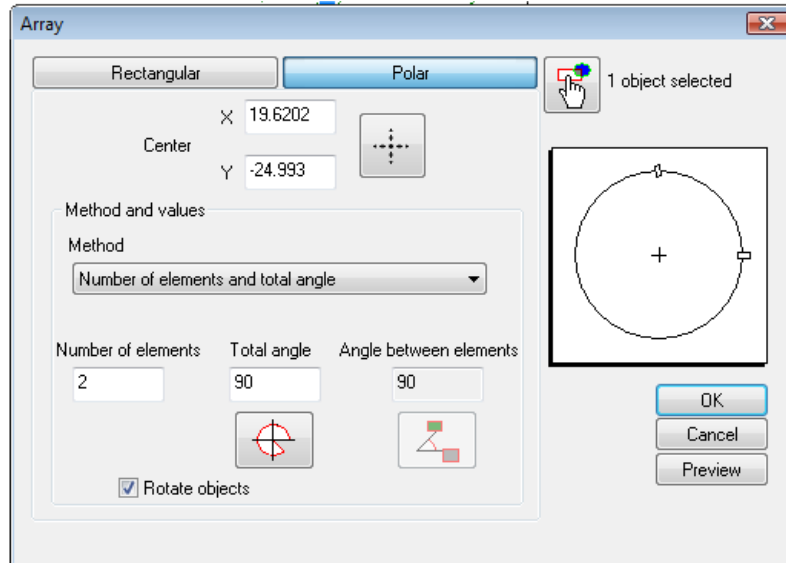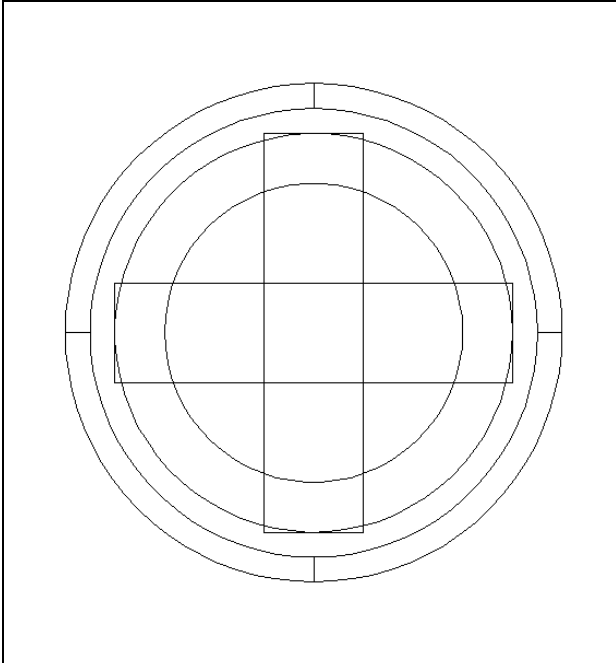

Figure 5.14 – The Array Window

Select the Array tool on the Modify toolbar to pull up the Array window shown in Figure 5.14. Select the Polar option and then the Select Objects button that will allow you to select the solid box, hitting Enter to return to the Array window. Next, select the Pick Center Point Button, which brings you back to the drawing to select the midpoint of the construction line. Change the "Number of Elements" textbox to **2** and the "Total Angle" to **90**, as well as checking the Rotate Objects box. Press the Preview to check your work; a second solid box should appear in the graphical display as shown in Figure 5.14. Now you need to proceed to removing the solid boxes and making the detail in the top of the fourth cylinder. Don't forget to erase the construction line.

Figure 5.14 – Top View of Arrayed Boxes

Subtracting a 3D Solid from Another Solid
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To remove the smaller solid boxes from the master solid, select the Subtract tool on the Solids Editing toolbar.

You will be prompted to "Select ACIS object to subtract from:." Select the larger master solid and the system will respond with "Entities in set: 1" (Figure 5.15). Hit ENTER to proceed to the next step, which is to "Select ACIS objects to subtract:." Pick the two solid boxes and the command line will respond with "Entities in set: 2" (Figure 5.16). Hit ENTER and a region exactly the shape of the two solid boxes has disappeared from the solid as shown in Figure 5.17.
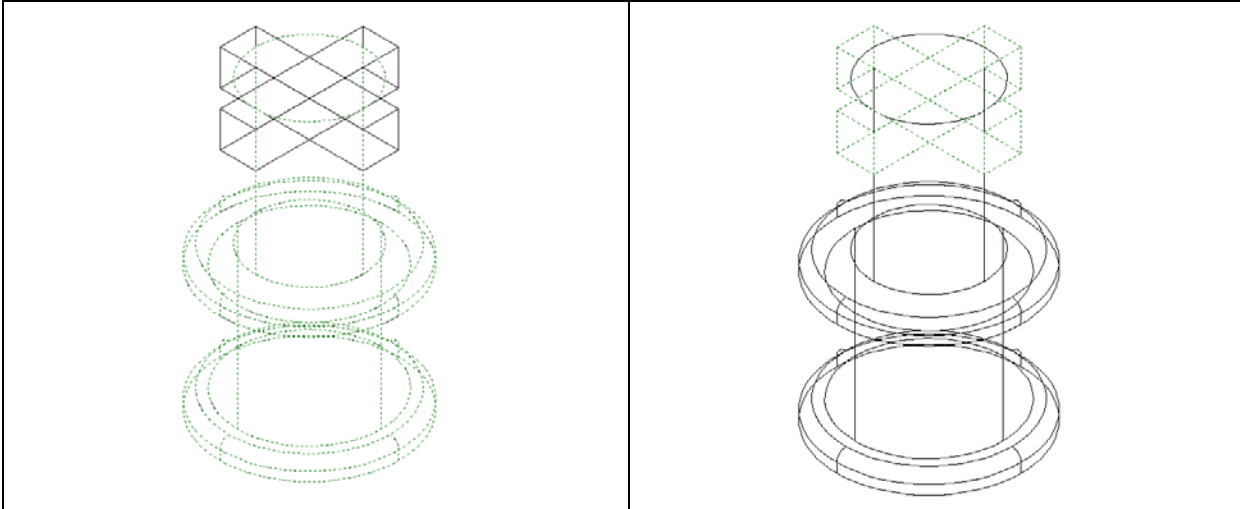
Figure 5.15 – Picking the Master Solid   **Figure 5.15 – Subtracting the Two Boxes**

Improve the View by Hiding Tessellation Lines

In Figure 5.15, you will notice that the tessellation lines representing the solid's outline on the far edge of the part are visible. In a real world solid part, you would not be able to see through solid unless the material was transparent. You can use the Hide command to remove the hidden lines from your graphical display.
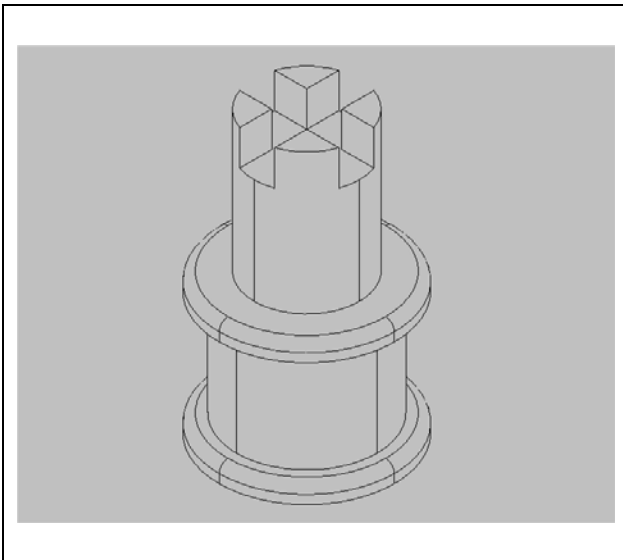

Select the Hide tool on the Shade toolbar and the tessellation lines representing the back of the part are removed from view. If you wish to return the graphical display to the previous setup where all the tessellation lines are seen, choose the first tool on the Shade toolbar called 2D Wireframe. By choosing the 2D wireframe tool, the solid part will return to its 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 5.16 – Using the Hide Command

Moving the Solid to the Origin Point

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To move Problem Four to the drawing origin of 0,0,0 on the x, y, and z axis, pick the Move tool on the Modify toolbar, select the 3D solid, and hit ENTER. When prompted to select a "**Vector/<Base point>:**," select the center of the very bottom face of Problem Four, which will become its insertion point if it were inserted into an assembly drawing. For the prompt to select a "Displacement point:," type **0,0,0** and hit ENTER. Problem Four will move to the new origin point as shown in Figure 5.17. Try using Zoom Extents if the part completely escapes your viewing area.

* World Class CAD Challenge 101-04 * - 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 under 5 minutes to maintain your World Class ranking.
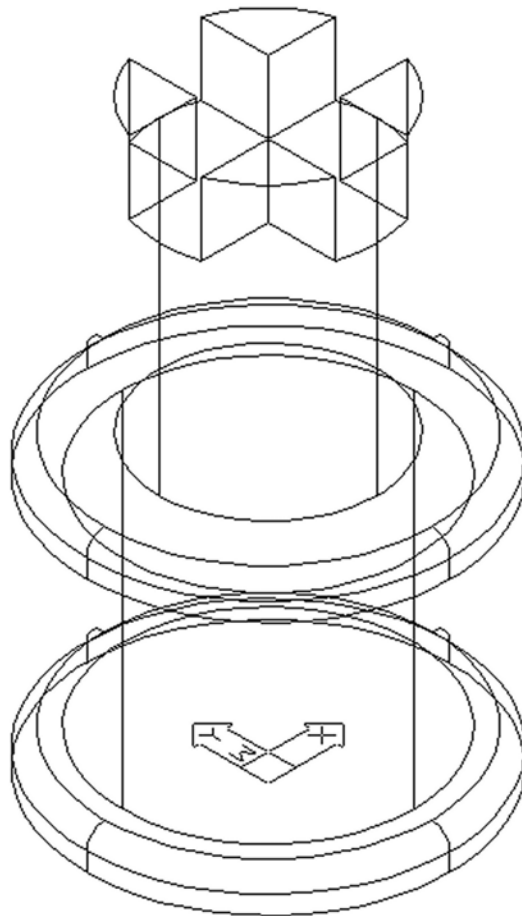
Figure 5.17 – Moving the Finished Solid

Saving the Solid Problem

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To save Problem Four, select the Save tool on the Standard 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 press the Save button to save the drawing (Figure 5.18).
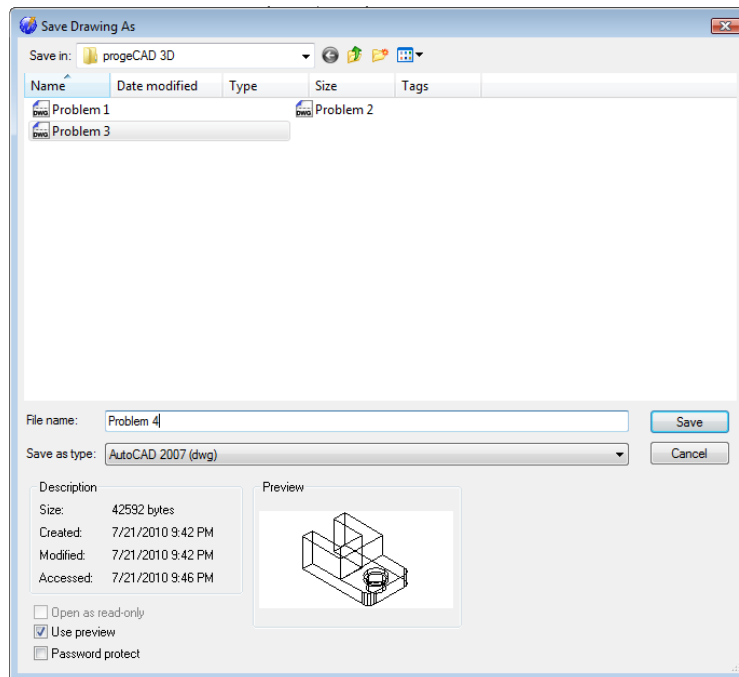

Figure 5.18 – Saving Problem Four

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