



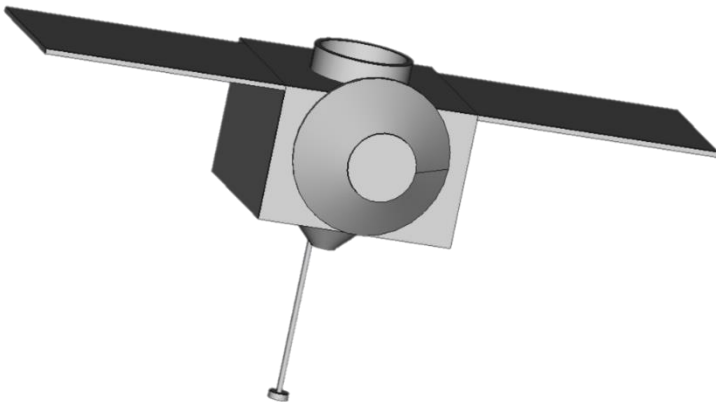
This exercise is part of STEAM Engine Virtual program, in which students learn the basic tools in FreeCAD and how to implement 3 shapes in a 3D model.

Introduction to CAD: 3D Asteroid Probe 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	
Rectangle Sketch		Radius Constraint	
Circle Sketch		Coincident Constraint	
View Finder		Padding	
3D View		Pocketing	
		Chamfer	

OSIRIS-REx 3D Model











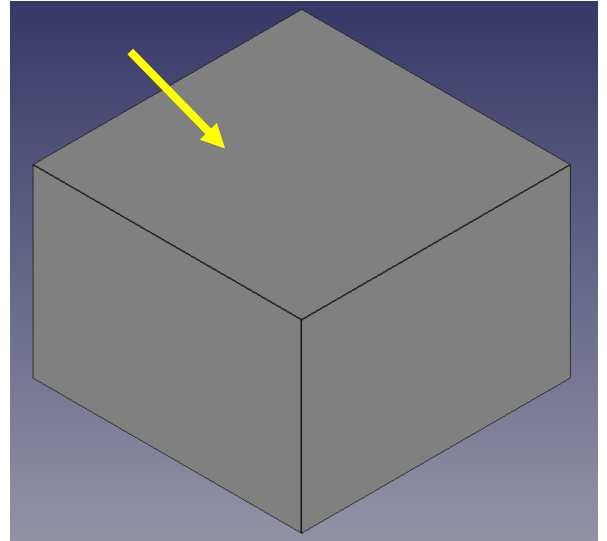
HELPFUL TIPS!

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 (Rectangle)






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 **Rectangle Sketch** tool and draw a smaller square in the center. 
6. Select top side of the rectangle and use the **Horizontal Distance**  tool to make the length **80 mm**.
7. Select the left side of the rectangle and use the **Vertical Distance**  tool to make the width **80 mm**.
8. 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 40 mm.
9. 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 40 mm.
10. All sides of your rectangle 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 length **55 mm**. Click OK.
14. Use your 3D view tool to see your shape in 3D!

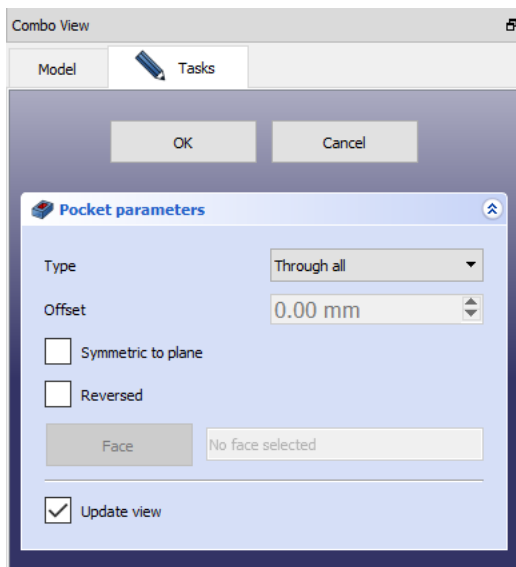
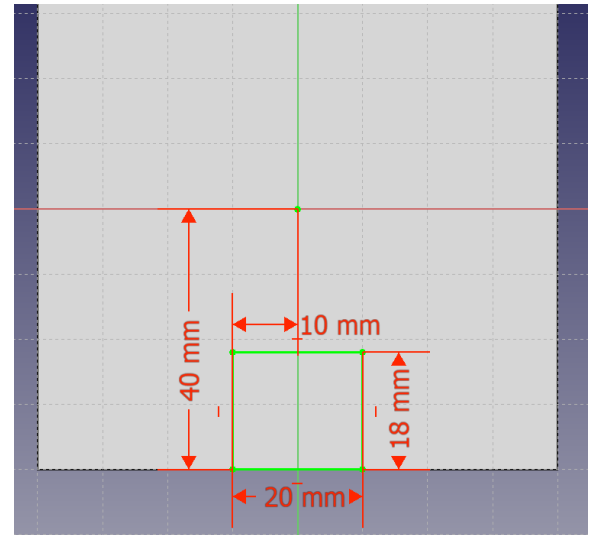


The image on the right shows what you should have up until this point.

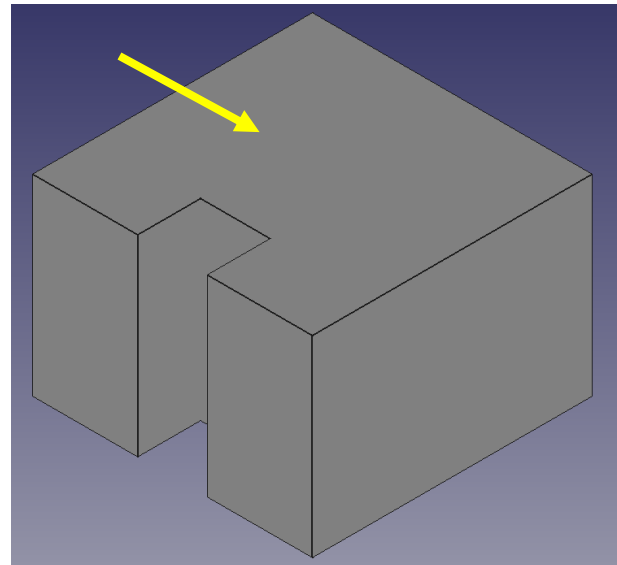
B. Creating the Cut-Out in the Base

1. Click on the top surface of the base. 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. 

4. Select top side of the rectangle and use the **Horizontal Distance**  tool to make the length **20 mm**.
5. Select the left side of the rectangle and use the **Vertical Distance**  tool to make the width **18mm**.
6. Click on the bottom left dot of the rectangle and click on the horizontal red line. Use the **Vertical Distance**  tool to make the distance 40 mm.
7. Click on the bottom left dot of the rectangle and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 10 mm.
8. Your rectangle should now be green and fully constrained against the bottom side of the square.
9. Click Close (on your left-hand Combo View panel).
10. Use the **Pocketing**  tool to take away material!
11. In the left-hand panel, change the *Type* to **Through All**. Click OK.










The image on the left shows what your left panel should look like when pocketing.



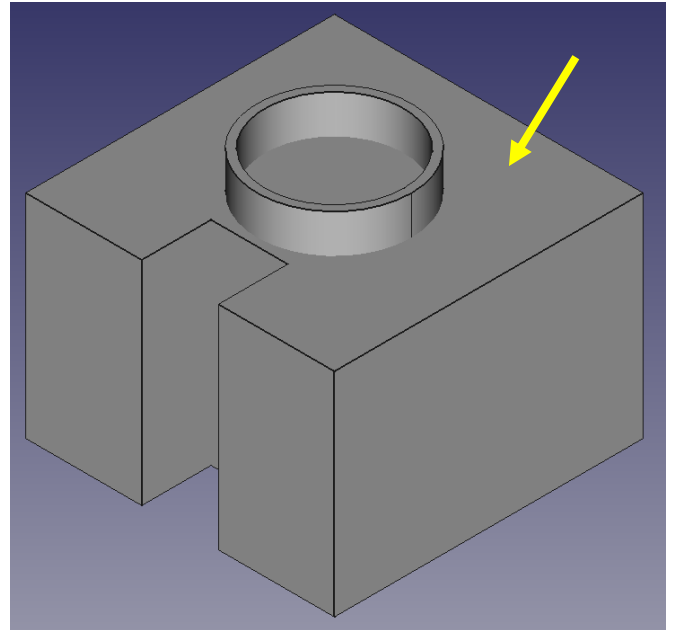
The image on the right shows what you should have up until this point.

C. Drawing the Propulsion Unit (Circles)







1. Click on the top surface of the base. 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 **20 mm**.
5. Click on the other circle and use the **Radius**  tool to make the radius **18 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 length **10 mm**. Click OK.

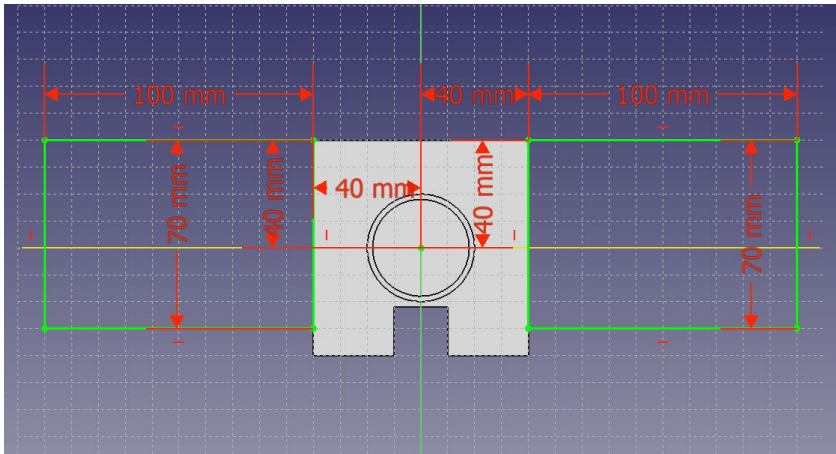
The image on the right shows what you should have up until this point.



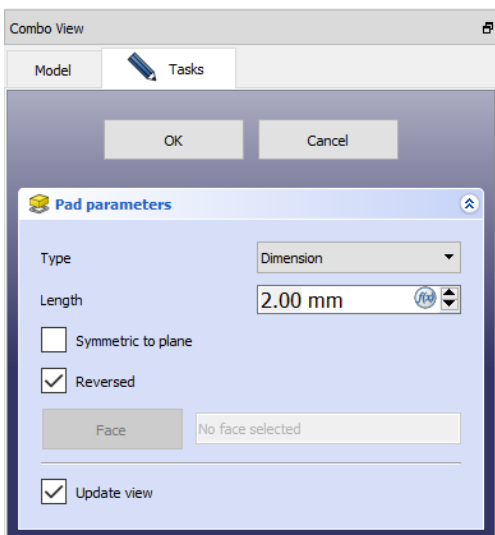
D. Drawing the Solar Panels (Rectangles)

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 2 rectangles. 
4. Select top side of the rectangle and use the **Horizontal Distance**  tool to make the length **100 mm**. Do the same for the second rectangle.
5. Select the left side of the rectangle and use the **Vertical Distance**  tool to make the width **70mm**. Do the same for the second rectangle
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 40 mm. Do the same for the second rectangle
7. Click on the top left dot of one of the rectangles and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 40 mm.

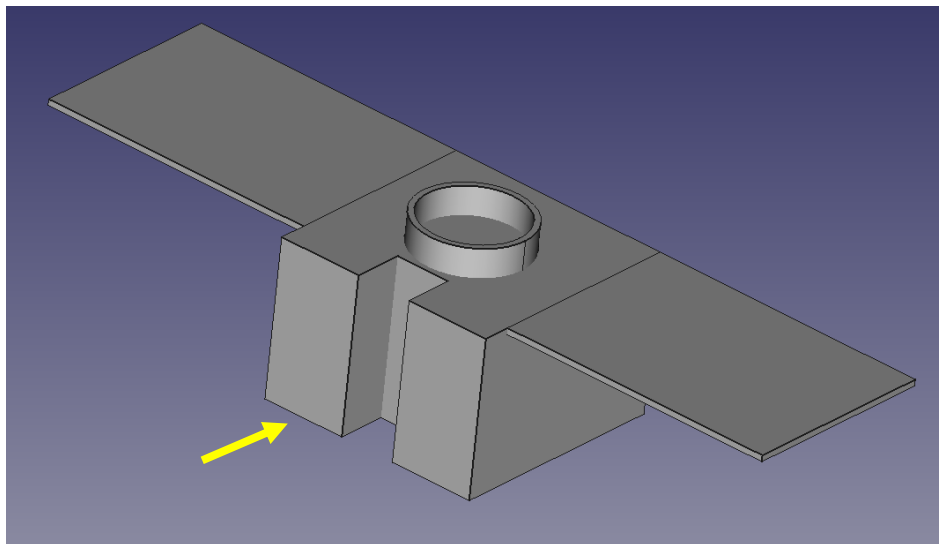
8. Next, constrain the second rectangle. Click on the top *right* dot of the second rectangle and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 40 mm.
9. Click Close (on your left-hand Combo View panel).
10. Use the **Padding**  tool to make it 3D!
11. In the left-hand panel, make the length **2 mm** and check the Reversed box. This will Pad in the opposite direction, you should now see your object on your screen. Click OK.



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









The image on the left shows what your left panel should look like when padding.



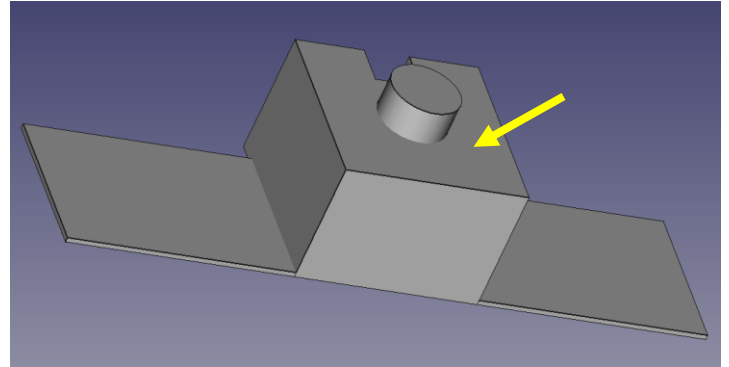
The image shows what 3D Object you should have up until this point.

E. Drawing the Sample Return Capsule (Circle)







1. Click on the bottom of the 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 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 on the base .
4. Click on the circle and use the **Radius**  tool to make the radius **15 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 length **15 mm**. Click OK.

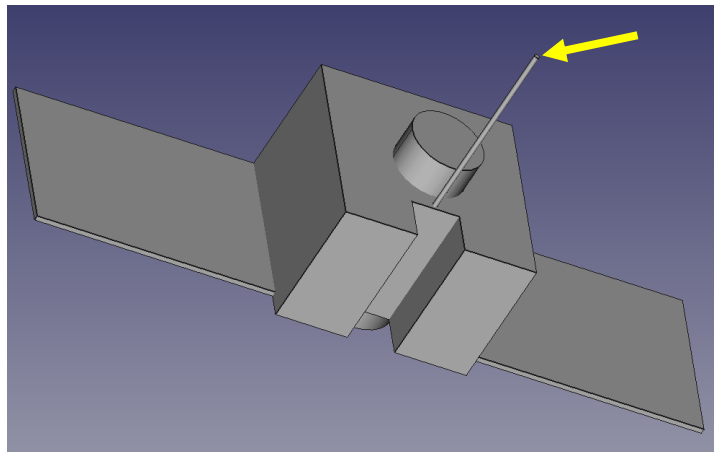
The image on the right shows what you should have up until this point.









F. Drawing the TAGSAM Arm (Circle)

1. Click on the bottom surface of the box (the one you just drew on). It will turn yellow or green (arrow pointing to the face in the image above).
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 **0.5 mm**.
5. Click on the dot at the center of the circle and click on the horizontal red line. Use the **Vertical Distance**  tool to make the distance 20 mm.
6. Click on the dot at the center of the circle and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 0 mm.
7. Click Close (on your left-hand Combo View panel).
8. Use the **Padding**  tool to make it 3D!
9. In the left-hand panel, make the length **80 mm**. Click OK.

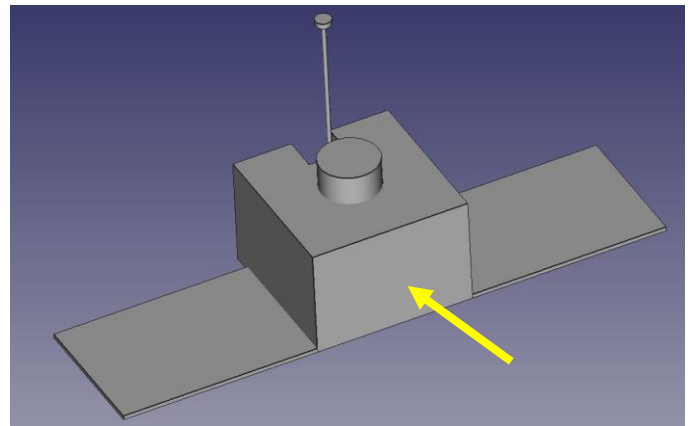
The image on the right shows what you should have up until this point.









G. Drawing the TAGSAM Head (Circle)

1. Click on the TAGSAM arm cylinder. When you have selected the top of the thin cylinder we just made, it should turn yellow or green (the arrow is pointing it in the previous image).
 - a. It might be easier to click on the circle face if you switch to the bottom view  and zoom in.
2. Click on the **Create a New Sketch** tool. 
3. Select the **Circle Sketch** tool and draw a circle. 
4. Click on one of the circles and use the **Radius**  tool to make the radius **4 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 length **2.5 mm**. Click OK.

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



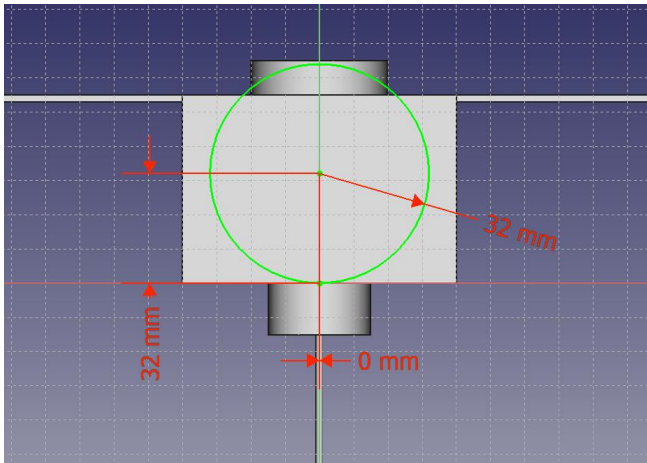
H. Drawing the Radio Dish (Circle)

10. Click on the side base (arrow point to it in the image above). You can change your view to see the side surface by using the 3D view icons (use the rear view ). When you have selected the side of the base it will turn yellow or green.
1. Click on the **Create a New Sketch** tool. 
2. Select the **Circle Sketch** tool and draw a circle. 
3. Click on the circle and use the **Radius**  tool to make the radius **32 mm**.
4. Click on the dot at the center of the circle and click on the horizontal red line. Use the **Vertical Distance**  tool to make the distance 32 mm.
5. Click on the dot at the center of the circle and click on the vertical green line. Use the **Horizontal Distance**  tool to make the distance 0 mm.

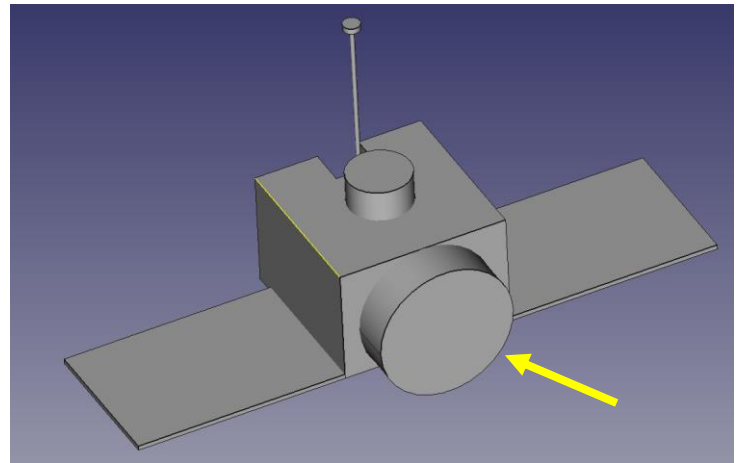
6. Click Close (on your left-hand Combo View panel).

7. Use the **Padding**  tool to make it 3D!

8. In the left-hand panel, make the length **20 mm**. Click OK.



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



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

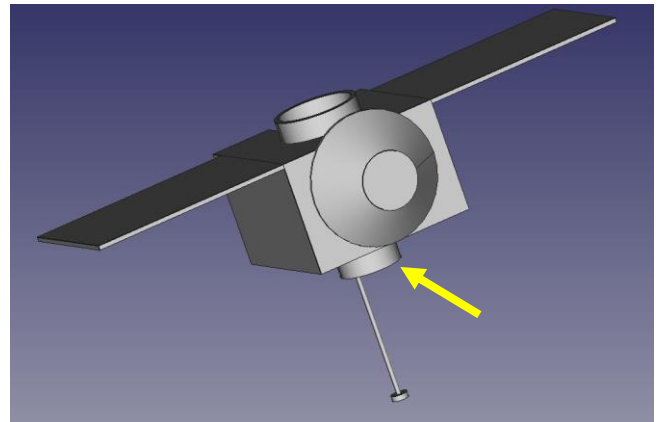
I. Creating the Radio Dish Shape Using Chamfer

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 Edge56 should appear. Enter **18 mm**. This will smooth down the edge by 18 mm.

4. Click OK.



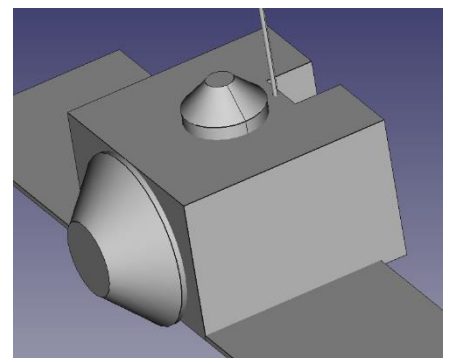
J. Creating the Sample Return Capsule Cone Shape Using Chamfer

5. Click on the top edge of the Sample Return Capsule (arrow is point to it on image above). Select only the edge, only the line should turn green.

6. Click on the **Chamfer** tool. 

7. In the left hand panel, only Edge54 should appear. Enter **10 mm**. Then, Click OK.

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



FINAL PRODUCT:

