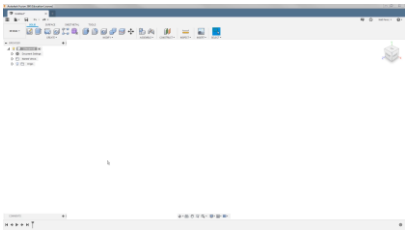
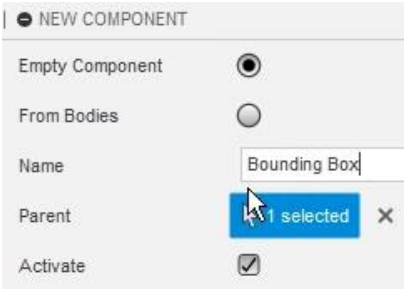
Lesson: Creating the Geometry Bounding Box

In this lesson, you will learn to create a 3d bounding box and control its opacity to help visualize the working area in 3d in order to meet micro class regulations.

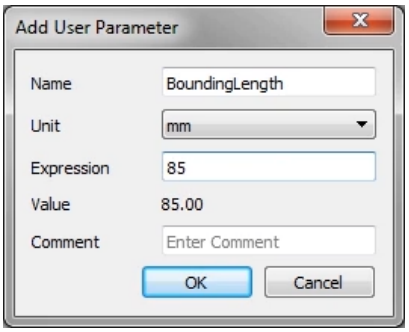
The completed exercise

Learning Objectives

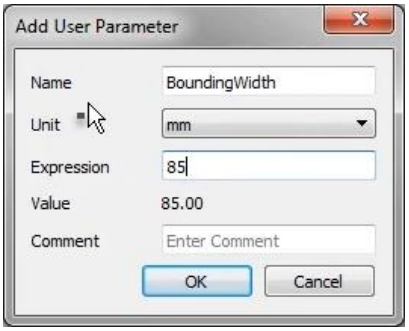
- Create a sketch.
- Create an extrude.
- Use Opacity Control.

1. Open a new, untitled document.	
2. Click Assemble> New Component. Name it “Bounding Box”, make sure the Activate box is checked, then click OK.	

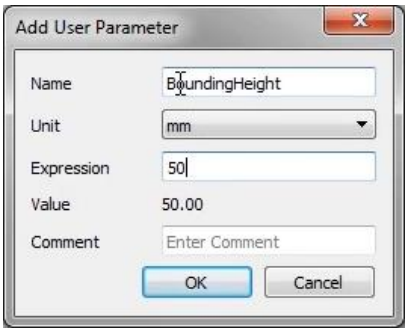
3. Click Modify> Change Parameters. Click the plus icon next to User Parameters to add new parameters. Enter a name of “BoundingLength”, enter a value of 85mm in the Expression field, then click OK.



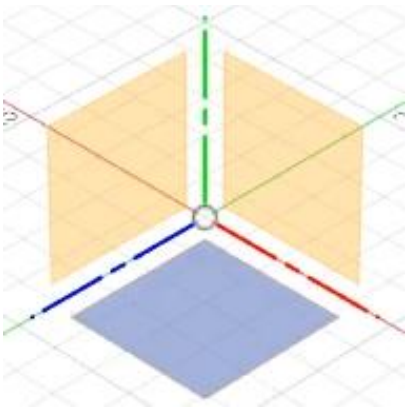
4. Click the plus icon next to User Parameters to add new parameters. Enter a name of “BoundingWidth”, enter a value of 85mm in the Expression field, then click OK.



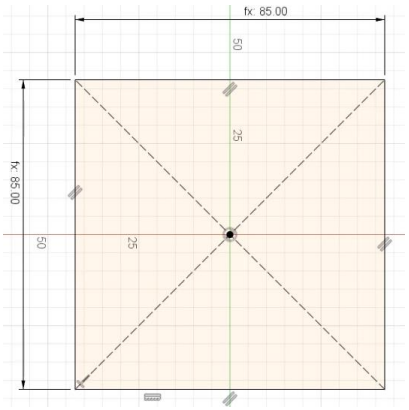
5. Click the plus icon next to User Parameters to add new parameters. Enter a name of “BoundingHeight”, enter a value of 50mm in the Expression field, then click OK in the Add User Parameter window. Click OK in the Parameters window.



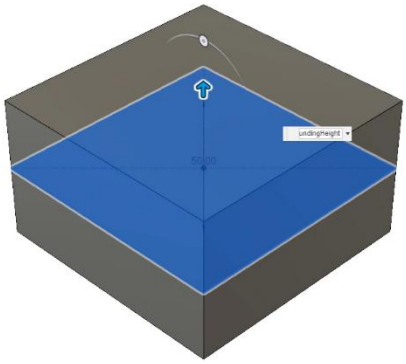
6. Click Create> Create Sketch and choose the top plane to sketch on.



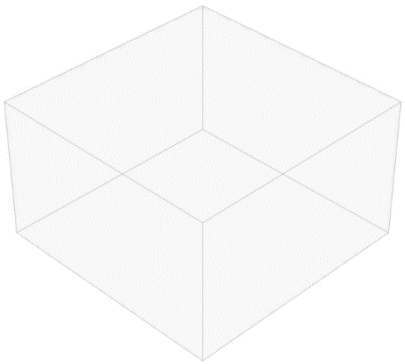
7. Click Create> 2-Point Rectangle and choose the Center Rectangle option in the Rectangle section of the control panel. Beginning at the origin, draw a rectangle. Enter a value of BoundingLength for one of the horizontal lines, and a value of BoundingWidth for one of the vertical lines. Click Stop Sketch.



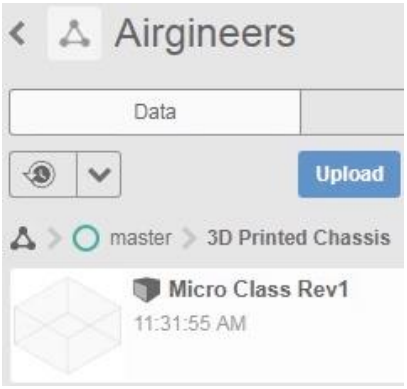
8. Press the E key, then extrude the shape upwards by a value of BoundingHeight. Change the Direction option to Symmetric and change the Measurement option to Whole Length. Click OK. The shape you just created is the envelope inside which you will build the micro drone chassis.



9. In the Browser, Expand the Bounding Box component, expand the Bodies folder, right-click Body1, then choose Opacity Control> 20%. Activate the top level of the Browser. The Bounding Box is now displayed at a lower opacity.

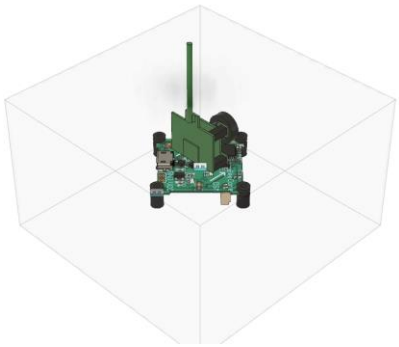


10. Expand the Data Panel. Inside the project's master folder, create a new folder named, "3D Printed Chassis." Save the current file into this new folder. Name the file "Micro Class Rev1". Minimize the Data Panel and continue to the next module.



Lesson: Insert and Locate Main Components

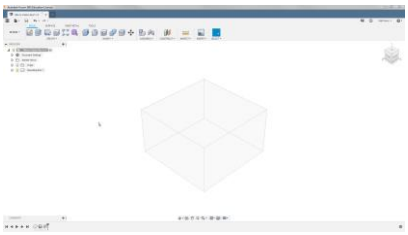
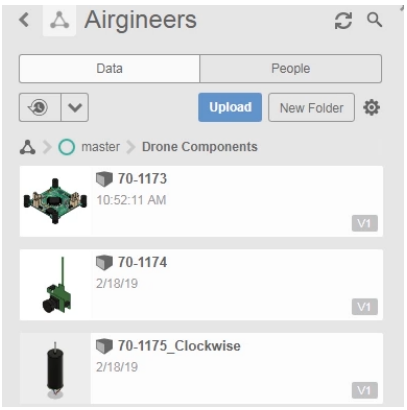
In this lesson, you will insert off the shelf components like the camera, motors, flight controller and battery to start planning geometry.



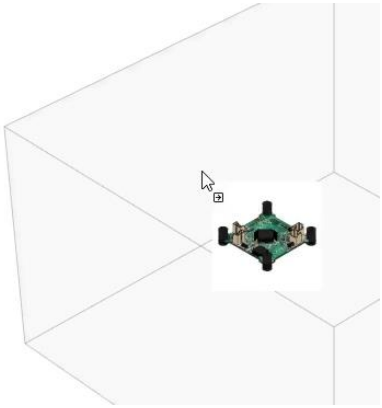
The completed exercise

Learning Objectives

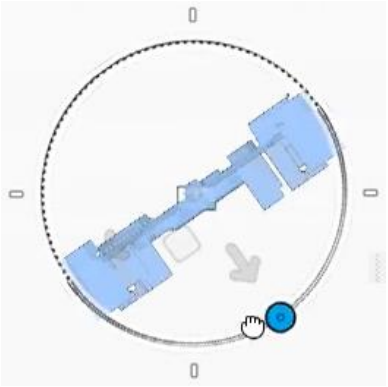
- Create a distributed design.
- Use Move/Copy when inserting a design.
- Ground components.
- Change display settings.

1. Continue with the file from the previous module.	
2. Create a sub folder inside the project's master folder and name it "Drone Components". Upload the drone component files to this folder. The necessary components are 70-1173, 70-114, 70-1175, 70-1176, 70-1191 (clockwise and counter clockwise), and 70-1192.	

3. Drag 70-1173 into the Canvas area.



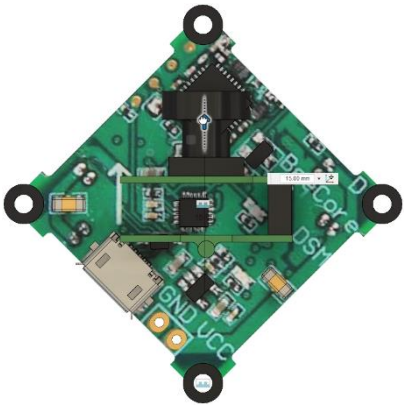
4. Go to the front view. Use the on-screen manipulators to rotate the part -180 degrees. The top should now be facing down.



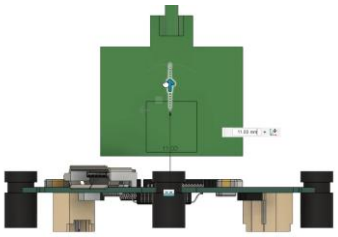
5. Go to the top view. Use the on-screen manipulators to rotate the part 135 degrees. The arrows on the PCB should be pointing upwards which is also the -Z direction. Click OK. In the Browser, right-click 70-1173 and choose Ground.

6. In the Browser, right-click the Bounding Box and the 70-1173 components, then choose Ground. Notice the 70-1173 component has a chain link icon; this indicates that the file cannot be edited inside this project. To make changes to this file, you would have to either open the source file for the component or break the current link. Turn off the visibility for the Bounding Box component

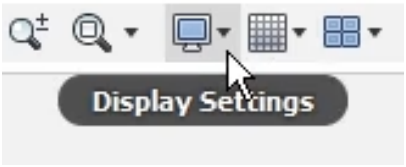
7. Drag 70-1174 from the Data Panel and drop it into the Canvas area. Use the on-screen manipulator to rotate the camera-180 degrees so the camera faces the same direction as the arrows printed on the PCB. Move the camera so it is approximately centered on the flight control PCB.



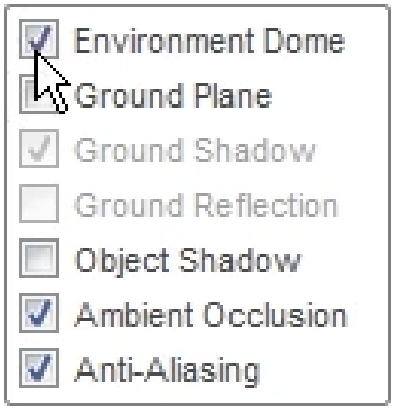
8. Rotate the view and raise the camera so its PCBs are above the flight control PCB. Click OK. Use the Browser to ground the 70-1174 component.



9. A helpful feature to mention relates to the camera view. Click the Display Settings button at the bottom of the screen, then choose Camera> Perspective with Ortho Faces. The view will appear to have perspective which means that the lines will appear to converge as they recede into the distance. However, when you go to the top, right, or front views, the perspective will be turned off. This feature might be useful as you continue to design your Micro Class Drone.

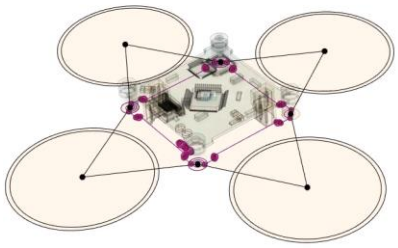


10. Click Display Settings> Effects, then investigate the options available here. These might also be helpful as you continue designing your drone; activate the options you prefer. When you are finished investigating the options, save the file and continue to the next module.



Lesson: Main Chassis Design Layout

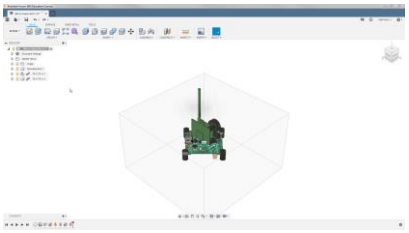
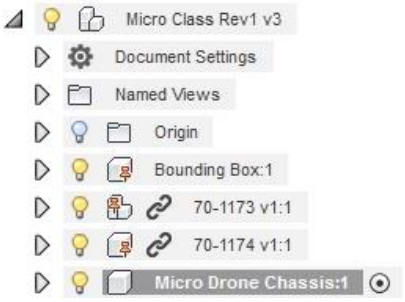
In this lesson, you will layout the main structure of the chassis to locate the motors and hold the flight controller.



The completed exercise

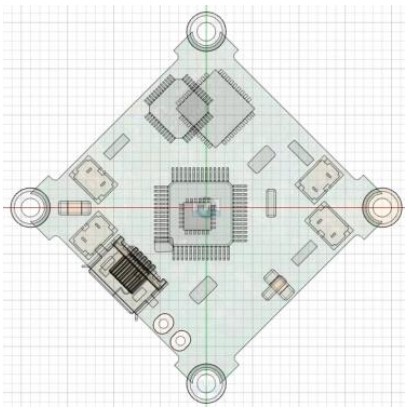
Learning Objectives

- Create a sketch.

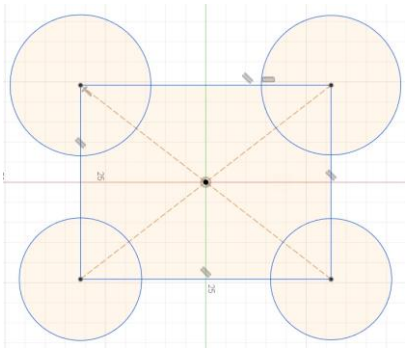
1. Continue with the file from the previous module.	
2. The chassis for the micro class drone needs to be designed. Activate the top level of the Browser, then click Assemble> New Component. Enter a name of “Micro Drone Chassis”. Make sure the Activate option is checked, then click OK. Hide the 70-1174 component.	

3. Select the bottom face on one of the rubber isolator standoffs. Because of the selection rules, you might have to zoom in to the part, hold the left mouse button, then select the face from the drop-down list. Alternately, you can change the selection rules by clicking Select> Selection Priority or Select> Selection Filters, then choose the new options you want to apply. Click Create> New Sketch. Hide the Bounding Box component.

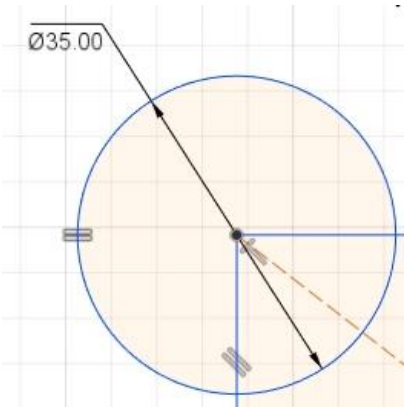
4. Go to a top view and make sure -Z is pointing upwards so that the flight controller and the flight direction are pointing upwards.



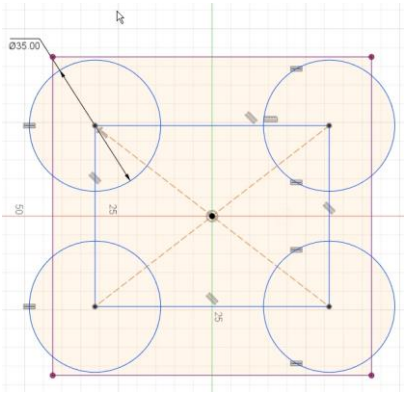
5. Click Create> 2-Point Rectangle, then choose the Center Rectangle option in the Rectangle section of the control panel. Beginning at the origin, draw a rectangle. Press the C key to open the Circle tool and draw a circle at each corner of the rectangle.



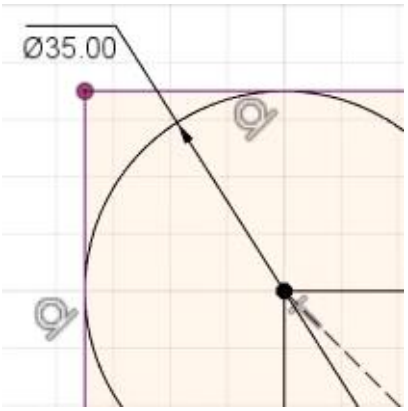
6. Click Constraints> Equal and add Equal constraints to all four circles. Press the Esc key to leave the Equal tool, then press the D key to open the Dimension tool. Add a dimension of 35mm to one of the circles. Press the Esc key.



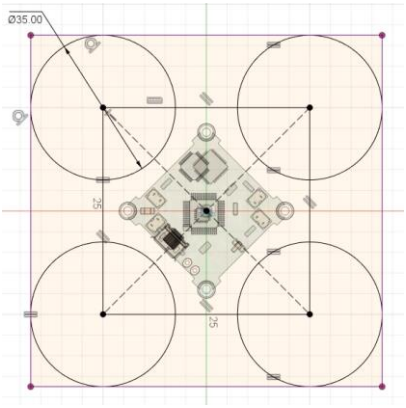
7. Make the Bounding Box component visible, select it, then press the P key to project its geometry into the sketch. Hide the Bounding Box again.



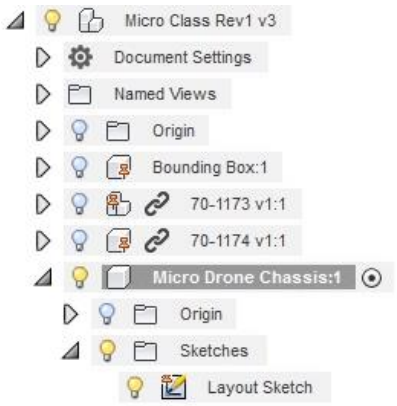
8. Click Constraints> Tangent and add the constraint between one of the circles and two sides of the projected geometry. Press the Esc key. These circles represent the propeller shrouds.



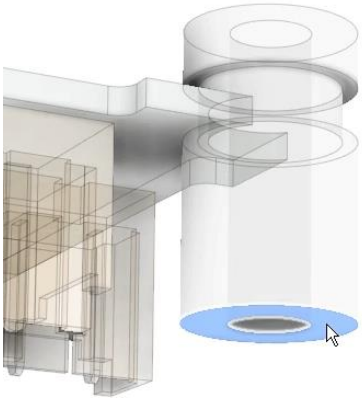
9. Make 70-1173 visible to check the clearance between the propeller shrouds and the flight controller's PCB. Click Stop Sketch.



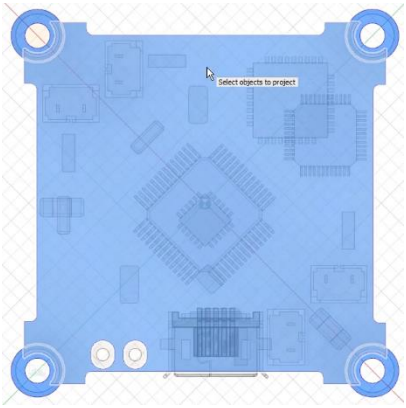
10. Hide the 70-1173 component. Expand the Micro Drone Chassis' Sketches folder. Rename Sketch1 as Layout Sketch. Save the file.



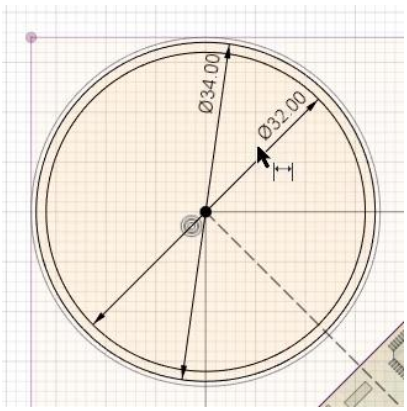
11. Make 70-1173 visible. Select the face on the bottom of the rubber isolator standoff. Create a new sketch on this face.



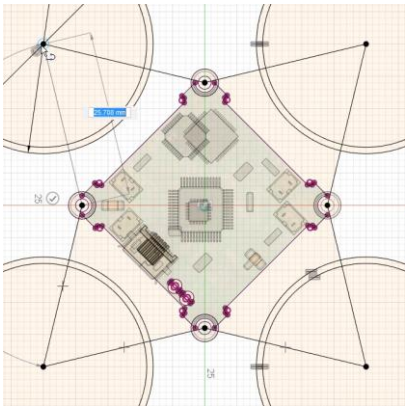
12. Press the P key to open the Project tool. Select each of the four rubber isolator standoffs by clicking on the top face. Next, select the top of the PCB. Click OK.



13. Go to the top view and rotate the view so that -Z is pointing upwards. Make the Layout Sketch visible. Open the Circle tool. Beginning at the center of one of the circles you drew in step 5, draw a 32mm and a 34mm circle. Draw two circles at each of the other three corners and make them equal to the first two circles.



14. Press the L key to open the Line tool. Connect the center of the circles to the center of the adjacent rubber isolators. Click Stop Sketch. Save the file and continue to the next module.



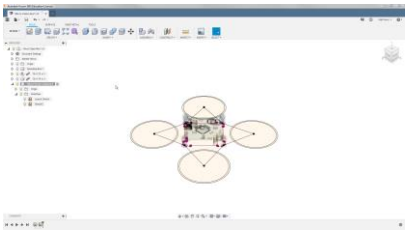
Lesson: Main Chassis Solid

In this lesson, you will design the main structure of the chassis.

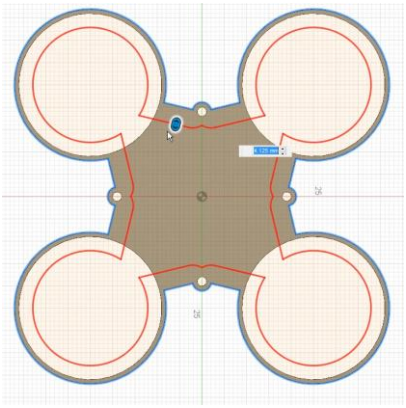
The completed exercise

Learning Objectives

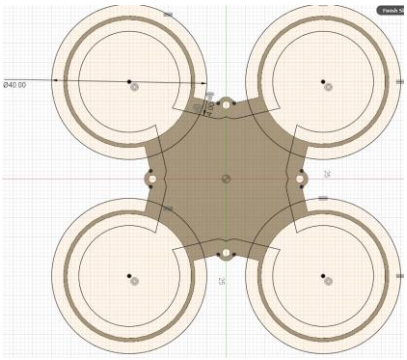
- Create a sketch.
- Use Offset.
- Create an extrude cut.
- Use Rule Fillet.

1. Continue with the file from the previous module.	
2. Make sure the Micro Drone Chassis component is selected and activated. Hide the 70-1173 component. Click Create> Extrude. Select all the geometry inside the sketch except for the regions inside the propeller shrouds and inside the holes for the rubber isolator standoffs. Click OK. If you make an incorrect selection, right-click the extrude feature in the Timeline and choose Edit Feature. Correct the mistake, then click OK.	

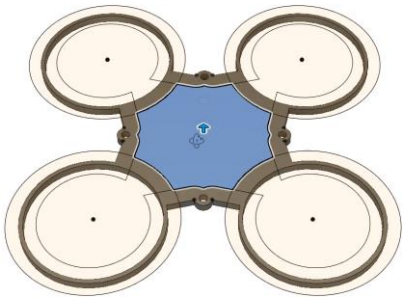
3. Some material needs to be removed for weight reduction. Go to the top view and rotate the view so that -Z is pointing upwards. Create a new sketch on the top face of the extrusion. Click Modify> Offset. Select the outside of the extrusion and use the on-screen manipulator to offset the geometry inwards 4mm.



4. Draw four equal circles, each beginning at the center of the propeller shrouds. Add a dimension of 40mm to one of the circles. Click Stop Sketch.



5. Click Create> Extrude. Select the middle region then use the on-screen manipulator to pull it downwards through the extrusion. Change the Extent option to All. Expand the Objects To Cut section and verify that only Body1 will be cut. Click OK.



6. Fillets need to be added to the chassis. Click Modify> Fillet. Change the Type to Rule Fillet and select the Timeline's extrude cut feature you created in step 5. Change the Radius value to 1mm, then change the Rounds/Fillets option to Fillets Only. Click OK.

7. Use the right-click marking menu to repeat the Fillet command. Select the first extrude as the Faces/Features selection and keep all the same settings you used in step 6. Click OK. All the internal and external corners now have fillets.

8. Make 70-1173 visible. Rotate the model to verify that the flight controller is sitting on top of the chassis and that there is clearance for accessing the connectors on the bottom of the board. Save the file and continue to the next module.

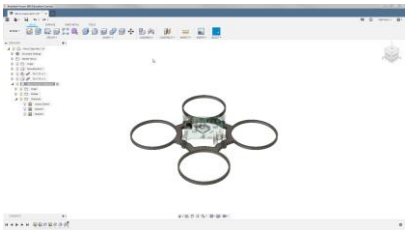
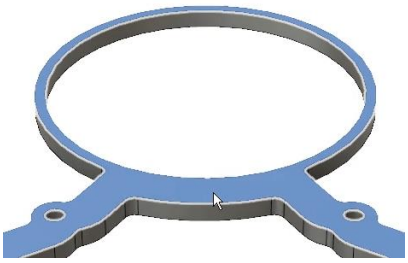
Lesson: Create the Propeller Guard Base Shape

In this lesson, you will create the propeller guard geometry and explore ducting system trying to understand some benefit of weight vs function.

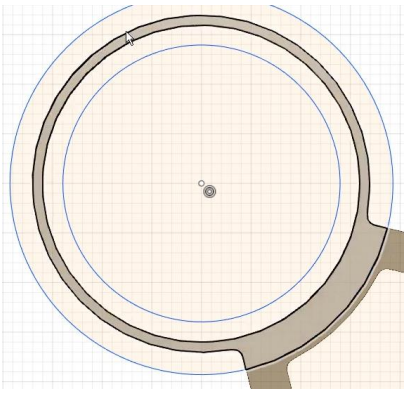
The completed exercise

Learning Objectives

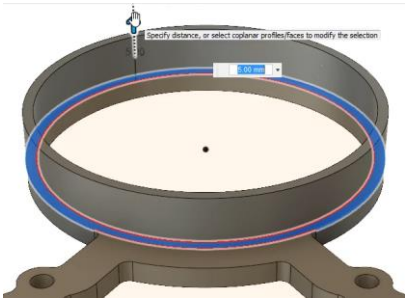
- Create a revolve.
- Use reference geometry.
- Create a reference axis.
- Use Intersect.

1. Continue with the file from the previous module.	
2. The propeller shrouds need to be added to the chassis. Make sure that the Micro Drone Chassis component is selected and activated. Hide the 70-1173 component. Create a new sketch on the top face of the chassis.	

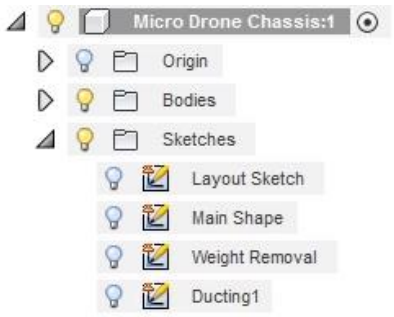
3. Open the Circle tool and draw two circles concentric with one of the large holes in the chassis.



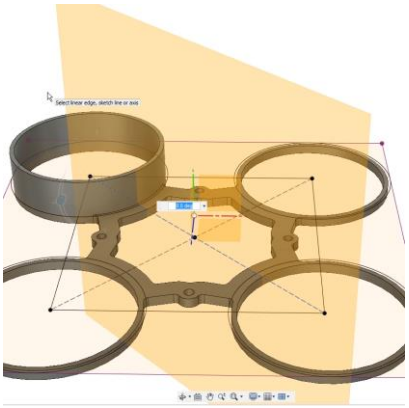
4. Add an Equal constraint between one of them and the outer circle of the propeller shroud, then add another Equal constraint between the other and the inner circle. Click Stop Sketch. Open the Extrude tool and extrude the region upwards 8mm. Set the Operation option to Join, then click OK.



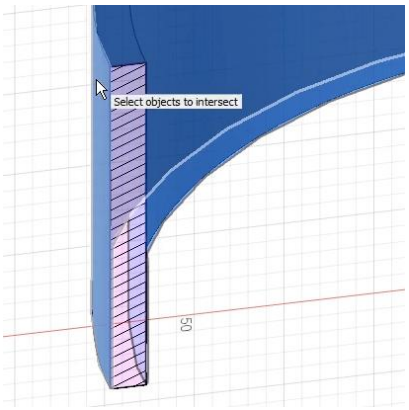
5. In the Browser, rename Sketch2 as “Main Shape”, Sketch3 as “Weight Removal”, and Sketch4 as “Ducting1”. The radiused edge on the shroud needs to be created. These edges will be designed so that no support material will be necessary during the printing process; this will reduce the clean-up time needed and encourage cleaner results. To do this, you need to know the amount of unsupported material your specific printer can print.



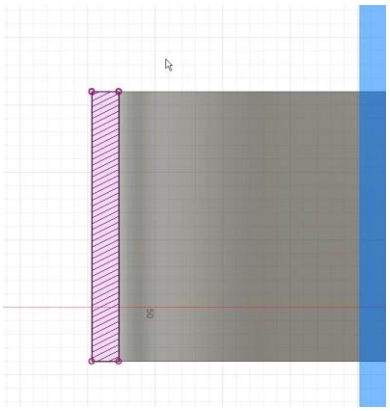
6. Make the Layout Sketch visible. Click Construct> Plane at Angle. For the Line selection, select the diagonal construction geometry line in the Layout Sketch. Click OK. Hide the Layout Sketch.



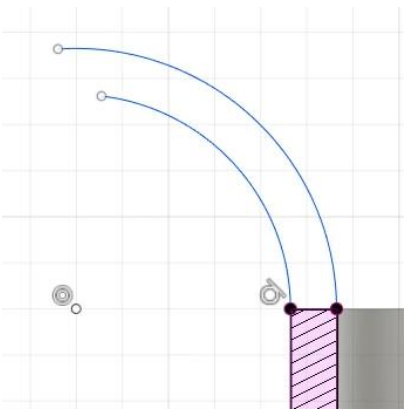
7. Expand the Micro Drone Chassis' Construction folder and hide Plane1. Right-click Plane1 and choose Create Sketch. Activate the Slice feature. Click Create> Project / Include> Intersect. Select the top, inside, and outside faces of the propeller shroud. Click OK.



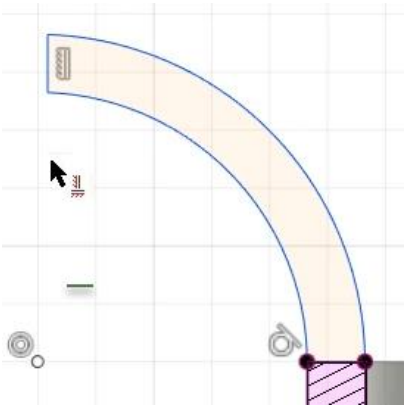
8. Select Plane1, then click the Look At button at the bottom of the screen. This will snap the camera to a view normal to the selection. Pan the view so the shroud's section view is centered in the screen.



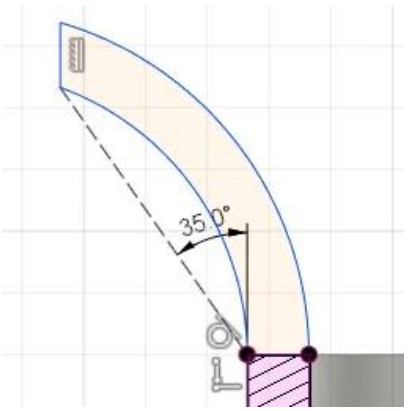
9. Click Create> Arc> 3-Point Arc. Draw two arcs to extend the section view of the propeller shroud. Add a constraint to make one of the arcs tangent with the vertical line it extends, then add a Concentric constraint between the two arcs.



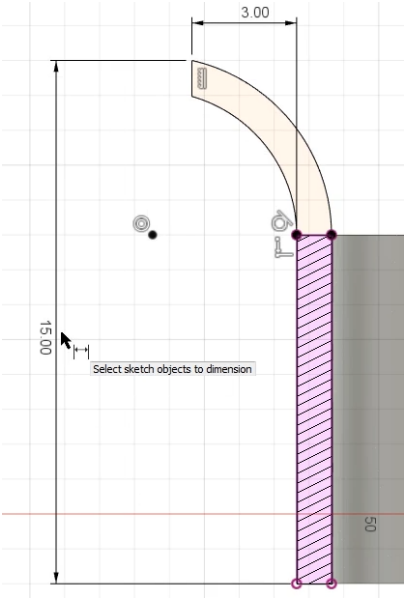
10. Open the Line tool and connect the free ends of the arcs. Make this line vertical.



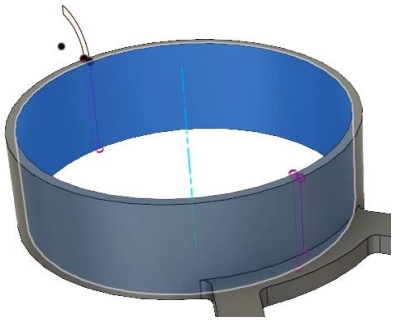
11. If the radiused shroud extension is too long, support material will need to be used during printing. Draw a line connecting the bottom of the shroud radius and the outer corner of the original shroud. Convert this line to construction geometry. Using the maximum unsupported angle of your specific printer, enter an angle dimension between the construction geometry and the vertical line. In this case, the printer this documentation will use has a maximum angle of 35 degrees.



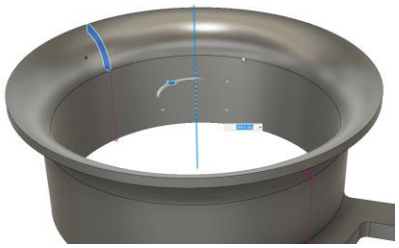
12. Delete the construction geometry you just created. An alternate method for fully constraining the geometry is to add two dimensions. Add a 3mm dimension between the top point of the extension and the top outer corner of the original shroud. Next, add a 15mm dimension between the top point of the extension and the bottom edge of the original shroud. This will print well on the printer used for this documentation. If you are unsure about your specific printer's capabilities, it is helpful to print a small section of the model to make sure the geometry is correct for your application. Click Stop Sketch.



13. Click Construct> Axis Through Cylinder/Cone/Torus. Select the inside face of the shroud as the Face selection, then click OK. The center of the shroud now has a visible axis you can select.



14. Click Create> Revolve. Select the shroud's radiused extension as the Profile selection. Choose the axis you created in step 13 as the Axis selection. Click OK. Use the Browser to hide the axis by clicking the lightbulb icon next to Axis1. Save the file and continue to the next module.



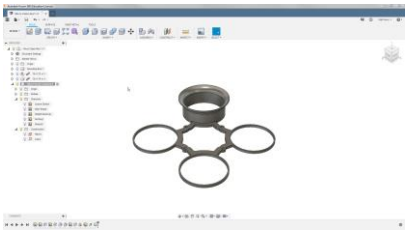
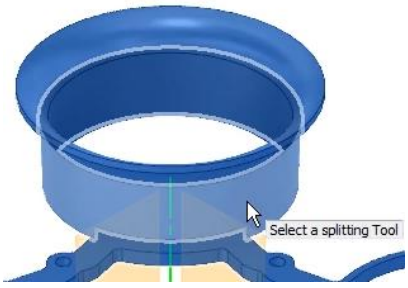
Lesson: Create the Propeller Guard Structure

In this lesson, you will create the propeller guard geometry and explore ducting system trying to understand some benefit of weight vs function.

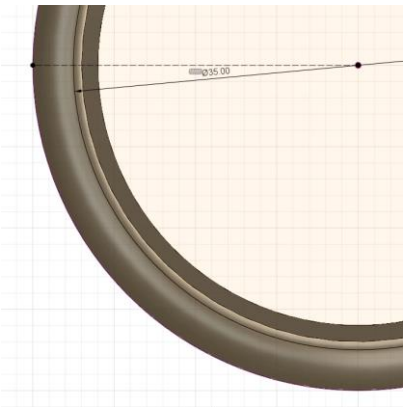
The completed exercise

Learning Objectives

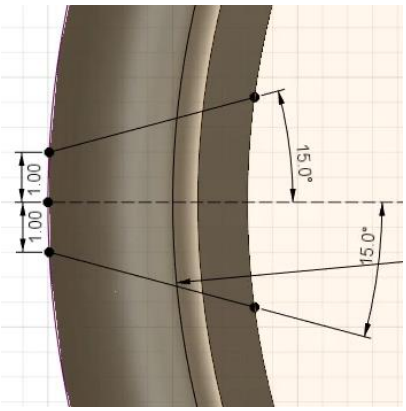
- Create an extrude.
- Pattern a feature.
- Pattern a body
- Use Combine.

1. Continue with the file from the previous module.	
2. The structure of the propeller shrouds could use a little extra structure to increase the rigidity of the part. Click Modify> Split Body. Select the Micro Drone Chassis as the Body to Split. For the Splitting Tool selection, choose the outer face of the propeller shroud. Activate the Extend Splitting Tool option, then click OK.	
3. Expand the Bodies folder and notice there are now three bodies in the Bodies folder: the chassis, the shroud cylinder, and the shroud radius extension. Hide the chassis, then click Modify> Combine. Select the shroud cylinder and the shroud radius extension, then click OK.	

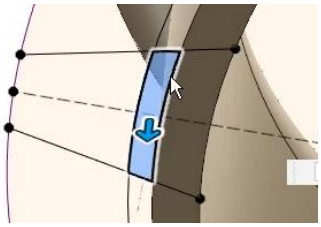
4. Create a new sketch on the bottom face of the propeller shroud. Rotate the camera view so that +Z is pointing to the right. Draw a horizontal line from the center of the shroud and extending to the left, reaching the outermost point on the radiused extension. Convert this line to construction geometry. Use the Circle tool to draw a 35mm circle concentric with the shroud.



5. Use the Line tool to draw two diagonal lines, one on either side of the construction geometry. The inside point of the line should be coincident with the inside of the shroud, and the outside point of the line should be coincident with the outside of the radiused extension. Add 1mm dimensions between the outer points of the lines and the construction geometry. Add an angle dimension of 15 degrees between the diagonal lines and the construction geometry. Click Stop Sketch.

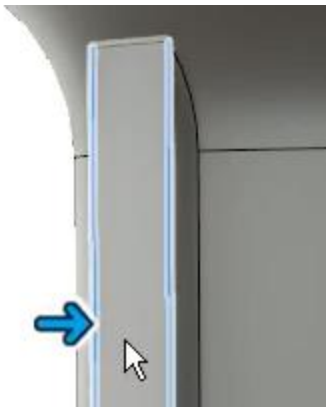


6. Open the Extrude tool. For the Profile selections, choose the middle region of the geometry you drew in step 5. Use the on-screen manipulator to extrude the geometry upwards towards the top of the shroud.



7. For the Extent option, choose To Object. Select the underside of the radiused extension as the Object selection. Make sure the Operation type is set to Join, then click OK.

8. Click Modify> Fillet. Change the Type to the Fillet option. Select the outside edges of the new extrusion and add a 1mm radius fillet. Click OK.

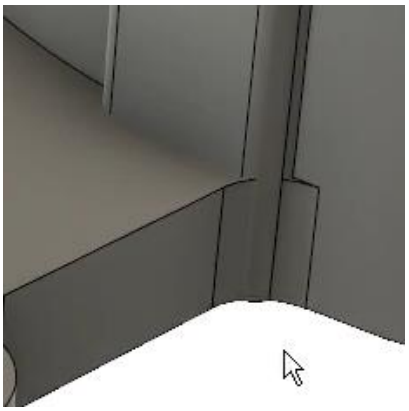


9. Click Create> Pattern> Circular Pattern. Change the Pattern Type to the Features option. In the Timeline, select the extrude and fillet features you created in steps 6 and 8. For the Axis selection, choose the circular edge at the top of the shroud. Change the Quantity value to 10, then click OK.

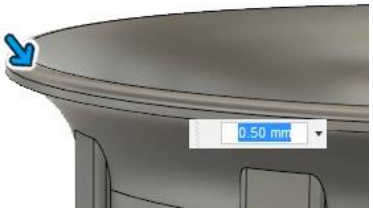
10. Rotate the part and notice that some of the instances did not terminate correctly. Edit the feature and change the Compute Option to Identical. Click OK. The ribs are all correctly calculated.

11. Edit the rib's fillet and reduce the radius to 0.5mm. Click OK. Notice that the change cascades to all the instances in the circular pattern.

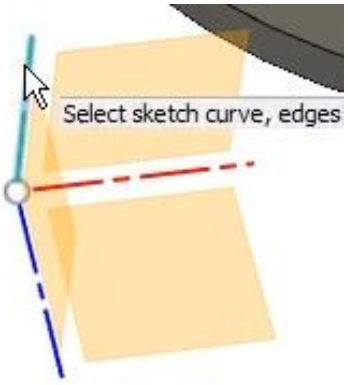
12. Make the chassis body visible. Zoom into the section where the rib meets the chassis. This is not ideal geometry. Edit the circular pattern and reduce the Quantity value to 9. Click OK. The geometry is now more ideal.



13. Click Modify> Fillet. Select the top edge of the radiused extension and specify a 0.5mm fillet. Click OK.

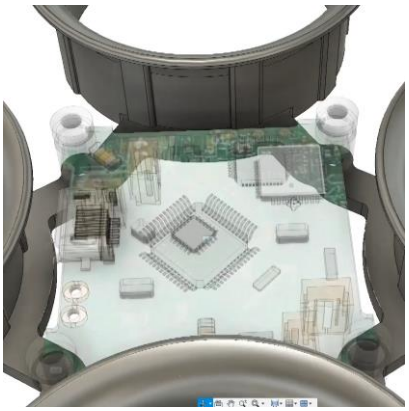


14. The propeller shroud is complete, but three more need to be created on the chassis. Click Create> Pattern> Circular Pattern. Change the Pattern Type to the Bodies option. Select the shroud as the Objects selection. Click the Select button in the Axis section of the control panel, then choose the green Y axis as the Axis selection. Change the Quantity value to 4, then click OK. The shroud is replicated three more times.



15. Click Modify> Combine. Select the main chassis body as the Target Body, then choose all four shrouds as the Tool Bodies selections. Click OK. The five bodies join into one body. In the Browser, rename the body as “Main Chassis”.

16. Make the 70-1173 component visible and verify that it still fits into the chassis. Hide 70-1173 when you are satisfied with the fit. Save the file and continue to the next module.



Lesson: Creation of Main Chassis Ribs and Motor Support

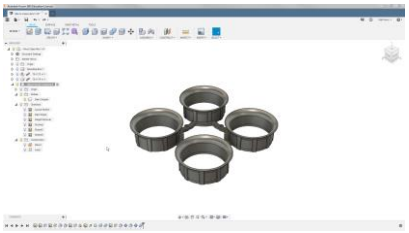
In this lesson, you will add more structure to the chassis by creating ribs to support the propeller ducting and motors.

The completed exercise

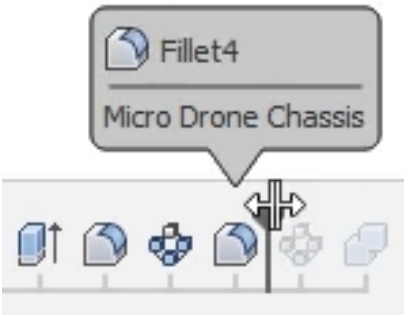
Learning Objectives

- Create solid geometry.
- Pattern a feature.
- Use Offset.

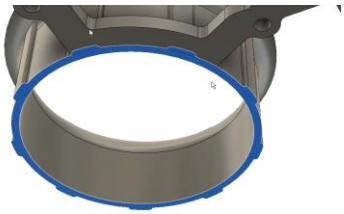
1. Continue with the file from the previous module.



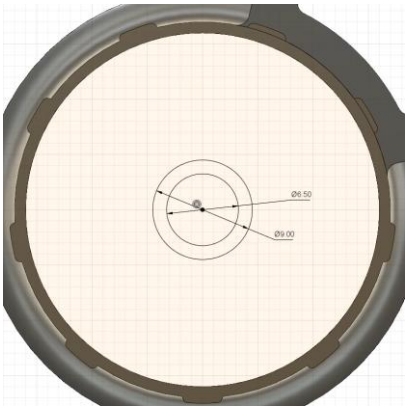
2. Features for holding the motors need to be added to the chassis. Roll the end of the Timeline backwards to the point before the propeller shroud was patterned.



3. Create a new sketch on the bottom face of the shroud.

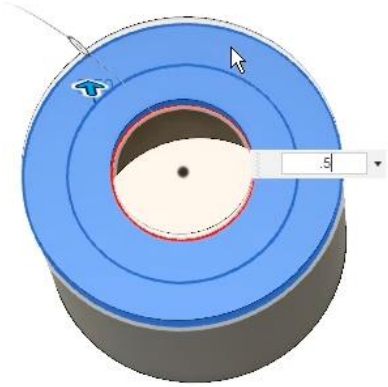


4. Beginning at the center of the propeller shroud, draw a 9mm circle and a 6.5mm circle. Click Stop Sketch. The printer used for this documentation is known to print 6mm circles when 6.5mm is specified. This is the reason for the larger-than-necessary inner diameter for holding the motor. Use a dimension appropriate for the specific machine you will use to print your chassis.

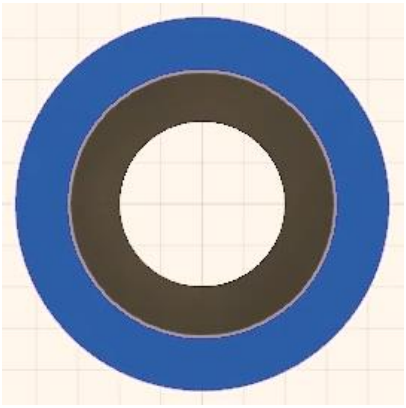


5. Use the Extrude tool to extrude the region between the two circles upward -6mm. Rotate the model so it is right-side up, then create a new sketch on the top of the new extrusion.

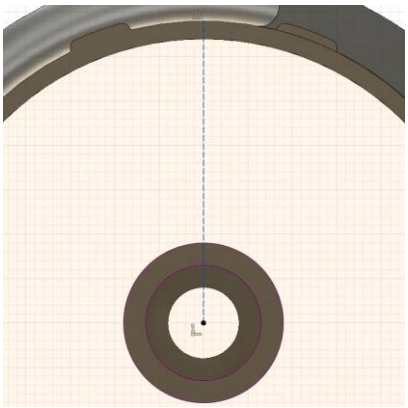
6. Beginning at the center of the new extrusion, draw a 4mm diameter circle. Click Stop Sketch. Select the two outer regions and extrude them upwards 0.5mm. Click OK. This new extrusion will create a physical stop so that the motor will press into the cavity and stop at a certain distance.



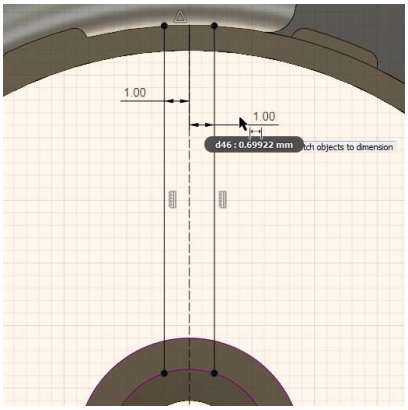
7. Ribs need to be created to join the motor holder to the shroud. Create a new sketch on the bottom face of the shroud. Press the P key to open the Project tool. Select the bottom face of the extrusion you created in step 5. Click OK.



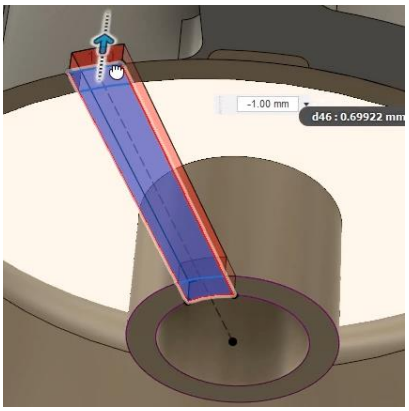
8. Open the Line tool. Beginning at the origin, draw a vertical line connecting the origin to the outer wall of the lower part of the shroud. Convert this line to construction geometry.



9. Draw two more vertical lines, one on each side of the construction geometry. These lines should connect the outside wall of the shroud's lower part to the inside wall of the motor holder. Make sure each line is 1mm away from the construction line. Click Stop Sketch.

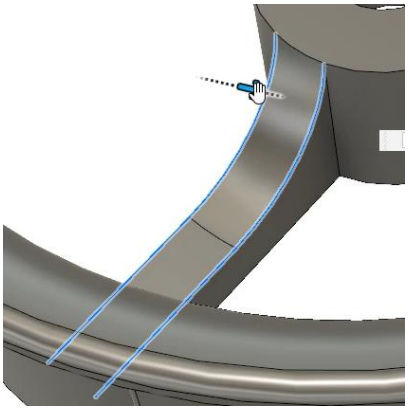


10. Open the Extrude tool. For the Profiles selections, choose the regions inside the geometry you just drew. Extrude this region upwards -2mm towards the top of the shroud. Change the Operation type to Join, then click OK.



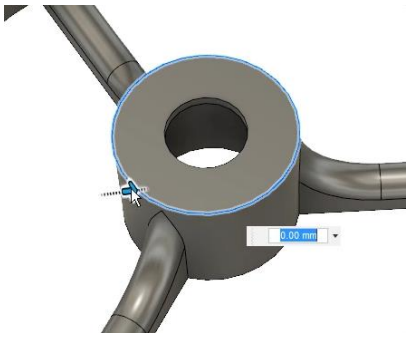
11. Click Modify> Fillet and make sure the Type is set to Fillet. Select the edge where the new extrusion meets the motor holder. Add a 4 mm radius. Click OK.

12. Repeat the fillet command. Select the two edges on top of the rib and add a 1mm fillet. Click OK.

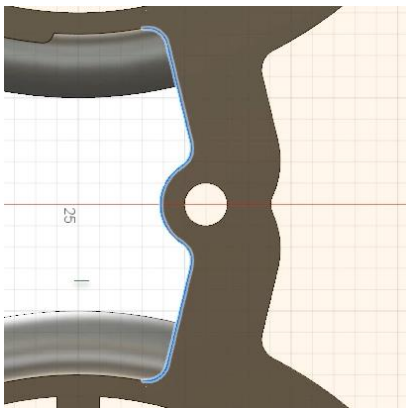


13. Click Create> Pattern> Circular Pattern. Make sure the Pattern Type is set to Features. In the Timeline, select the extrudes that created the motor holder, the extrude that created the rib, and the fillets on the rib. For the Axis selection, choose the circular edge on the top of the motor holder. Click OK.

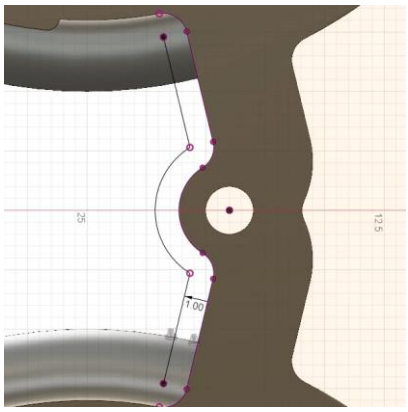
14. Open the fillet tool and select the edges on the top of the motor holder. Add a 0.5mm fillet to this edge, then click OK. Roll the Timeline marker back to the end of the Timeline. The circular pattern automatically updates with the recently added geometry.



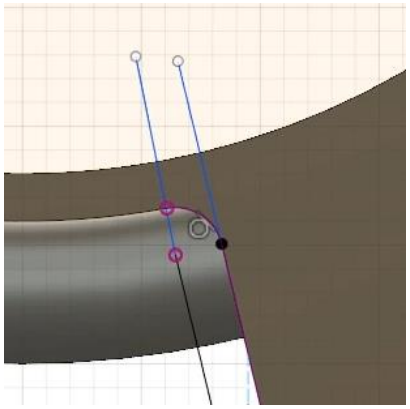
15. Start a new sketch on the bottom face of the chassis. Press the P key to open the Project tool. Select the geometry on the outside of the chassis between the propeller shrouds. Click OK.



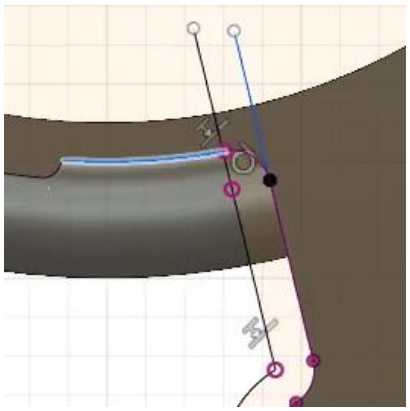
16. Click Modify> Offset. Deactivate the Chain Selection option. Omitting the fillet geometry at the end of the projected geometry, select the remaining lines and offset them 1mm towards the outside of the chassis. Click OK.



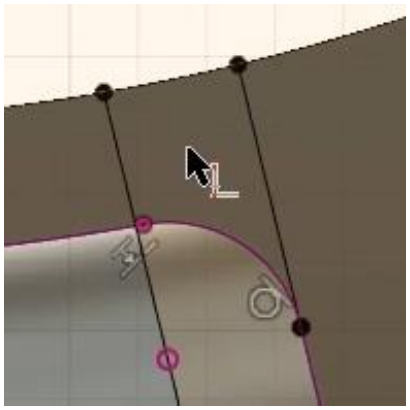
17. Use the Line tool to extend the original and the offset geometry past the inside of the propeller shroud. Repeat this process for the other side as well. Make sure all the lines are collinear with the line they are extending.



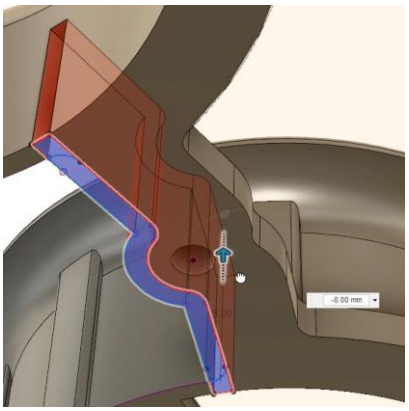
18. The extensions of the offset line do not intersect the fillet you projected in step 15. Open the Project tool and chose the shroud's edge that extends from the fillet you selected in step 15. Repeat this selection on the other side as well. Click OK.



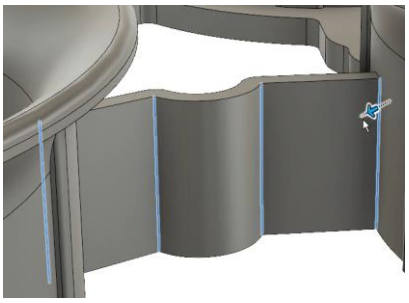
19. Add a Coincident constraint between the free ends of the lines and the inside wall of the shroud. Repeat this process for the other side as well. The inside region of the new geometry is selectable for extruding. If the control panel's Show Profile option is activated, the closed region inside the geometry will highlight as a profile when you hover over it. Click Stop Sketch.



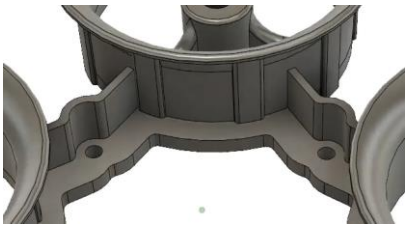
20. Open the Extrude tool and select the three new regions as the Profile selection. Extrude the regions upwards towards the top of the drone -8mm. Change the Operation type to Join, then click OK.



21. Open the Fillet tool and select the corners on the outside of the new extrusion. Add a radius of 1mm, then click OK.

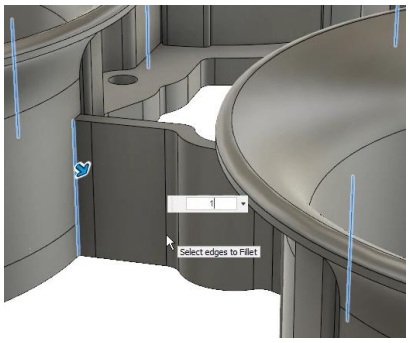


22. Open the circular pattern tool. In the Timeline, choose the extrusion you made in step 20 and the fillet you created in step 21. Choose the green Y axis as the Axis selection, then change the Quantity to 4. Click OK. Rotate the model and check to make sure the features appear as-intended.



23. Some of the fillets didn't resolve.

24. Edit the circular pattern feature and change the Compute Option to Identical. Click OK and inspect the results. The missing fillets did not appear. Manually add 1mm fillets to the affected corners. Save the file and continue to the next module.



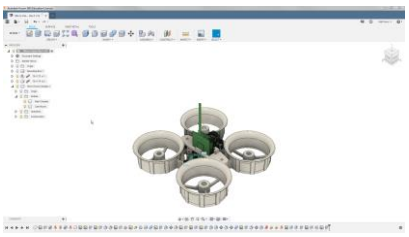
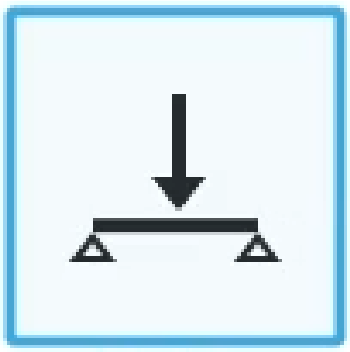
Lesson: Static Simulation Study

In this lesson, you will get a crash course on setting up and running a static simulation study.

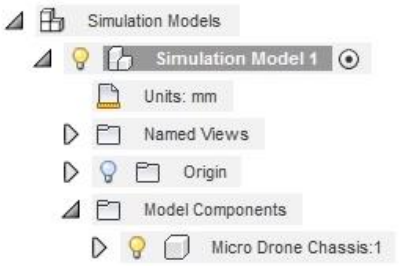
The completed exercise

Learning Objectives

- Set up and run a static stress simulation.
- Analyze simulation results.

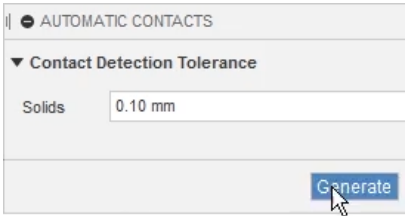
1. Continue with the file from the previous module.	
2. A static simulation needs to be solved to see how forces affect the chassis. Click the Change Workspace button and choose the Simulation workspace from the drop-down menu. In the New Study window, choose the Static Stress option, then click the Create Study button.	

3. For simulations, it is important to reduce the number of bodies to the bare essentials. Click Simplify> Simplify. In the Browser, expand the Model Components folder, right-click the Bounding Box component, and choose Remove. Also remove 70-1173 and 70-1174. Click Finish Simplify. Removing the bodies in the Simulation workspace does not affect the model in the Design workspace. Return to the Design workspace to verify the bodies are still present, then navigate back to the Simulation workspace.

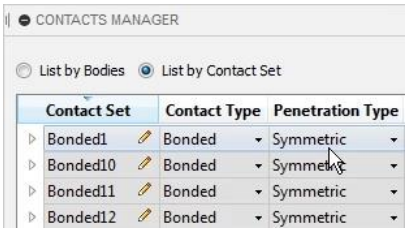


4. Notice the Pre-check icon has a red X; this is because the necessary input has not been specified and the study is not ready to solve. Click Solve> Pre-check. The window tells you the input needed before the study can be solved. Click the Close button in the Pre-check window.

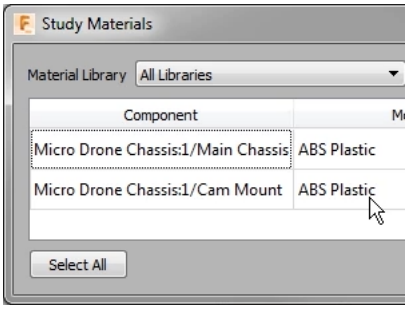
5. Click Contacts> Automatic Contacts. Click the Generate button in the control panel. The contact between the camera holder and the main chassis is calculated.



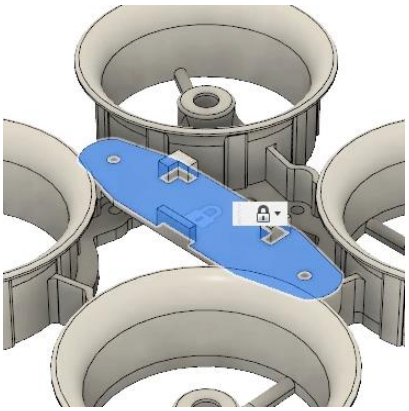
6. Click Contacts> Manage Contacts. The list in the Contacts Manager describes the various places the two bodies contact. Highlight one of the Contact Sets in the manager and notice the area is highlighted in the Canvas. Click OK when you are done investigating the contacts.



7. Click Materials> Study Materials. The materials used in this study are listed in the Study Materials window. The selected materials are acceptable, so click OK.

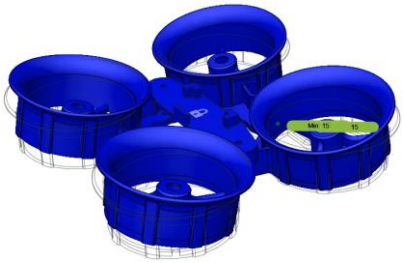


8. This study will simulate the upwards thrust from the propellers. Click Constraints> Structural Constraints. Make sure the Type is set to the Fixed option, then select the top face of the camera holder body as the Targets selection. Click OK.

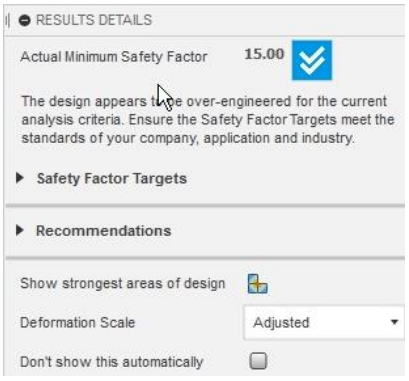


9. Click Loads> Structural Loads. Change the Type to the Force option. Select the top face inside each of the motor holder bodies. Change the Change Units option to ounceforce. For the Magnitude value, enter 0.5 ounceforce. Activate the Force Per Entity option, then click OK.

10. Notice the Pre-check icon changes from a red X to a green check, indicating the study can be solved. Click Solve> Solve. The Solve window shows that the study can be solved on the cloud for a cost of 5 Cloud Credits, or solved on your local machine for free. Choose one of the options, then click the Solve 1 Study button. Click the Close button in the Job Status window when the simulation is complete.

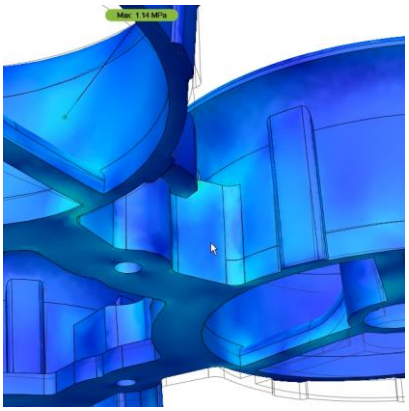


11. The Results Details control panel shows that the minimum safety factor is 15. Click the Close button after you are finished investigating the information in the panel.

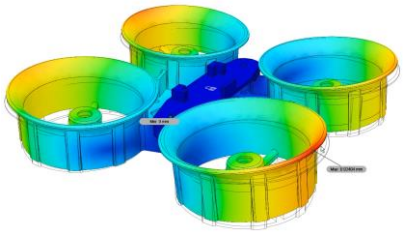


12. Change the ColorBar's drop-down menu from Safety Factor to Stress.

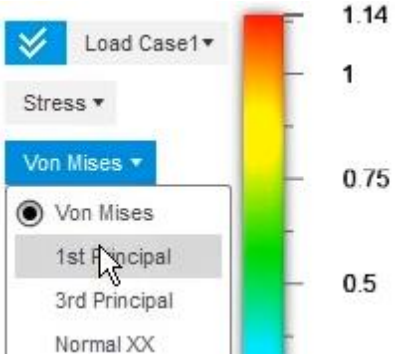
13. The model in the Canvas is re-colored to show the areas with higher stress concentrations. The highest concentration of stress is in the areas where there is a crisp corner instead of a fillet.



14. Change the ColorBar's drop-down menu from Stress to Displacement. The model is re-colored to show the amount an area has displaced from its original position because of the forces enacting on the bodies. Investigate the other options in the ColorBar's drop-down menu.

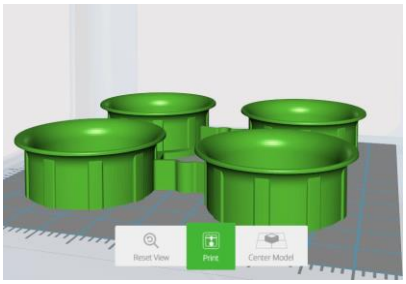


15. Change the ColorBar's drop-down menu back to Stress, then change the type of stress to 1st Principal. If the forces described in this study were the only forces the chassis would see, then several areas of the design can be tweaked to make the parts lighter. However, many additional forces (such as bumping into walls) need to be factored into the design. Return to the Design workspace, save the file, and continue to the next lesson.



Lesson: 3D Print a Drone

In this lesson, you will export and 3D print the micro drone chassis.



The completed exercise

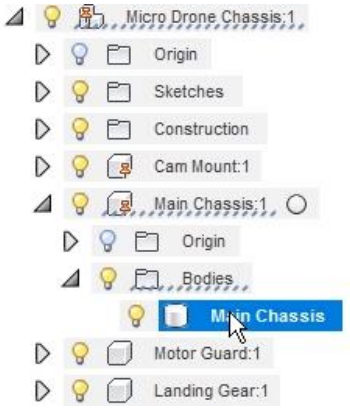
Learning Objectives

- Save an STL file.
- 3D print a part.

1. Open the supplied file “Micro Class Rev1 Print.F3D”.

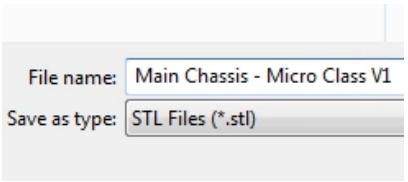
2. The chassis needs to be exported as an STL file as preparation for 3D printing. In the Browser, select the Micro Drone Chassis component. Right-click it and choose Isolate. All the components other than the chassis disappear

3. Expand the Micro Drone Chassis component, then expand the Main Chassis component, then expand the Bodies folder. Right-click the Main Chassis body, then choose Save As STL.

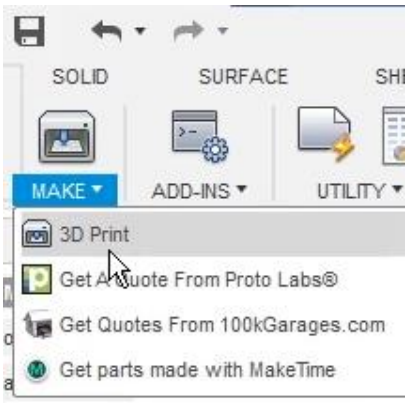


4. The Refinement option in the control panel allows you to customize the number of polygon faces in the STL file. The more polygon faces the model has, the smoother the model's curves will be. The file size grows in relation to the number of polygon faces included in the file. Choose a Refinement setting based on the size of the file you need and the resolution capabilities of the specific 3D printer you intend to use. The Send to 3D Print Utility can be activated if you want the file to automatically open in a print utility. Several options, such as Autodesk Meshmixer, are available in the drop-down menu.

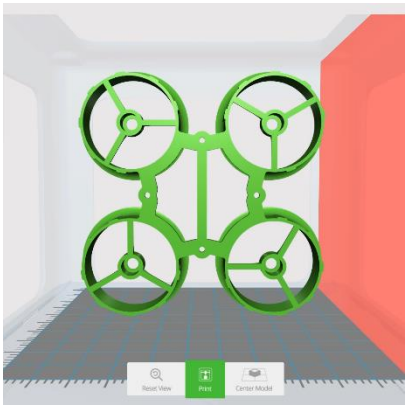
5. Click OK and save the STL file. Extend the file name to "Main Chassis – Micro Class V1", then click the Save button.



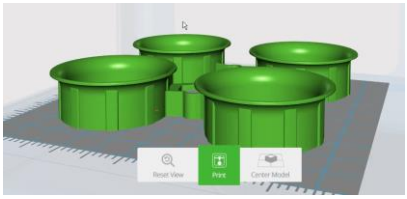
6. Click Make> 3D Print. This opens the same 3D Print control panel with one exception: the Send to 3D Print Utility option is already activated.



7. Choose the print utility you want to use and use it to open the STL file. This documentation will use the print utility that came with the Micro 3D printer. During the design process, special attention was devoted to making sure the chassis could print flat on the build tray without any support material or raft needed. This means that the current orientation of the chassis is not correct, and the model needs to be rotated.

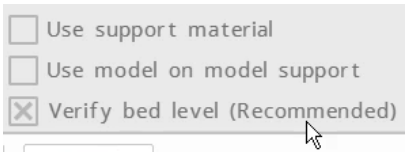


8. Rotate the model so the chassis sits flat on the floor.



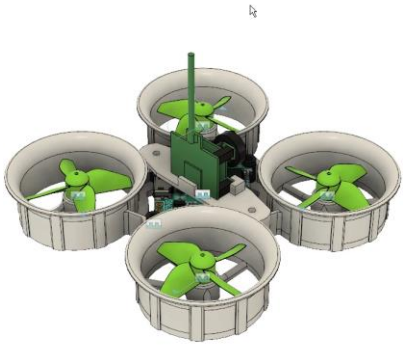
9. Choose the print quality and the fill density if your printer includes these options.

10. Investigate the other options your printer has. Make the appropriate selections. Again, the chassis was designed so that support material and rafts do not need to be used. Deactivate these options if it makes sense for your printer. The file is ready to print. There are too many print utilities for this documentation to cover. Make sure you understand the capabilities and options of your printer before you print your final chassis. One good method for learning the capabilities of a printer is to print small sections of complex geometry. Analyze the printed results and make any necessary adjustments to your model.



Lesson: Create an Exploded View Assembly

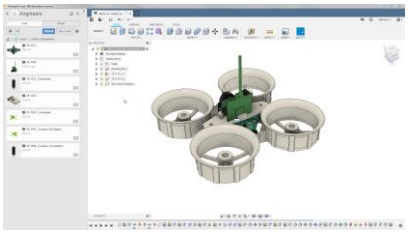
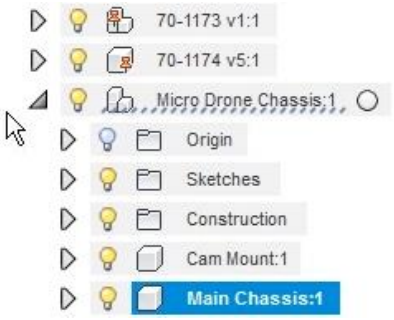
In this lesson, you will create the assembly for use in an exploded view and learn the importance of the component/assembly structure.



The completed exercise

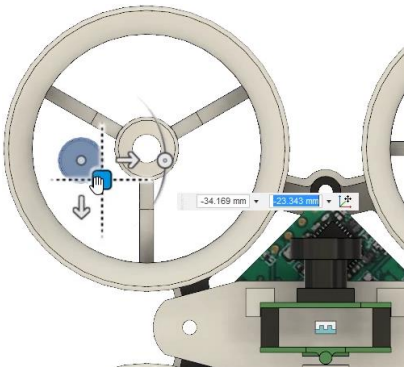
Learning Objectives

- Create a distributed design assembly.
- Apply a revolute joint.
- Create a rigid group.

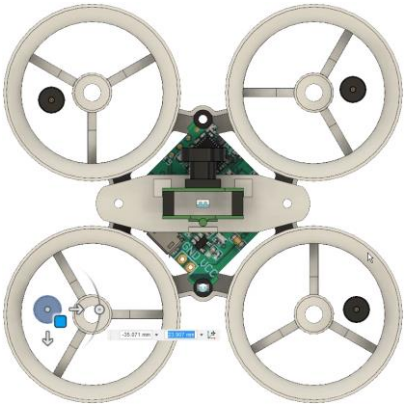
1. Continue with the file from the previous module or open the supplied file “Micro Class Rev1 Assembly.F3D”. The Assembly file intentionally breaks the links between 70-1173 and 70-1174 and their original source files.	
2. An exploded view of the drone needs to be created. Before that can happen, the various components need to be assembled. The Micro Drone Chassis component has two bodies inside of it: the Main Chassis body and the Cam Mount body. Select both the bodies, right-click them, then select Create Components from Bodies.	

3. Now that the bodies have been converted to components, they are no longer fixed in 3D space. Right-click each of the new components, then choose Ground.

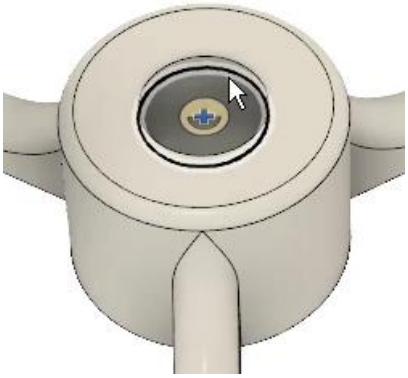
4. Various parts need to be added to the assembly before an exploded view can be made. Go to the top view, then expand the Data Panel. In the Data Panel, click on 70-1175_Clockwise and drag it into the Canvas area. Use the on-screen manipulator to move the motor to the upper left propeller shroud area. Click OK. Repeat this process to put another instance of 70-1175 at the lower right propeller shroud area.



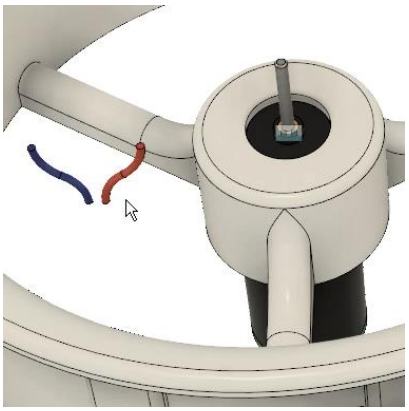
5. Drag two instances of 70-1192_Counter_Clockwise into the Canvas. Move them to the upper right and lower left propeller shroud areas. In the Browser, the motors have a :1 or a :2 designation after the file name. This indicates that Fusion 360 realizes they are multiple instances of the same part. The parts list will populate correctly and show that there are two of each type of motor in this assembly.



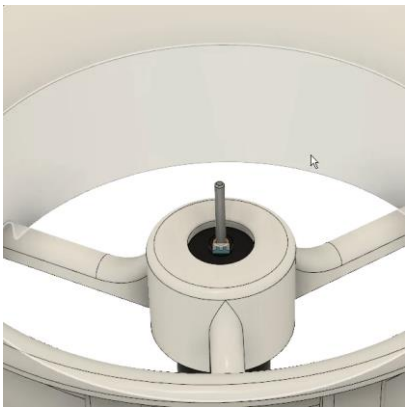
6. Click Assemble> Joint. Make sure the Type is set to Rigid. For the Component1 selection, choose the circular edge on the top face of a motor. For the Component2 selection, choose the inside lower edge of the corresponding motor holder body. Click OK.



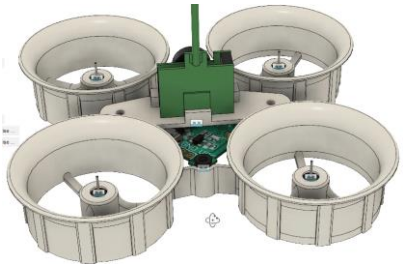
7. Notice the wires are left behind after the motor snaps into position. Press Ctrl + Z to undo the command.



8. In the Browser, expand the 70-1175_Clockwise component. Notice that the motor and the wires are two separate bodies inside the component. Select the two bodies, then click Assemble> Rigid Group. Click OK. Repeat step 6 to move the motor into place, then click OK. Notice that the wires move with the motor after you click OK.



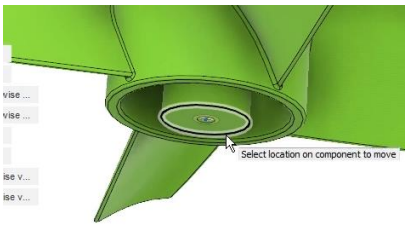
9. Repeat step 8 for the other three motors. Make each of them a rigid group, then move them into the corresponding motor holder body.



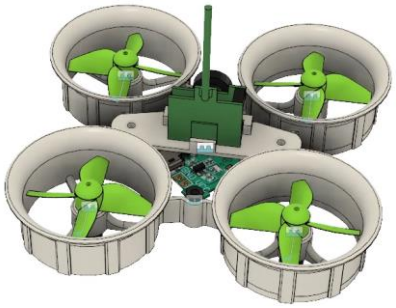
10. The propellers need to be placed into the assembly. Drag 70-1191_Clockwise into the Canvas. Move it to the upper left propeller shroud where the clockwise motor is placed. It is important to keep the clockwise propeller with the clockwise motor. In the Browser, select the 70-1191_Clockwise propeller, right-click it, and choose Copy. Right-click in the Canvas and choose Paste. A second instance of 70-1191 is added to the Canvas. Move it to the lower right propeller shroud.

11. Add two instances of 70-1192_Counter_Clockwise to the Canvas. Move one to the upper right propeller shroud and the other to the lower left propeller shroud. Minimize the Data Panel.

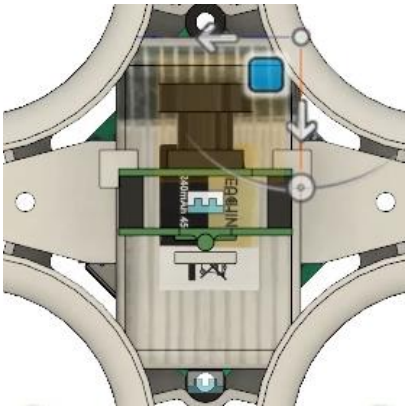
12. Click Assemble> Joint. Change the Type to the Revolute option. Select the bottom edge on one of the propellers as the Component1 selection. For the Component2 selection, choose the circular line on the top face of the corresponding motor holder body. Fusion 360 will show a brief animation to illustrate the rotational freedom of the joint. Click OK.



13. Repeat the step 12 process for the other three propellers.

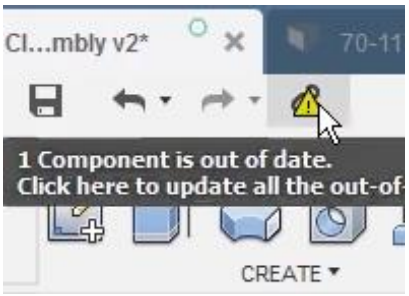


14. Expand the Data Panel and drag the 70-1176 component into the Canvas. Rotate the battery 90 degrees so the longer edge points in the forward direction of travel, then move the battery to the approximate center of the drone.

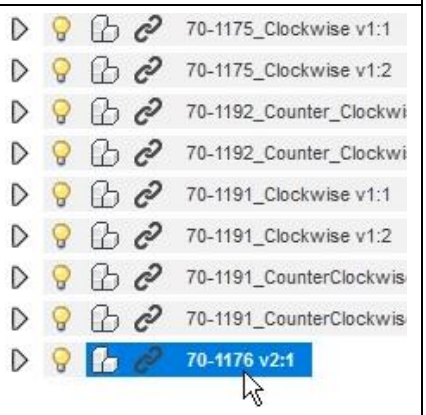


15. Go to the front view and move the battery so it is just below the bottom of the chassis. Click OK. Notice the battery's coordinate system is visible. The visibility for this cannot be turned off inside the current file because the battery in the current file is linked to the original battery file.

16. In the Browser, right-click the 70-1176 component, then choose Open. Hide the Origin by clicking the lightbulb icon, save the file, then close the 70-1176 tab. Return to the Micro Class Rev1 Assembly file tab and click the caution icon at the top of the screen to update the link. The origin disappears. Right-click the 70-1176 component in the Browser and choose Ground.



17. The chain link icons next to the components in the Browser indicates that these are linked files. To break the link between the current file and the source file, right-click a component and choose Break Link. Save the file and continue to the next module.

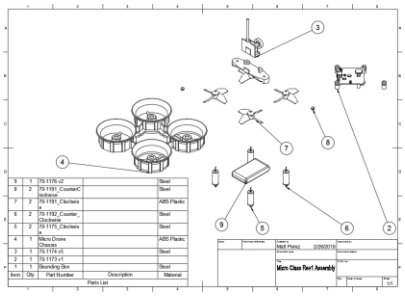


Lesson: Create a Detailed Drawing

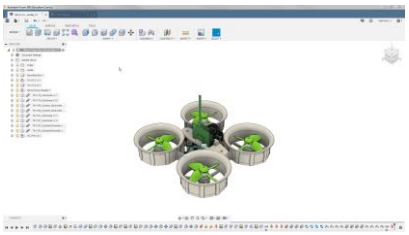
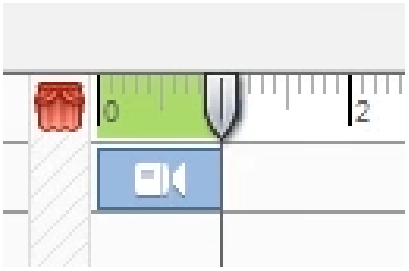
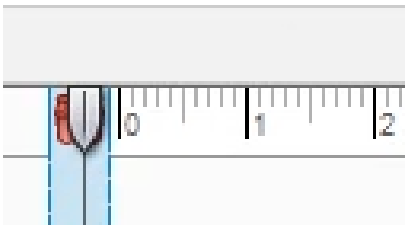
In this lesson, you will create an exploded view to produce a detailed drawing and parts list.

Learning Objectives

- Create an animation exploded view.
- Create a detailed drawing.
- Place a drawing view.
- Place a parts table.

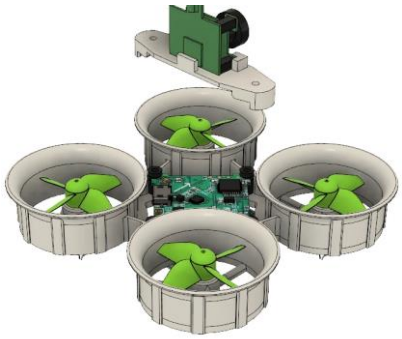


The completed exercise

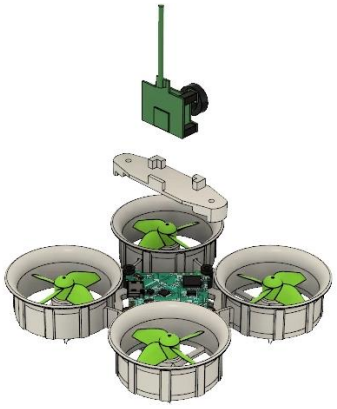
1. Continue with the file from the previous module.	
2. Click the Change Workspace button at the top left corner of the screen. Choose the Animation workspace. Rotate the view of the model slightly and notice that an icon appears in the Timeline at the bottom of the screen. If you press the Play button at the bottom of the screen, the camera movement will animate. Right-click the camera icon in the timeline and choose Delete.	
3. To avoid adding a camera movement to the timeline, drag the play head to the curtain area of the timeline. Altering the camera view will not be recorded. Move the model to the desired location, then drag the play head to the two second mark in the timeline. No animations have been recorded.	

4. Notice the options in the Transform drop-down menu. The difference between the Auto Explode: One Level and the Auto Explode: All Levels is that the One Level explode will only affect the top-level components. If a top-level component has subcomponents (indicated by the multiple cubes icon), these sub-components will not be exploded. If the all levels option is selected, the sub-components will also explode.

5. Click Transform> Transform Components. Select the camera, then Ctrl select the camera mount. Use the on-screen manipulator to pull both of the components upwards. Left-click in the Canvas area to end the movement.

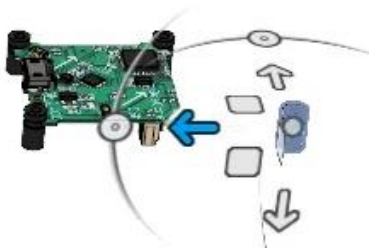


6. Zoom out from the model slightly, then move the play head to the 4 second mark in the Timeline. Select the camera and pull it further upwards. Left-click in the Canvas.



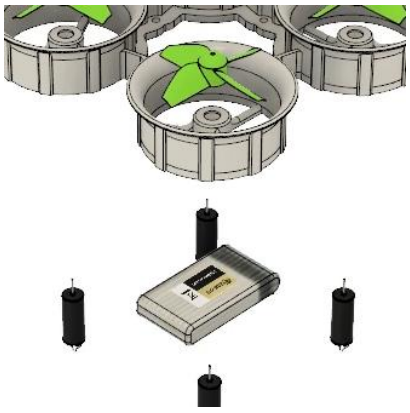
7. Drag the play head to the 6 second mark in the Timeline. In the Browser, select 70-1173. Pull the component upwards, then sideways. Selecting the component in the Browser will ensure that all the sub-components will move with it. Left-click in the Canvas.

8. Pull one of the rubber standoffs to the side of the flight controller. Left-click in the Canvas.

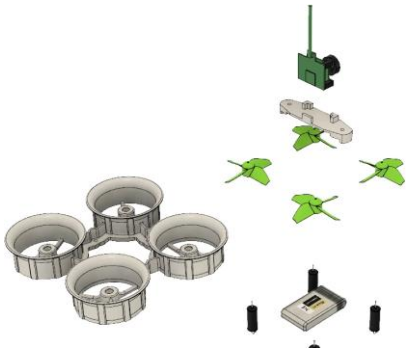


9. Select all the propellers and move them upwards slightly. Left-click in the Canvas. Select the battery and move it downwards. Left-click in the Canvas. The play head hasn't moved snice the beginning of step 7, so all of the actions in steps 7 through 9 will happen at the same time.

10. Move the play head to the 8 second mark. Use the Browser to select all four motors. Pull them downwards. Left-click in the Canvas.



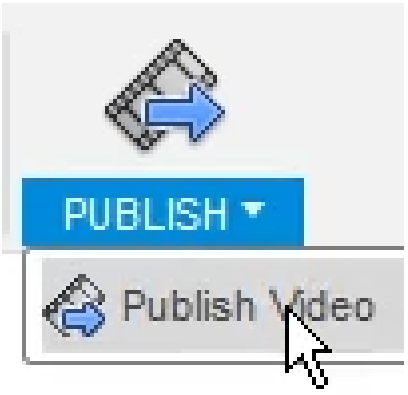
11. Drag the play head to the 13 second mark. Select the chassis and move it to the side. Left-click in the Canvas.



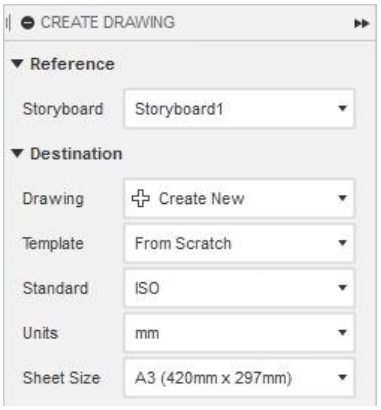
12. Move the play head to the 18 second mark. Zoom out from the model and rotate the view slightly. Left-click in the Canvas.

13. Press the Play button at the bottom of the screen and watch the animation. If a detailed drawing is created from this animation, the final position of the animation is the view that will be used in the drawing. Right-click the final animation segment you created in step 12 and choose Delete. The view for the drawing will now be the state of the animation resulting from step 11.

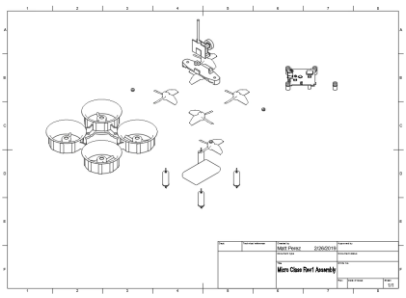
14. This animation can be published as a video. If you want to publish the video, click Publish> Publish Video. Save the file.



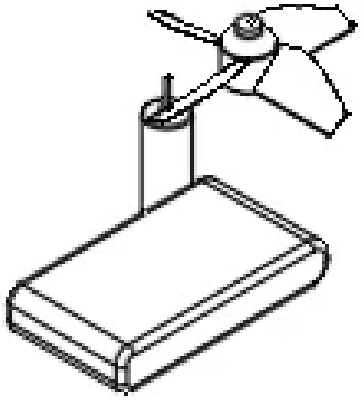
15. Navigate from the Animation workspace to the Drawing> From Animation workspace. Examine the options in the Create Drawing control panel but don't make any changes. Click OK. Click OK in the dialog box that appears to tell you that mesh, T-Spline, and surface bodies will not be included.



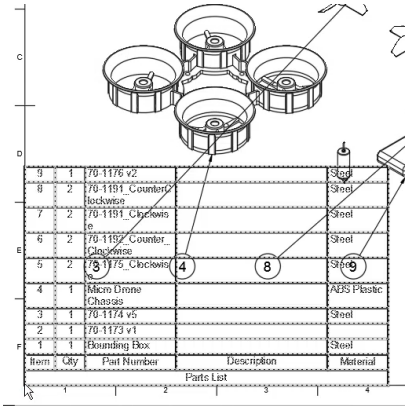
16. Position the view on the drawing sheet. Click OK.



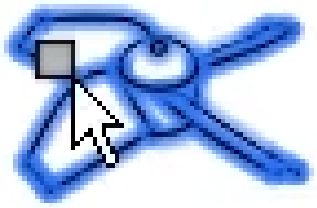
17. To modify the drawing view, double-click on the parts explosion. Change the Tangent Edges option to Full Length. Click Close. The appearance of the drawing is updated.



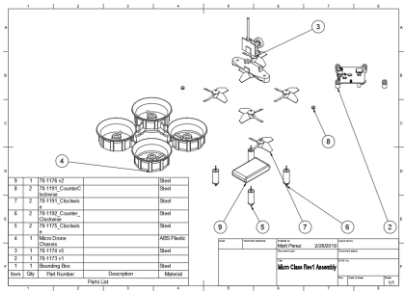
18. Click Tables> Table. Place the table in the lower left corner. Balloons leading to each item represented in the table are automatically created.



19. To move the drawing view, left-click on the view, then left-click the gray square in the center of the view. Drag the view to the new location.

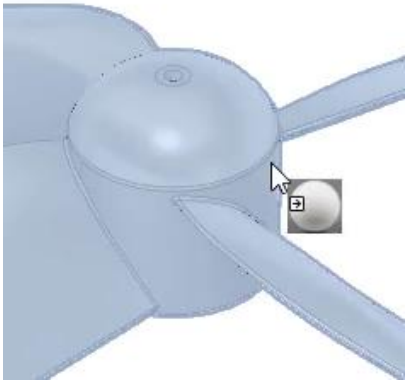


20. The balloons are overlapping the table. To move balloons, left-click the balloon, then left-click the gray square in the center of the balloon. Drag the balloon to a new position. Move all the balloons so they do not overlap the table.



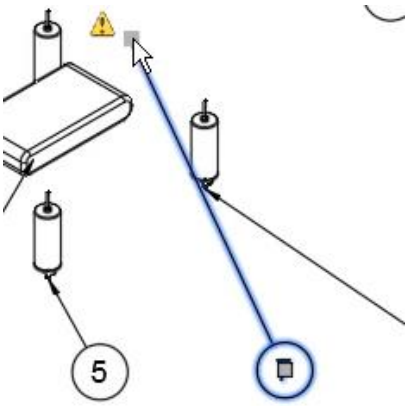
21. The table describes the propellers as having a steel material which means that some of the components need to have their materials updated. Return to the Micro Class Rev1 Assembly tab and navigate to the Design workspace. Right-click on 70-1191_Clockwise and choose Open. Expand the Propeller CW component, then expand the Bodies folder. There is only one body in this folder. However, there is another Bodies folder outside the Propeller CW component. This folder has three bodies and a surface body. Select these four entities, right-click them, then choose Remove.

22. Right-click the Propeller CW component and choose Physical Material. Drag the ABS Plastic icon onto the propeller to apply this material to the component. Save the file.

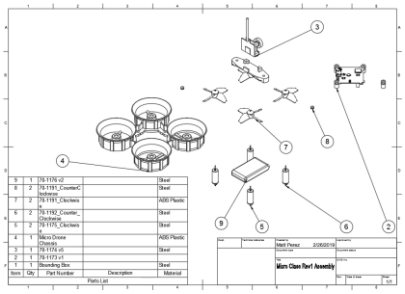


23. Navigate back to the main assembly tab and click the caution icon at the top of the screen to update the references. Save the file.

24. Navigate to the drawing tab. Click the caution icon at the top of the screen to update the references. The clockwise propeller's material listed in the table is now ABS Plastic. However, there is a caution icon at the end of the balloon's leader. This is because the leader does not attach to the component. Left-click the leader, left-click the gray box at the end of the leader, then move the leader to the propeller. If necessary, move the balloon so the leader does not overlap other components.



25. This module has only covered the absolute basics of detailed drawings. Autodesk has several courses which cover much more information about creating and modifying detailed drawings. Save the file and continue to the next module.



Lesson: Photorealistic Renderings

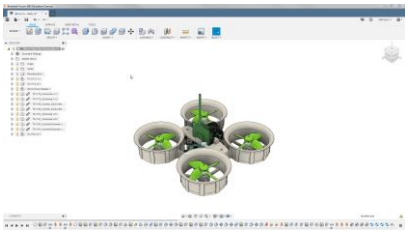
In this lesson, you will learn to set up and create photorealistic renderings using Fusion 360.

The completed exercise

Learning Objectives

- Set up a scene.
- Apply appearances.
- Produce a rendering.

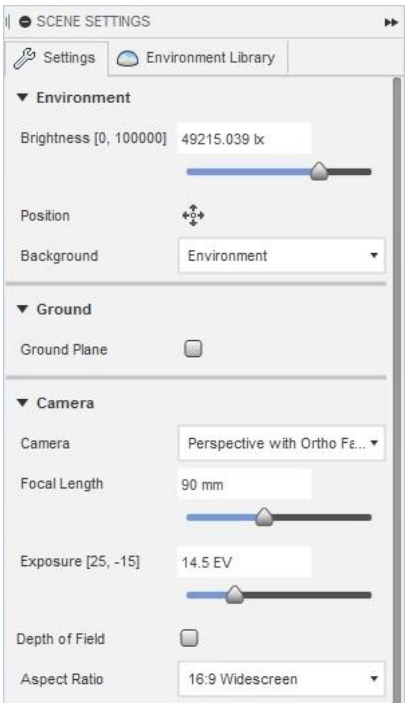
1. Continue with the file from the previous module.



2. A photorealistic rendering of the drone can easily be made from the current model. Click the Change Workspace button in the upper left corner to change to the Render workspace. Click Setup> Scene Settings. In the Scene Settings control panel, change the Background option to Environment. Click on the Environment Library tab in the control panel, then look through the available environments in the Library.

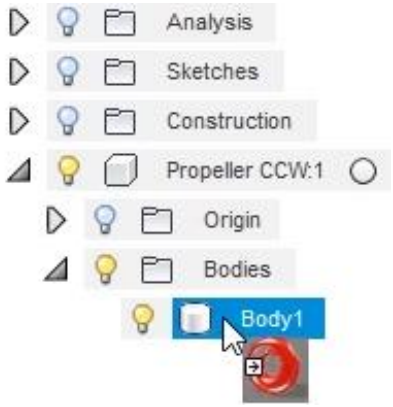
3. Select the Field environment, then drag it into the Canvas. Rotate the view so the underside of the drone is visible. Renders usually look more realistic when they are not directly interacting with the environmental objects like grass, so placing the drone against a sky backdrop is a good judgement call if realism is a high priority.

4. Return to the control panel's Settings tab. Un-check the Ground Plane option; this feature allows shadows to fall on the ground and that feature is not needed for this render. Change the Aspect Ratio to the 16:9 Widescreen option. Click the Close button.



5. Click Setup> Appearances. Search through the Library section and choose an appearance you want to apply to the chassis and the camera mount. Drag these appearances onto the components in the Canvas. Choose a color for the propellers and drag the appearance onto the propellers. A warning dialog box will appear to tell you that the propeller components already have appearances applied.

6. Navigate back to the Design workspace. Right-click the 70-1191_CounterClockwise component in the Browser, then choose Open. Expand the Propeller CCW folder, then expand the Bodies folder. Press the A key to open the Appearances control panel, then drag the desired appearance onto Body1 in the Browser. Click the Close button in the control panel, then save the file. Close the 70-1191_CounterClockwise tab. Repeat this process to change the appearance of the 70-1191_Clockwise component.



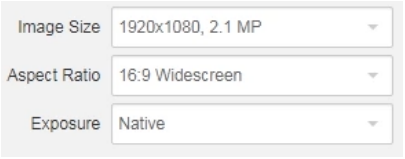
7. Click the caution icon at the top of the screen to update the linked files.

8. Return to the Render workspace and adjust the view so that the underside of the drone is visible again.

9. Click In-canvas Render> In-canvas Render. A status bar appears in the lower right corner of the canvas. The triangle marker on the status bar can be adjusted as a target for the render quality.

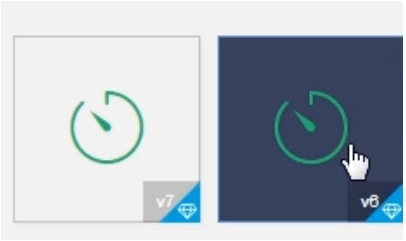
10. When you are happy with the quality of the render and you want to save the image, click In-canvas Render> Capture Image. For now, click In-canvas Render> In-canvas Render to stop the render. Click Render> Render.

11. In the Render Settings window, change the Width value to 1920 and the Height value to 1080. Alternately, choose the 1920x1080, 2.1 MP option from the Image Size drop-down menu. The image can be rendered on the cloud for a cost of two Cloud Credits, or on your local machine for free. Choose one of these options, then click the Render button.

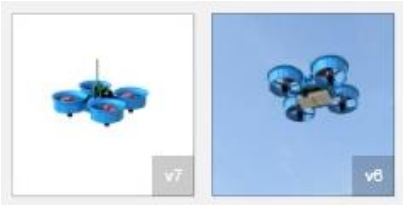


12. If you choose to render on the cloud, you can set up multiple renders and add them to the queue. Rotate the view so that the top of the drone is visible. Click Setup> Scene Settings, then change the Background option to Solid Color. Click the Color swatch to open the color palette. Choose a white color, then click the Ok button. Click the Close button. Click Render> Render. Choose to render on the cloud or locally, then click the Render button.

13. If multiple renders are in the queue, the job thumbnails will be visible at the bottom of the screen. Hover over each thumbnail to see information about the job.



14. When the render is complete, the job icon will change to a thumbnail of the render. Click on an image thumbnail to open it in the Rendering Gallery. The left and right arrows on the sides of the gallery will allow you to cycle through the available renders.



15. At the top of the Rendering Gallery, there is a Turntable button. This feature will render either 6 or 36 frames from different angles so that you can see the drone from multiple angles. These frames can be assembled into an animation. The Download button allows you to download the images as PNG, JPEG, TIFF, or EXR files. Click the Close button in the Rendering Gallery. Save the file.