

## Solid Problem Four

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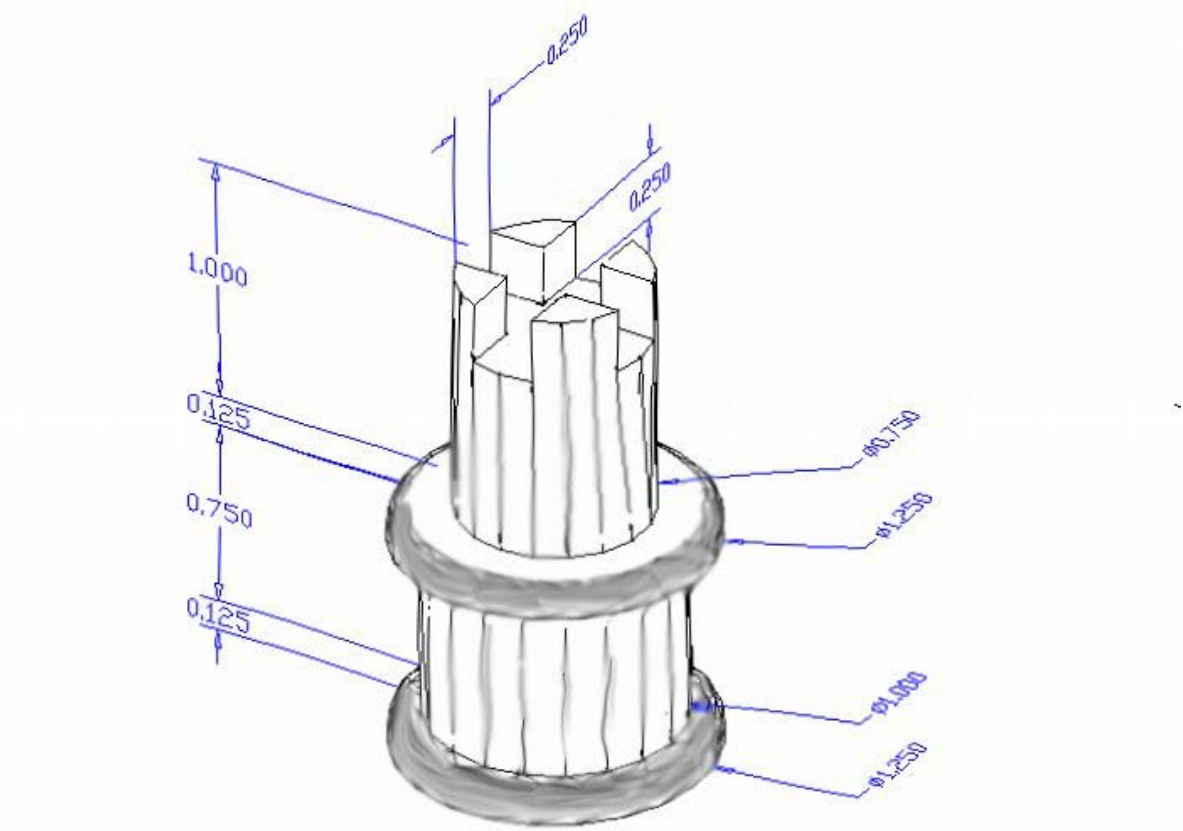
**In this chapter, you will learn the following to World Class standards:**

- 1. Sketch of Solid Problem Four**
- 2. Starting a 3D Part Drawing**
- 3. Drawing a Solid Cylinder**
- 4. Union Four Solids**
- 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. Arraying 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, union them 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 create each sequentially and union them together. This problem will help you address basic solid parts where there are different complexities and that each addition component is 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 ten drills in the Fundamentals of 3D Drawing textbook will give you those repetitive maneuvers which will make you a successful in the 3D modeling.

## Starting a 3D Part Drawing

In Problem Four, you will begin the 3D drawing by selecting the Mechanical template. In Figure 5.2, the window “Select template” window is loaded by selecting the New tool on the Standard Toolbar. A list of templates is loaded in the Select a Template list box. 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.

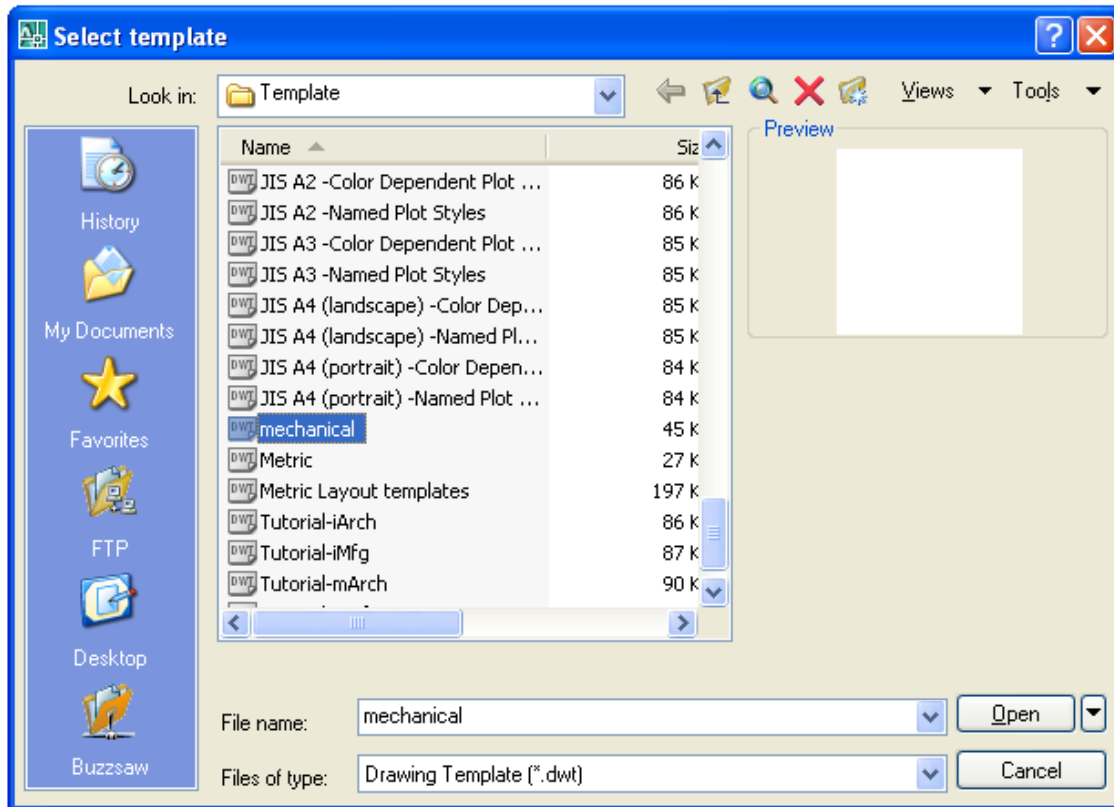


Figure 5.2 – Starting the Drawing Using the Mechanical Template

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

## Drawing a Solid Cylinder

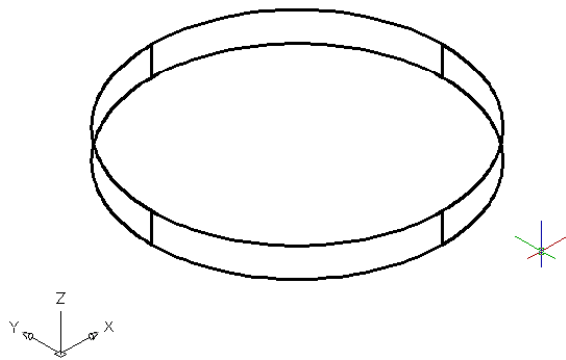
In problem three, you used the circle and extrude method to obtain a cylinder in a solid problem. In this exercise, there will be fewer steps to building the master solid when drawing four different cylinders on top of each other.

Command: **CYLINDER**  
Current wire frame density: ISOLINES=4  
Specify center point for base of cylinder or [Elliptical] <0,0,0>:  
Specify radius for base of cylinder or [Diameter]: **d**

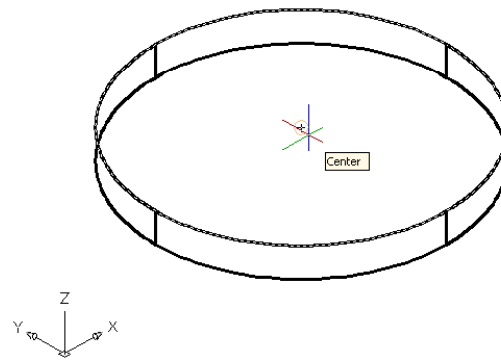
Specify diameter for base of cylinder: **1.25**  
Specify height of cylinder or [Center of other end]: **0.125**

**Figure 5.3 – The Cylinder Text from the Command Line**

On the Solids toolbar pick the Cylinder tool. Specify the center point for the base of the cylinder anywhere in the lower center 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** for 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 appears in the graphical display as shown in Figure 5.4.

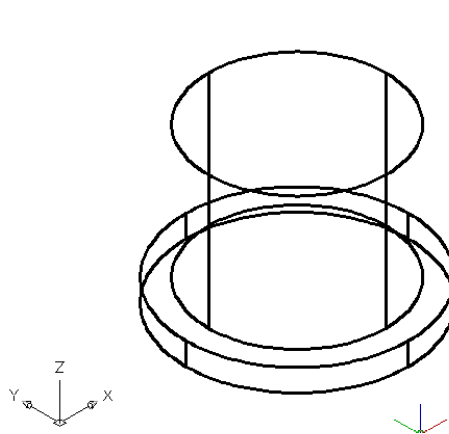


**Figure 5.4 – The First Cylinder**

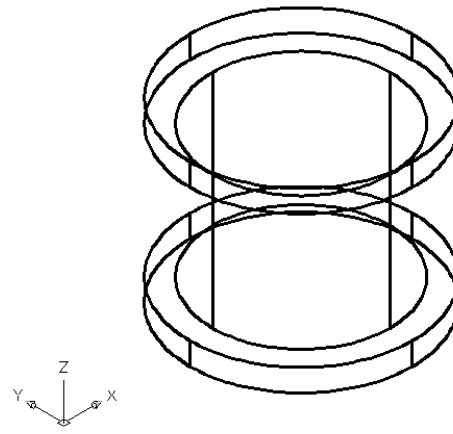


**Figure 5.5 – Picking the Center of the Top**

To draw the second cylinder, hit **Enter** to repeat the command. Specify the center point for the base of the cylinder on the top of the first oval solid as shown in Figure 5.5 using the Center Osnap. Type “D” for diameter and **Enter** to input the sketch’s measurement of **1.00**. Hit **Enter** to the next prompt, which is “specify the height of the cylinder”. Key in **0.75** for the elevation of the canister shaped solid and **Enter**. The second of four cylinders will appear on the top of the first in the graphical display as shown in Figure 5.6.

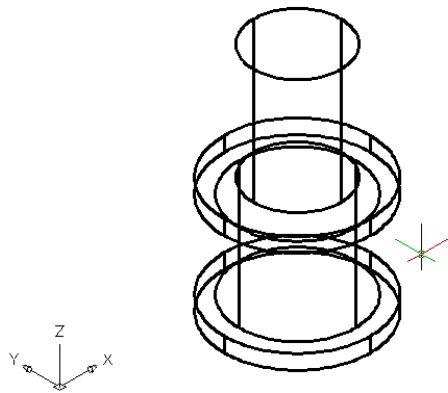


**Figure 5.6 – Adding the Second Cylinder**



**Figure 5.7 – Adding the Third Cylinder**

To draw the third cylinder, hit **Enter** to repeat the Cylinder command. Specify the center point for the base of the cylinder on the top of the second circular solid using the Center Osnap. Type “**D**” for diameter and hit **Enter** to input the sketch’s measurement of **1.25**. Hit **Enter** to the next prompt, which is “specify the height of the cylinder”. Type **0.125** and hit **Enter**. The third of four cylinders will appear on the top of the second in the graphical display as shown in Figure 5.7.

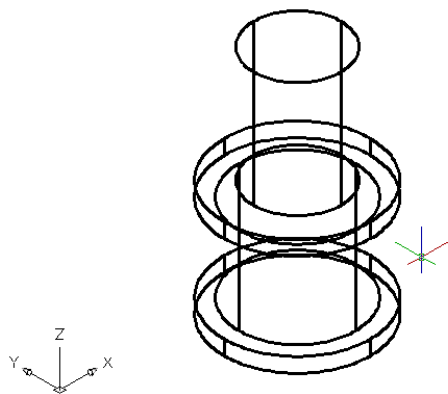


To draw the fourth cylinder, hit **Enter** to repeat the Cylinder command. Specify the center point for the base of the cylinder on the top of the third circular solid using the Center Osnap. Type “**D**” for diameter and hit **Enter** to input the sketch’s measurement of **0.75**. Hit **Enter** to the next prompt, which is “specify the height of the cylinder”. Type **1.0** and hit **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 Four Solids

For the next modification of a 3D solid shape in AutoCAD, you will use the second Boolean command, Union. With the Union command, you can join one or more shapes to each other.



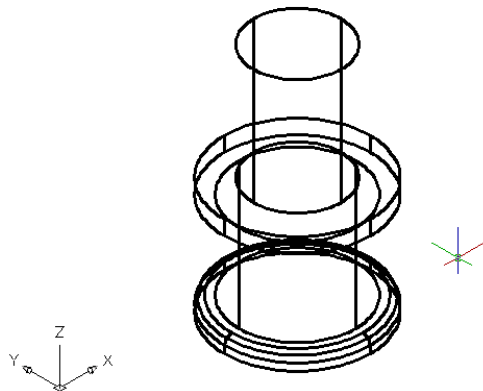
To add four solid together, select the Union tool on the Solids Editing toolbar. You will be prompted to “Select objects”. Select all four cylindrical shapes and the system will respond with “4 found”. Hit **Enter** and now all the solids become as one entity as shown in Figure 5.9. You cannot see in the graphical display any difference in that the tessellation lines outlining all the cylinders and were touching each other are still visible. To test your work, select the solid with one pick of the mouse and the entire solid will become highlighted.

**Figure 5.9 – Union All Four Solids**

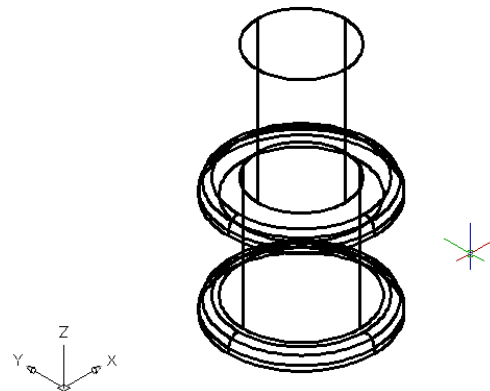
## Placing a Curved Edge on a Solid Using the Fillet Tool

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To place a fillet or curve on two converging straight lines in the Fundamentals of 2D Drawing, you needed to select both lines to identify the position of the radius. When placing a three dimensional curve on a solid in problem three, you pick the straight line on the corner. In this case, you will put a curvature on the lip of a cylinder.



**Figure 5.10 – The First Fillet**



**Figure 5.11 – The Second Fillet**

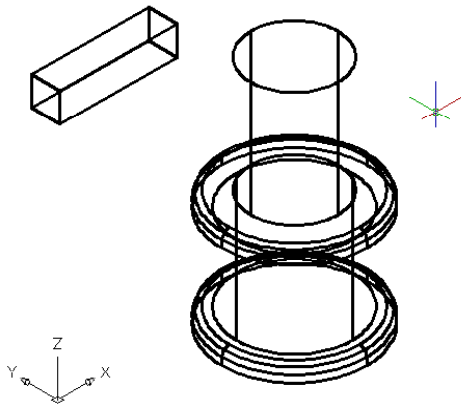
Select the Fillet tool on the Modify toolbar. Type an “**R**” for radius and then **0.0625** for the measurement. Now pick the top loop of on the first cylinder and hit Enter and the line will become dotted. At the prompt, “**Select an edge or [Chain/Radius]:**” just hit **Enter** again since you will 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. You can actually pick more than one edge to fillet at a time on a single solid with the same measurement, so you may want to try this method of picking both loops when prompted for “**select an edge**”.

## 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 the corner on the graphical display and the system will ask three questions. The first prompt is “Specify Length” where you will designate the **X** coordinate when you type a number and hit Enter. The second prompt is “Specify Width” where when you type a number and hit Enter it will designate the **Y** coordinate. The third prompt is “Specify Height” where when you type a number and hit Enter it will designate the **Z** coordinate.



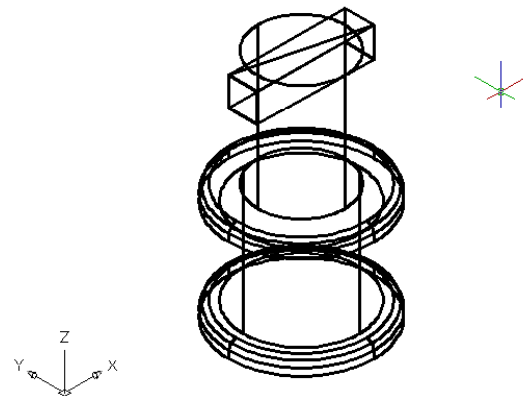
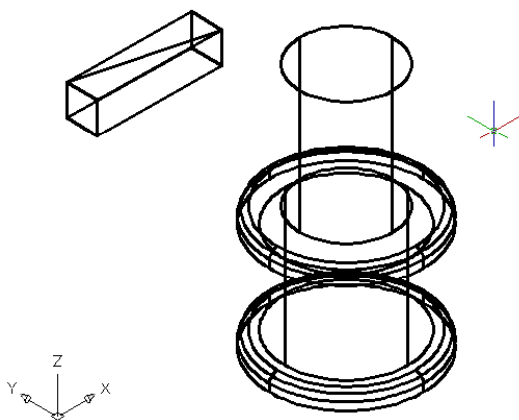


Select the Box tool on the Solids toolbar. At the command line, when you are prompted to specify the corner of the solid and for this box, specify any point to the left of the solid as shown in Figure 5.11. Type **L** after specifying the starting point and the system will ask you three questions. The first prompt is “Specify Length” where you will type **1.0** and **Enter** for the X coordinate. The second prompt is “Specify Width” where you will type **0.25** for the Y coordinate and **Enter**. The third prompt is “Specify Height” where when you 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

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 the textbook, Fundamentals of 2D Drawing, periodically you draw a construction line to assist in the placement of an entity. In this exercise, you will establish the top-middle of the solid box, so that you can place the three dimensional shape on top of the master component. After moving the part, do not forget to erase the construction line.



**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.. Enter to exit the Line command.

To move the box, select the Move tool on the Modify toolbar. Once you choose the Move command, then you will be prompted to “Select Objects”. Pick the solid box and line and the command line will respond with “2 found”, so just press **Enter** to go the second part of the command. Next, you need to “specify base point or displacement” on the graphical display. Pick your base point with the Midpoint Osnap selecting the midpoint of the construction line. The “second point of displacement” is the center point of the top of the cylinder. Pick the second point using the Center Osnap and the solid box and line will move as shown in Figure 5.13. Finally, select the Erase tool on the Modify toolbar and pick the construction line and Enter to remove the entity.

## Arraying a 3D Solid Using the Array Command

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

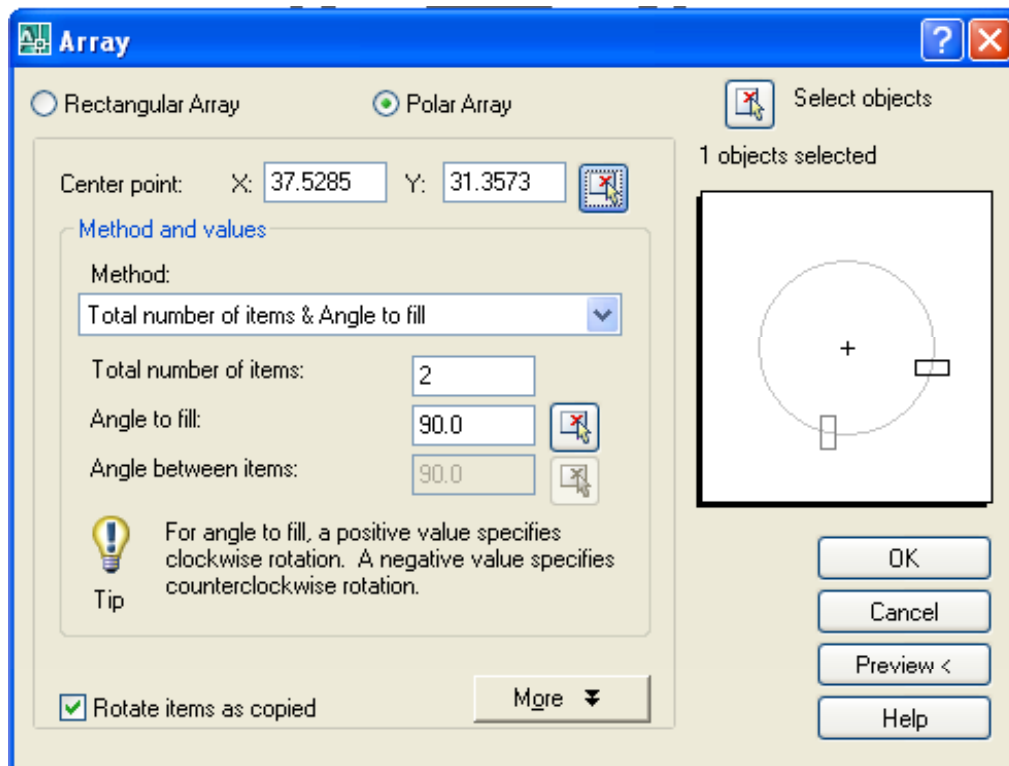
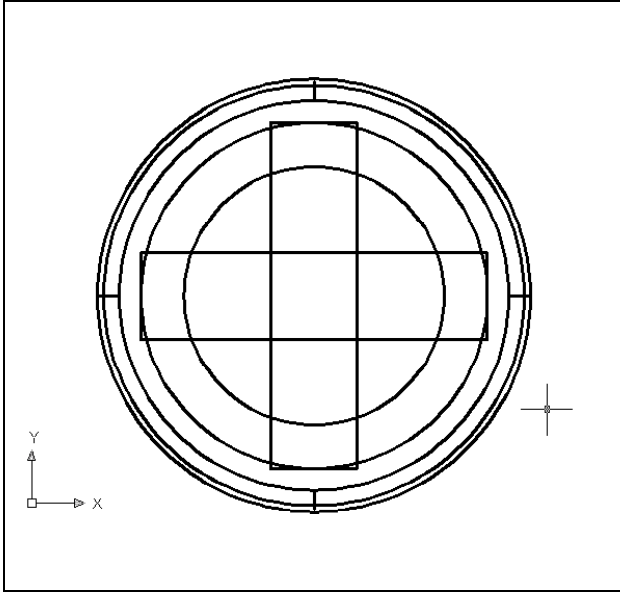


Figure 5.14 – The Array Window





Select the Array tool on the Modify toolbar which will cause the Array window shown in Figure 5.14 to appear. Pick the Polar radial button, then the Select Objects button that will allow you to select the solid box and Enter to return to the Array window. Next, select the Pick Center Point Button, which brings you back to the drawing to select the center of the cylinder. Change the “total number” textbox to **2** and the “angle to fill” to **90**. Press the OK button and the array will be completed. A second solid box will 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.

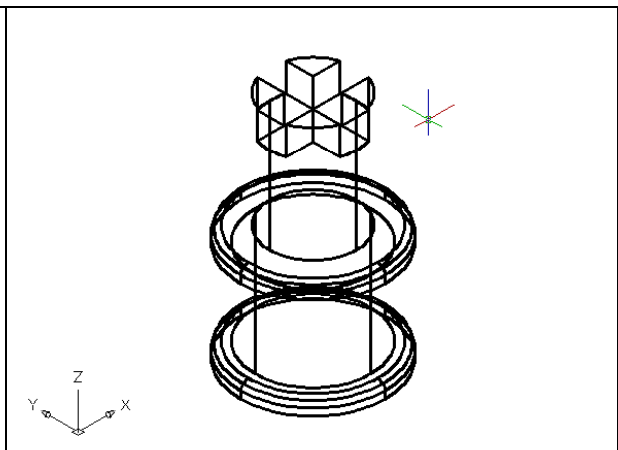
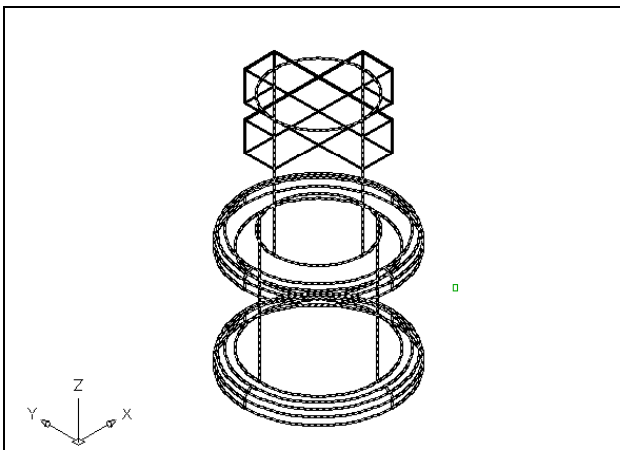
**Figure 5.14 – The Array Window**

## Subtracting a 3D Solid from Another Solid

To remove the smaller solid boxes from the master solid, select the Subtract tool on the Solids Editing toolbar.



Then the AutoCAD program will prompt you with “Select solids and regions to subtract from”. Select the larger master solid and the system will respond with “1 found” as shown in Figure 5.15. You need to Enter to proceed to the next step which is “Select solids and regions to subtract”. Pick the two solid boxes and the software application will counter with “2 found” as shown in Figure 5.16. Enter and a region exactly the shape of the two solid boxes is missing from the larger one as shown in Figure 5.17.



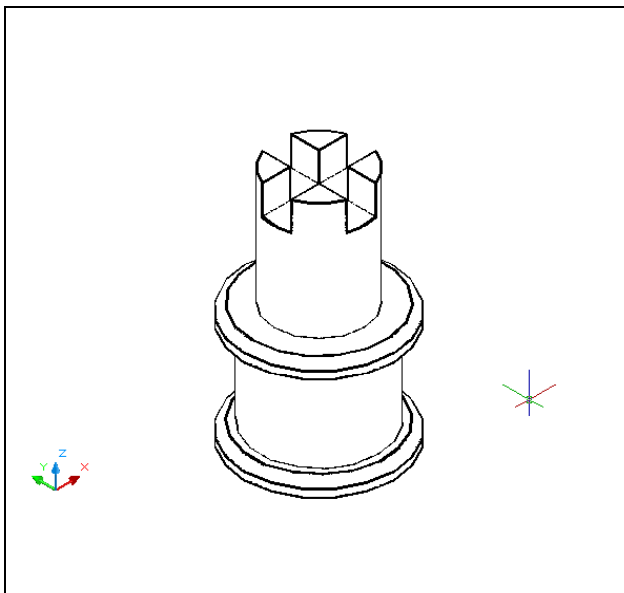
**Figure 5.15 – Picking the Master Solid**

**Figure 5.15 – Subtracting the Two Boxes**

## Improve the View by Hiding Tessellation Lines

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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 3D Hidden Visual Style command to remove the hidden lines from your graphical display.



Select the 3D Hidden Visual Style tool on the Visual Styles toolbar. This is a very simple command, because moments after picking the tool, 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, then choose the first tool on the Visual Styles toolbar, called 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.

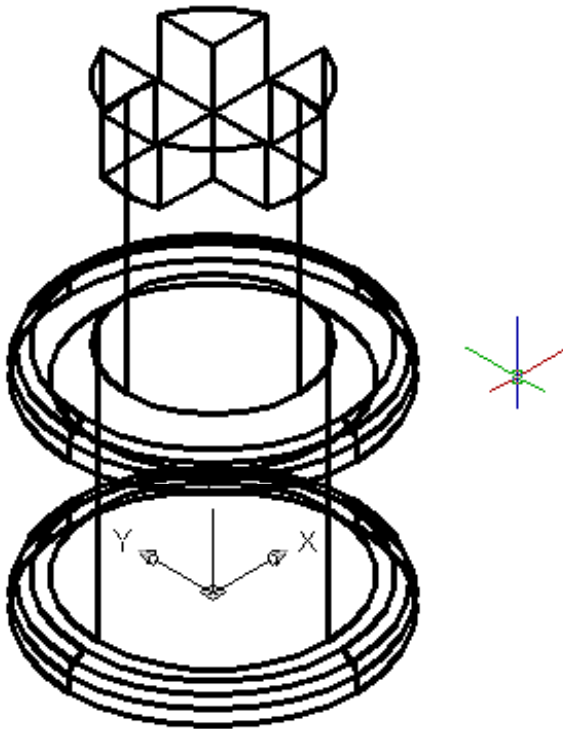
Figure 5.16 – Using the Hide Command

## 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 and select the 3D solid and Enter. At the prompt, “specify base point or displacement”, select the center of lowest loop at the bottom of the solid, which will become the Problem Four insertion point into an assembly drawing. At the “second point of displacement”, type **0,0,0** and **Enter**. Problem Four will move to the new origin point as shown in Figure 5.17. There is more than one way to do many actions in AutoCAD, but the end result of having a part at the origin is important when you wish to insert the solid into an External Referenced Assembly drawing.

**\* 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 under 5 minutes to maintain your World Class ranking.**



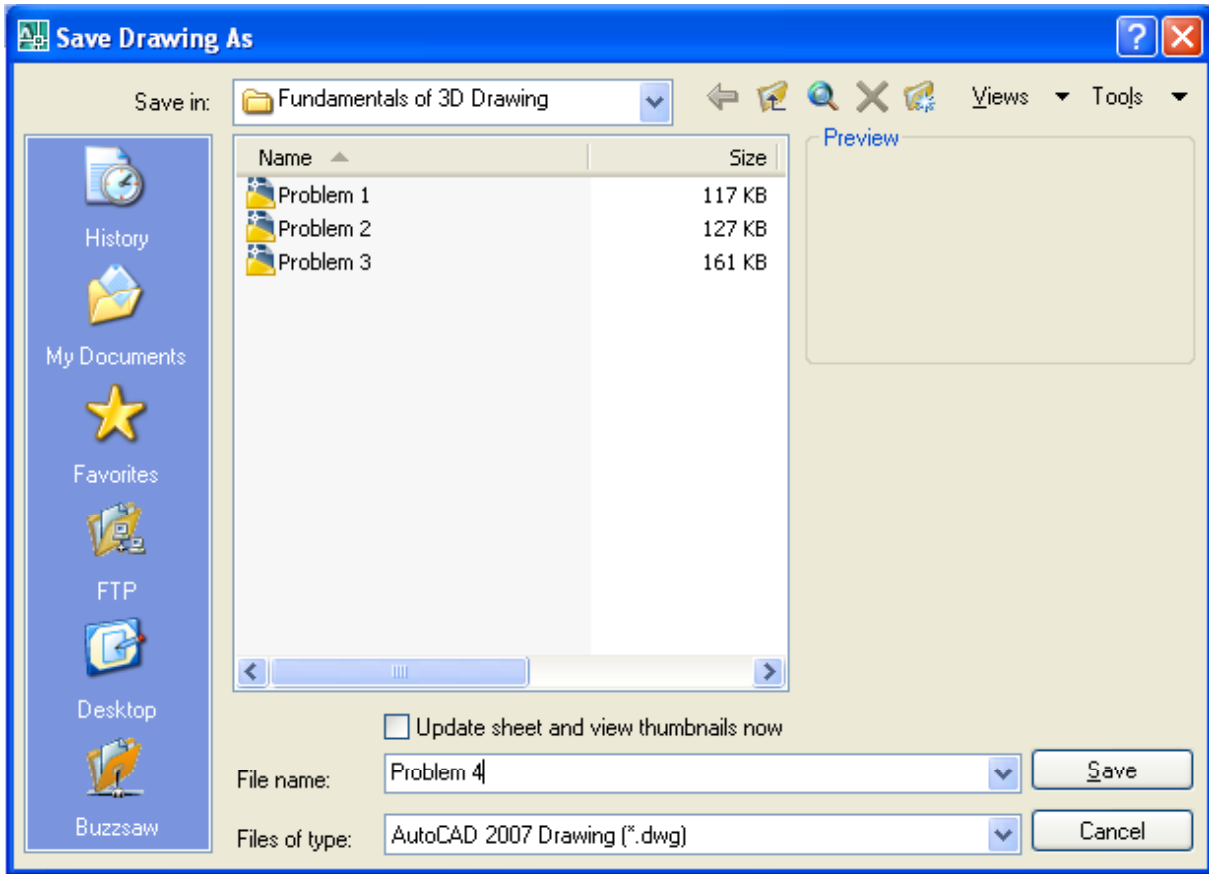
**Figure 5.17 – Moving the Finished Solid**

## **Saving the Solid Problem**

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To save Problem 4 in your Fundamentals of 3D Drawing Folder, 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. (See 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](http://www.worldclasscad.com) to obtain your world class ranking.**