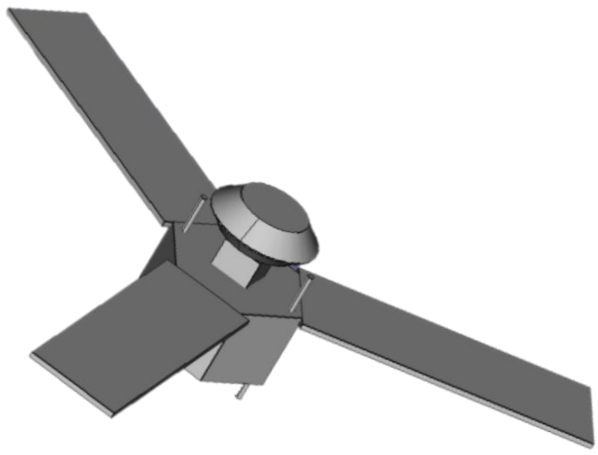
This exercise is part of STEAM Engine Virtual program, in which students learn the basic tools in FreeCAD and how to implement 3 shapes in a 3D model.

Introduction to CAD: 3D Juno Satellite Exercise

You will learn how to use the following tools in FreeCAD:

TOOL	SYMBOL	TOOL	SYMBOL
Create a New Document		Horizontal Distance	
Create a New Sketch		Vertical Distance	
Hexagon Sketch		Length Constraint	
Rectangle Sketch		Radius Constraint	
Circle Sketch		Coincident Constraint	
Construction Mode		Padding	
Edge Tool		Polar Pattern	
Viewfinder		Chamfer	
		3D View	

Juno Spacecraft 3D Model



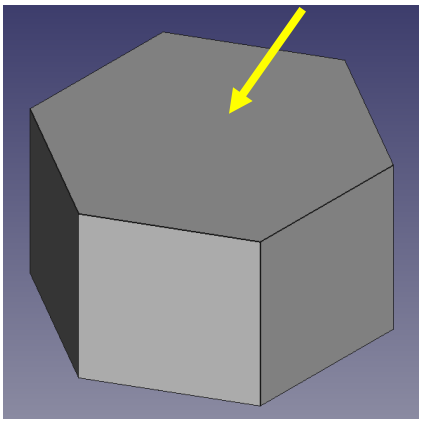
HELPFUL TIPS!

1. If at any point you made a mistake, use the **UNDO** button to go backwards! 
2. When done using a tool, use the **ESC** key on your keyboard to get rid of it.
3. If you cannot find your image on the screen, select the viewfinder 

Instructions

A. Drawing the Base (Hexagon)

1. Click on the **Create a New Document** tool.
2. In the drop-down menu, select **Part Design.**
3. Click on the **Create a New Sketch** tool.
4. Select XY Plane (your square will turn green) and click OK.
5. Select the **Hexagon Sketch** tool (click on the Hexagon).
    a. *Note this tool may be hidden with the other "sketching" tools. If so, locate the other sketching tools and click on the double arrow to reveal all the tools.*
6. Draw your hexagon (any size).
7. Click on one side of the Hexagon and use the **Length Constraint** tool to make the side **75 mm**.
    a. Note that this will change all the sides to 75 mm.
8. Click on the top dot of the hexagon and the vertical green line. When both are selected, use the **Horizontal Distance** tool to make the distance **0 mm**.
9. Click on the center dot of the hexagon and the origin point where the horizontal red line and the vertical green line meet. When both are selected, use the **Coincident Constraint** tool. This will center the hexagon over the origin.
    a. Make sure you have selected the constraint tool, it will be next to the other constraint tools (solid red tools).
10. All sides of your hexagon should now be green – your sketch is *fully constrained*.
11. Click Close (on your left-hand Combo View panel).
12. Use the **Padding** tool to make it 3D!
13. In the left-hand panel, make the **size 80 mm**. Click OK.
14. Use your 3D view tool to see your shape in 3D!

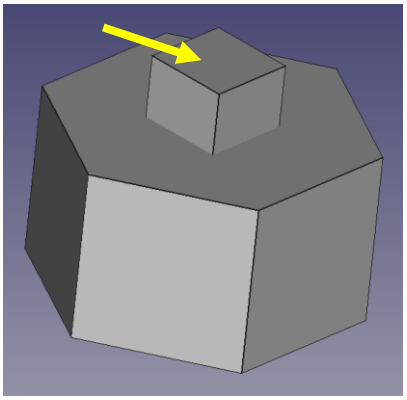


The image on the right shows what you should have up until this point.

B. Drawing the Gravity Science Unit (Square)

1. Click on the top surface of the hexagon shape once. It will turn yellow or green (arrow pointing to it in the image above).
2. Click on the **Create a New Sketch** tool.
3. Select the **Rectangle Sketch** tool and draw the rectangle.

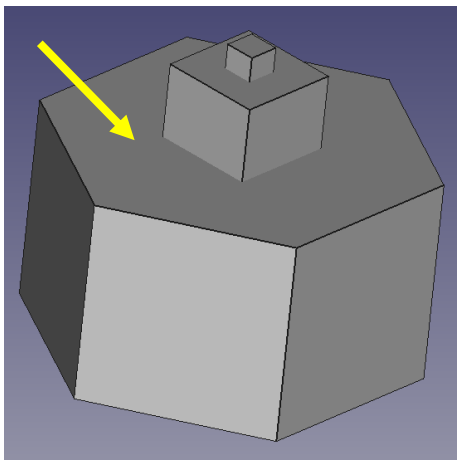
4. Select top side of the rectangle and use the **Horizontal Distance** tool to make the length **40 mm**.
5. Select the left side of the rectangle and use the **Vertical Distance** tool to make the width **40 mm**.
6. Click on the top left dot of the rectangle and click on the horizontal red line. Use the **Vertical Distance** tool to make the distance 20 mm.
7. Click on the top left dot of the rectangle and click on the vertical green line. Use the **Horizontal Distance** tool to make the distance 20 mm.
8.
9. Click Close (on your left-hand Combo View panel).
10. Use the **Padding** tool to make it 3D!
11. In the left-hand panel, make the size **30 mm**. Click OK.



The image on the right shows what you should have up until this point.

C. Drawing the Radio Dish Base (Square)

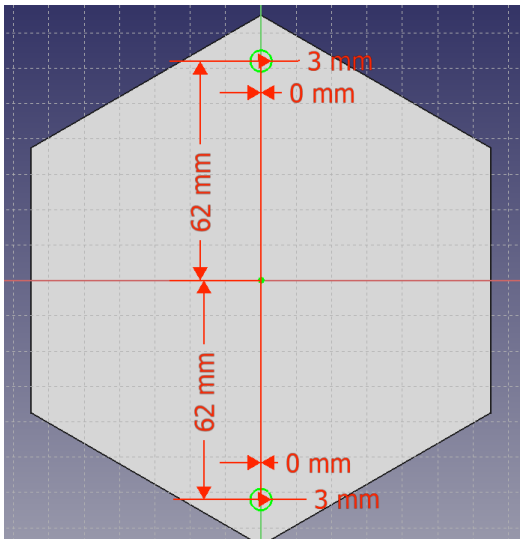
1. Click on the top surface of the box. It will turn yellow or green (arrow pointing to it in the image above).
2. Click on the **Create a New Sketch** tool.
3. Select the **Rectangle Sketch** tool and draw a smaller square in the center.
4. Select top side of the rectangle and use the **Horizontal Distance** tool to make the length **12 mm**.
5. Select the left side of the rectangle and use the **Vertical Distance** tool to make the width **12mm**.
6. Click on the top left dot of the rectangle and click on the horizontal red line. Use the **Vertical Distance** tool to make the distance 6 mm.
7. Click on the top left dot of the rectangle and click on the vertical green line. Use the **Horizontal Distance** tool to make the distance 6 mm.
8. Click Close (on your left-hand Combo View panel).
9. Use the **Padding** tool to make it 3D!
10. In the left-hand panel, make the size **10 mm**. Click OK.



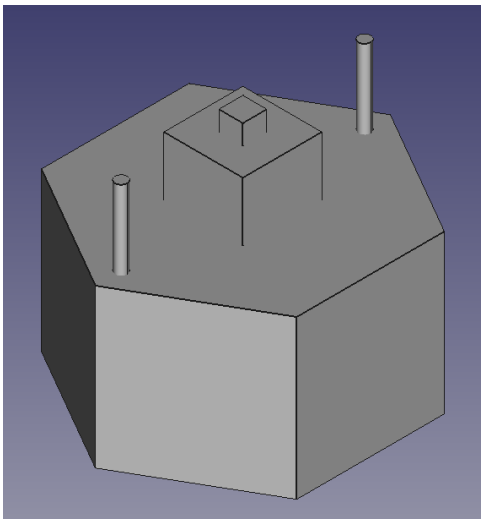
The image shows what you should have up until this point.

D. Drawing the Top Orientation Thrusters (Circles)

1. Click on the top surface of the hexagon where you just drew your squares. It will turn yellow or green (arrow pointing to it above). Make sure you have only selected the hexagon surface (not the squares).
2. Click on the **Create a New Sketch** tool. 
3. Select the **Circle Sketch** tool and draw **2 circles** on the hexagon  .
4. Click on the circle and use the **Radius**  tool to make the radius **3 mm** for both circles.
5. Click on the dot of the circle and click on the horizontal red line. Use the **Vertical Distance**  tool to make the distance 62 mm.
6. Repeat step 5 for the other circle
7. Click on the dot of the circle and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 0 mm.
8. Repeat Step 7 for the other circle
9. Your 2 circles should now be green – the sketch is fully constrained.
10. Click Close (on your left-hand Combo View panel).
11. Use the **Padding**  tool to make it 3D!
12. In the left-hand panel, make the size **40 mm**. Click OK.



The image on the left shows the sketch you should have.

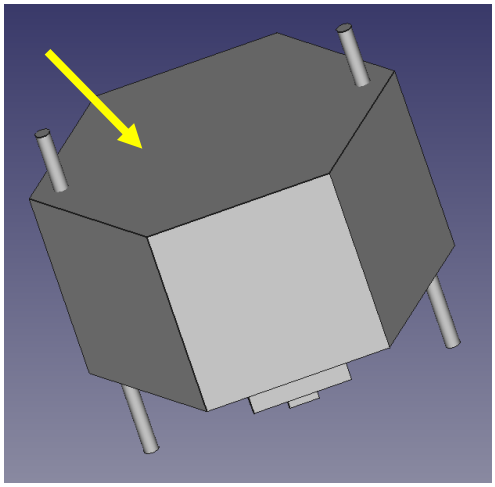


The image on the right shows the 3D object you should have up until this point.

E. Drawing the Bottom Orientation Thrusters (Circles)

1. Click on the bottom of the hexagonal base, it should be flat with no other shapes on it. You can change your view to see the bottom surface by using the 3D view icons (use the bottom view). When you have selected the bottom of the hexagon base it will turn yellow or green.
2. Click on the **Create a New Sketch** tool.
3. We will draw two circles just like the last step
4. Select the **Circle Sketch** tool and draw **2 circles** on the hexagon .
5. Click on the circle and use the **Radius** tool to make the radius **3 mm** for both circles.
6. Click on the dot of the circle and click on the horizontal red line. Use the **Vertical Distance** tool to make the distance 62 mm.
7. Repeat step 5 for the other circle
8. Click on the dot of the circle and click on the vertical green line. Use the **Horizontal Distance** tool to make the distance 0 mm.
9. Repeat Step 7 for the other circle
10. Your 2 circles should now be green – the sketch is fully constrained.
11. Click Close (on your left-hand Combo View panel).
12. Use the **Padding** tool to make it 3D!
13. In the left-hand panel, make the size **25 mm**. Click OK.

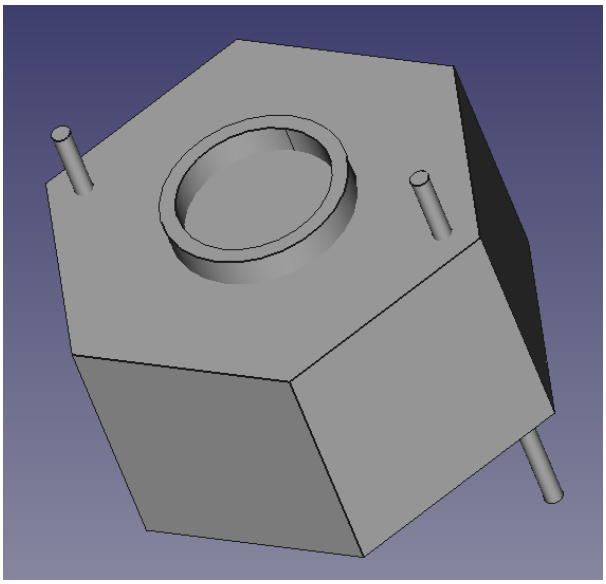
The image on the right shows what you should have up until this point.



F. Drawing the Propulsion Unit (Circles)

1. Click on the bottom of the hexagon base again. It will turn yellow or green (arrow pointing to it in the image above).
2. Click on the **Create a New Sketch** tool.
3. Select the **Circle Sketch** tool and draw **2 circles**.
4. Click on one of the circles and use the **Radius** tool to make the radius **30 mm**.
5. Click on the other circle and use the **Radius** tool to make the radius **25 mm.**

6. Click on the center dot of the both circles. Once both center dots are selected (both have turned green, use the **Coincident Constraint** tool. This will move the small circle to the center of the larger circle.
    a. Make sure you have selected the constraint tool, it will be next to the other constraint tools (solid red tools).
7. Next, click on the center of the circles and the origin point where the horizontal red line and the vertical green line meet. When both are selected, use the **Coincident Constraint** tool. This will center the circles over the origin.
8. Click Close (on your left-hand Combo View panel).
9. Use the **Padding** tool to make it 3D!
10. In the left-hand panel, make the size **10 mm**. Click OK.

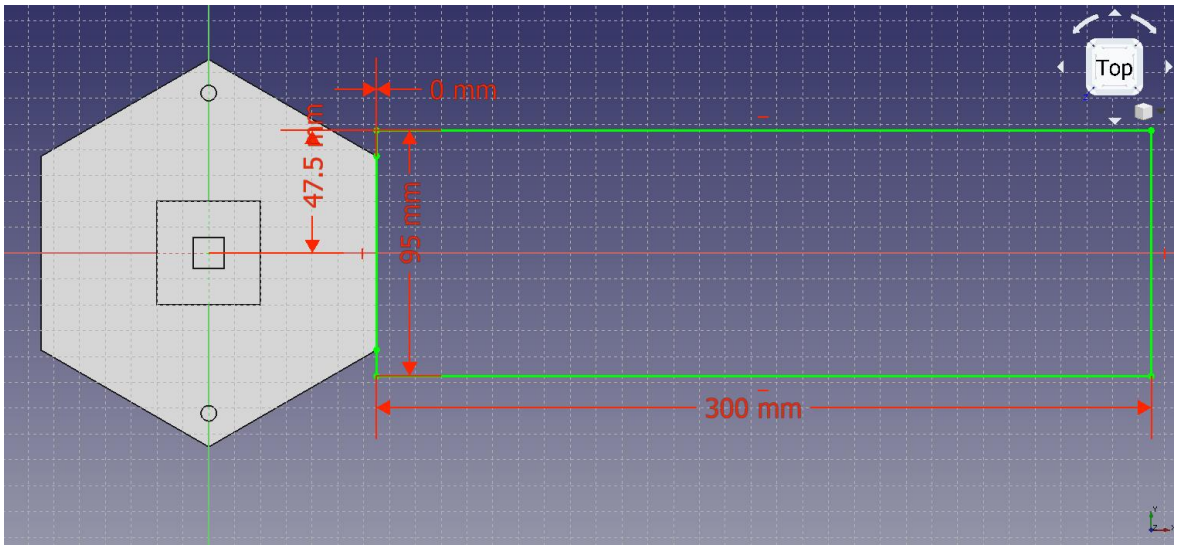


The image on the right shows what you should have up until this point.

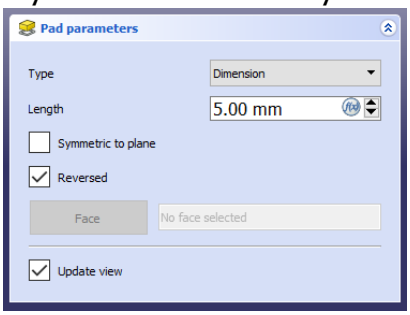
G. Drawing the Solar Panel (Rectangle)

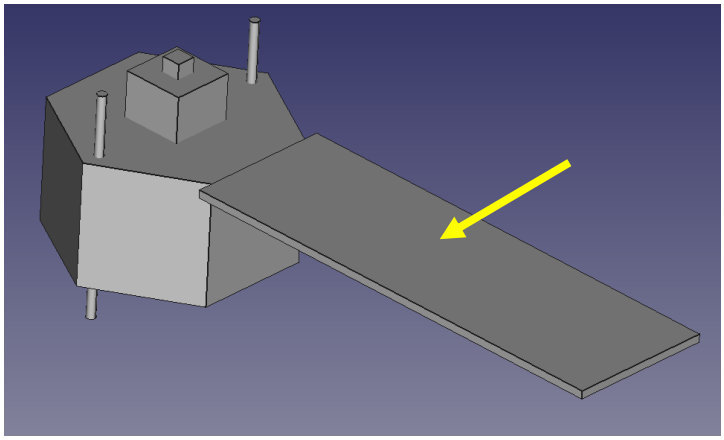
14. Click on the top of the hexagonal base. You can change your view to see the top surface by using the 3D view icons (use the top view). When you have selected the top of the hexagon base it will turn yellow or green.
1. Click on the **Create a New Sketch** tool.
2. Select the **Rectangle Sketch** tool and draw the rectangle.
3. Select top side of the rectangle and use the **Horizontal Distance** tool to make the length **300 mm**.
4. Select the left side of the rectangle and use the **Vertical Distance** tool to make the length **95 mm**.
5. There are two options to constrain the position of the rectangle. We can constrain it relative to the origin (the green and red axis) or we can bring forward an edge.
6. To constrain relative to the origin:
    a. Click on the top left dot of the rectangle and click on the horizontal red line. Use the **Vertical Distance** tool to make the distance 47.5 mm.
    b. Click on the top left dot of the rectangle and click on the vertical green line. Use the **Horizontal Distance** tool to make the distance 64.95 mm.

7. OR If you would like to try a new method, you can use the Construction mode (this step is **optional**, choose to do either step 6 **or** 7)
    a. Click on the top left dot of the rectangle and click on the horizontal red line. Use the **Vertical Distance** tool to make the distance 47.5 mm.
    b. Enter construction mode by clicking **Construction Mode**
        i. When in Construction Mode, the other draw sketch tools will turn blue
    c. Once you have entered Construction mode, bring forward the right most edge of your hexagon. Once you have selected the right vertical side, selecting the **Edge Tool**, to bring forward the edge
    d. Once the edge has been brought forward it should turn purple. Now exit construction mode by clicking **Construction Mode** again. You draw sketch tools should turn back to white.
    e. Click on the top left dot of the rectangle and click on the top dot of the purple line you just made. Use the **Horizontal Distance** tool to make the distance 0 mm



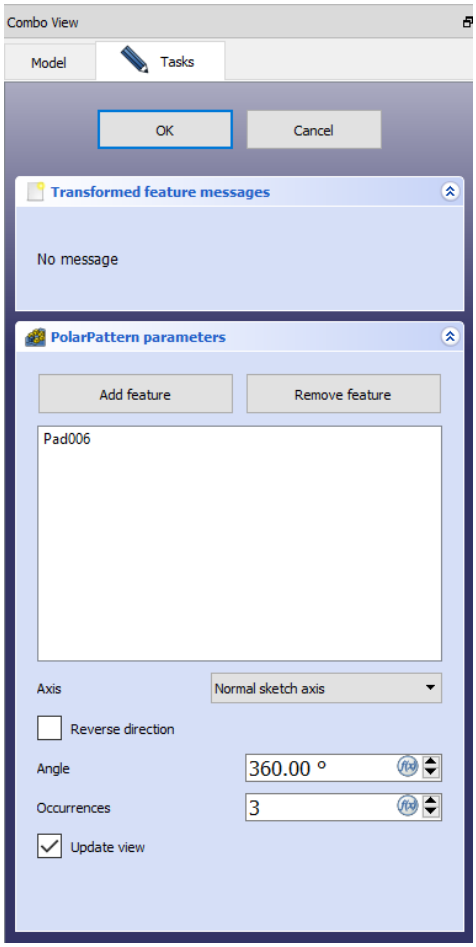
8. Click Close (on your left-hand Combo View panel).
9. Use the **Padding** tool to make it 3D!
10. In the left-hand panel, make the size **5 mm** and click the box next to **Reversed**. This will Pad in the opposite direction and you should now see your object on your screen. Click OK.

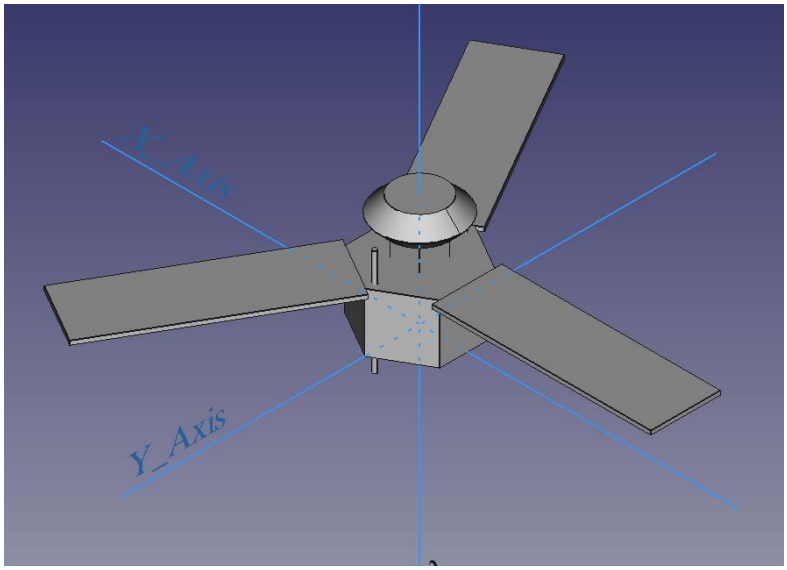




H. Making Multiple Solar Panels using Polar Pattern

1. Click on the solar panel, make sure you have only the padded rectangle selected. It will turn yellow or green (arrow pointing to it in the image above).
2. Click on the **Polar Patter** tool. 
3. In the left-hand panel, Pad006 should be selected.
4. In the box next to **Occurences**, enter **3.** This will create 3 solar panels (the rectangle will appear 3 times).
5. Click OK.





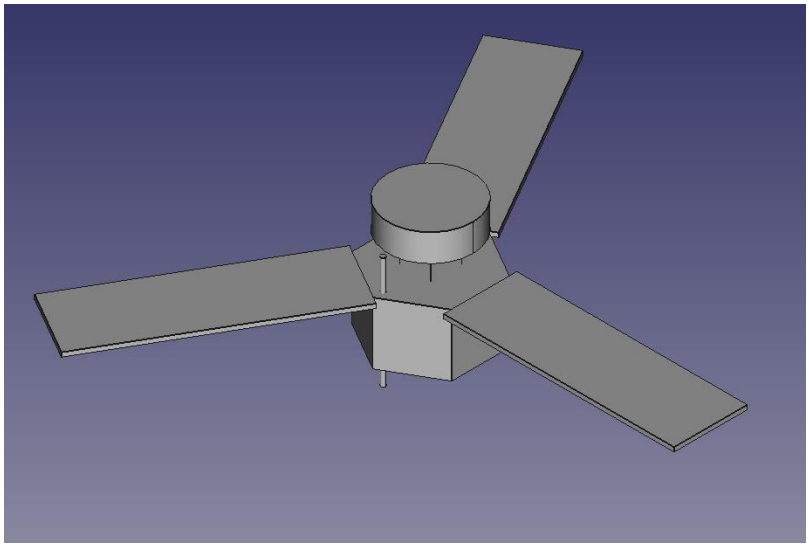
The image on the right shows what you should have up until this point.

I. Drawing the Radio Dish (Circle)

1. Click on the top of the small box on top of the hexagon base. You can change your view to see the top surface by using the 3D view icons (use the top view ). When you have selected the top of the smallest base it will turn yellow or green.
2. Click on the **Create a New Sketch** tool. 

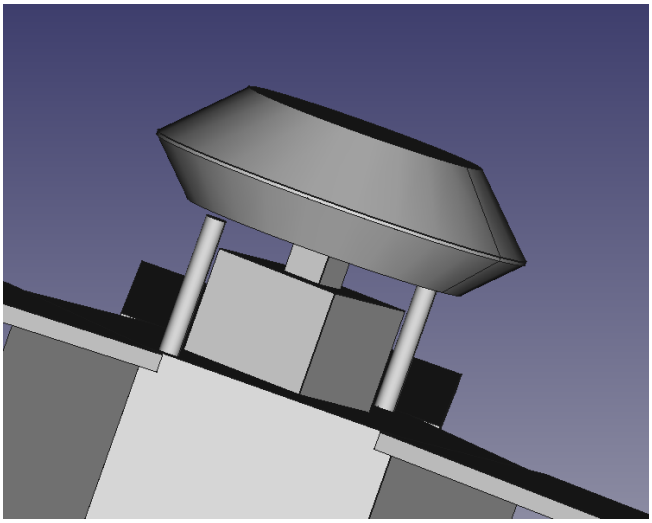
3. Select the **Circle Sketch** tool and draw a circle. 
4. Click on the circle and use the **Radius**  tool to make the radius **55 mm**
5. Click on the center of the circle and the origin point where the horizontal red line and the vertical green line meet. When both are selected, use the **Coincident Constraint**  tool. This will center the circle over the origin.
6. Click Close (on your left-hand Combo View panel).
7. Use the **Padding**  tool to make it 3D!
8. In the left-hand panel, make the size **35 mm**. Click OK.

The image on the right shows what you should have up until this point.



J. Creating the Radio Dish Shape Using Chamfer

1. Click on the top edge of the Radio Dish Cylinder. Select only the edge (not the flat face). Only the line should turn green.
2. Click on the **Chamfer** tool. 
3. In the left hand panel, only Edge3 should appear. Enter **20 mm**. This will smooth down the edge by 20 mm.
4. Click OK.
5. Now click on the bottom edge of the Radio Dish Cylinder. Select only the bottom edge, only the line should turn green.
6. Click on the **Chamfer** tool. 
7. In the left hand panel, only Edge3 should appear. Enter **14 mm**. This will smooth down the edge by 14 mm.
8. Click OK.



9. Click File > Save > Give your file a name and click Save.

FINAL PRODUCT: