

TR469255

Creating a Drone Chassis using Generative Design

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Learning Objectives

- Designing a Drone Chassis using different Materials and Manufacturing Techniques at the same time
- Explaining of Generative Design Workflow; starting without a shape
- Tips and Tricks about the algorithm of Generative Design to create much durable shapes
- Finding out selecting optimum and desirable tens of shape

Description

How cool to watch or drive a Drone, right? Well, there is a more cool way to think Drones, you can create a Drone chassis after joining this Hands-on Lab. Fusion 360 software is an amazing product, with lots of environments to master, and Generative Design is also available. Using the power of GD, you can find out lots of details on how to use Fusion 360 to create a specific product. No matter if you are a beginner or a seasoned veteran, it's a detailed course to understand for everyone. Come along for an action-packed 90 minutes of learning, and find out how to create a design using Generative Design!

Speaker



Cengiz Kurtoglu is a *Mechanical Design Engineer*. He is working with Autodesk for 5 years to provide Fusion 360 lectures and workshops to university students and academic staff from basic to advanced levels. He has 3 years of experience supporting Start-Ups to develop new smart products in the field of medical technologies. He's currently working on a research project in the Soft Robotics field. He also the founder of *Designwagoon*.

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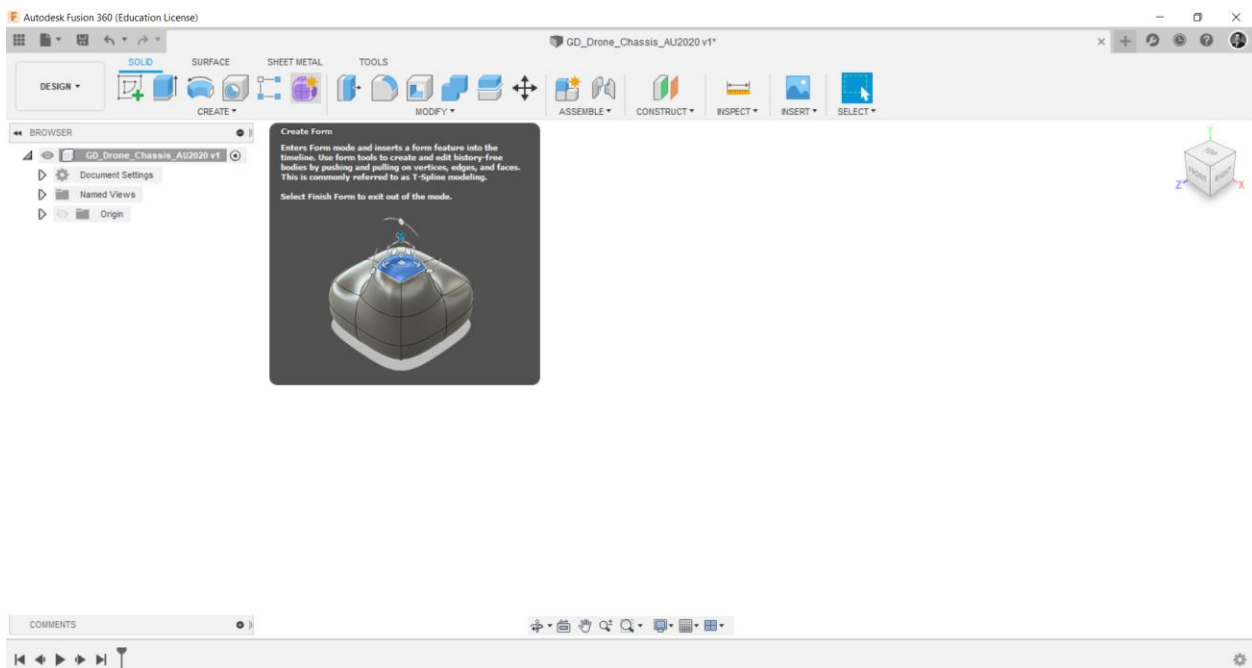
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INTRODUCTION

MODELING and PREPARATION for GENERATIVE DESIGN

Designing a Starting Shape for Generative Design Module

To create the necessary parts for Generative Design module, we can use **CREATE FORM** workspace.

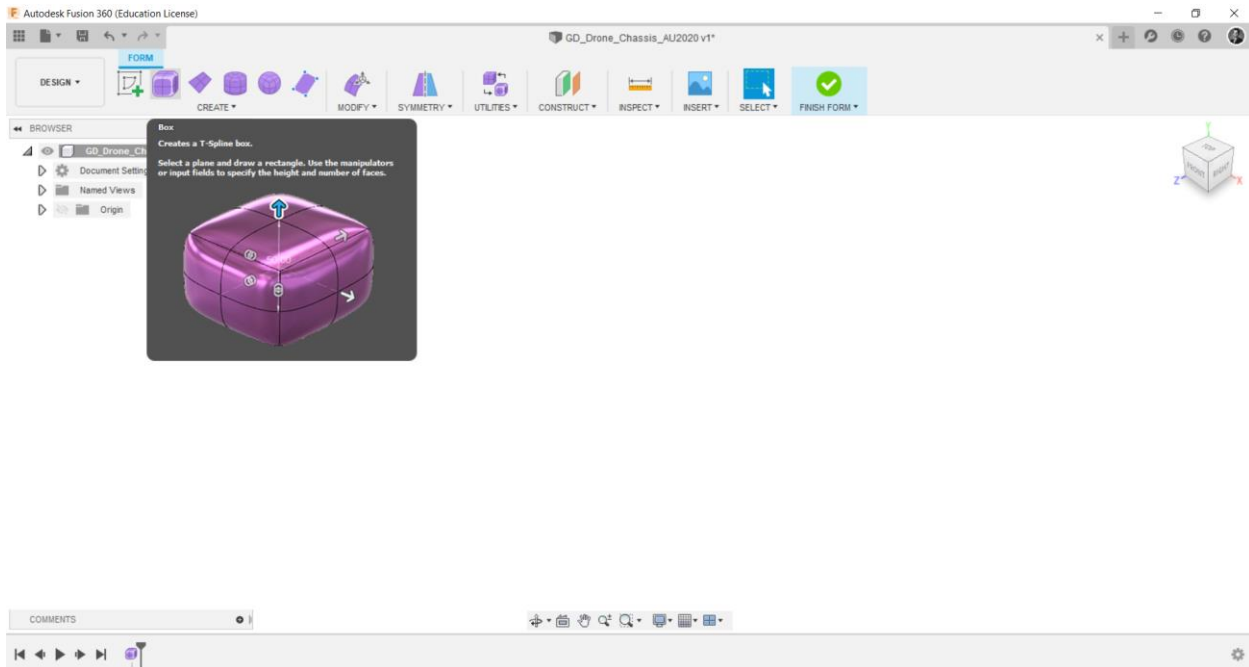


In the **SOLID** tab, there are 2 possibilities to design a part like **CAD**(*Computer Aided Design*) Modeling and **Form Modeling**(*T-Splines*).

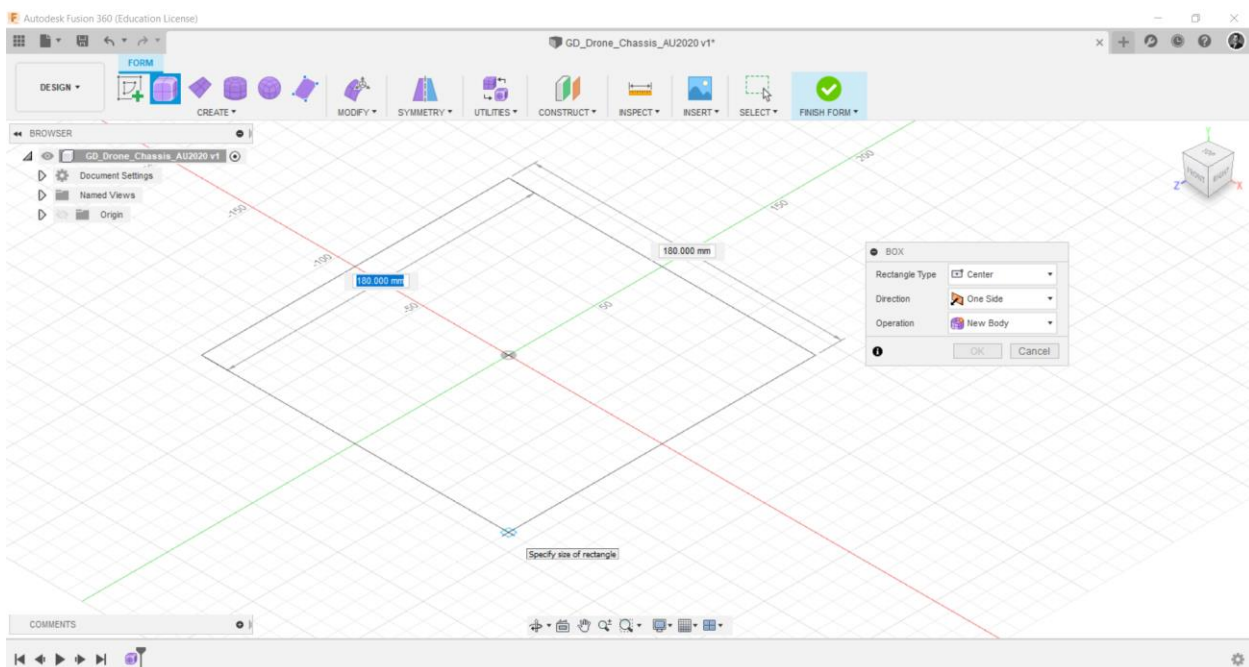
In this Hands-on Lab, concept drone chassis needs to Preserve Bodies in Generative Design Study. Well, you can easily create using the next steps to obtain approximate parts for your study.

Follow the next steps;

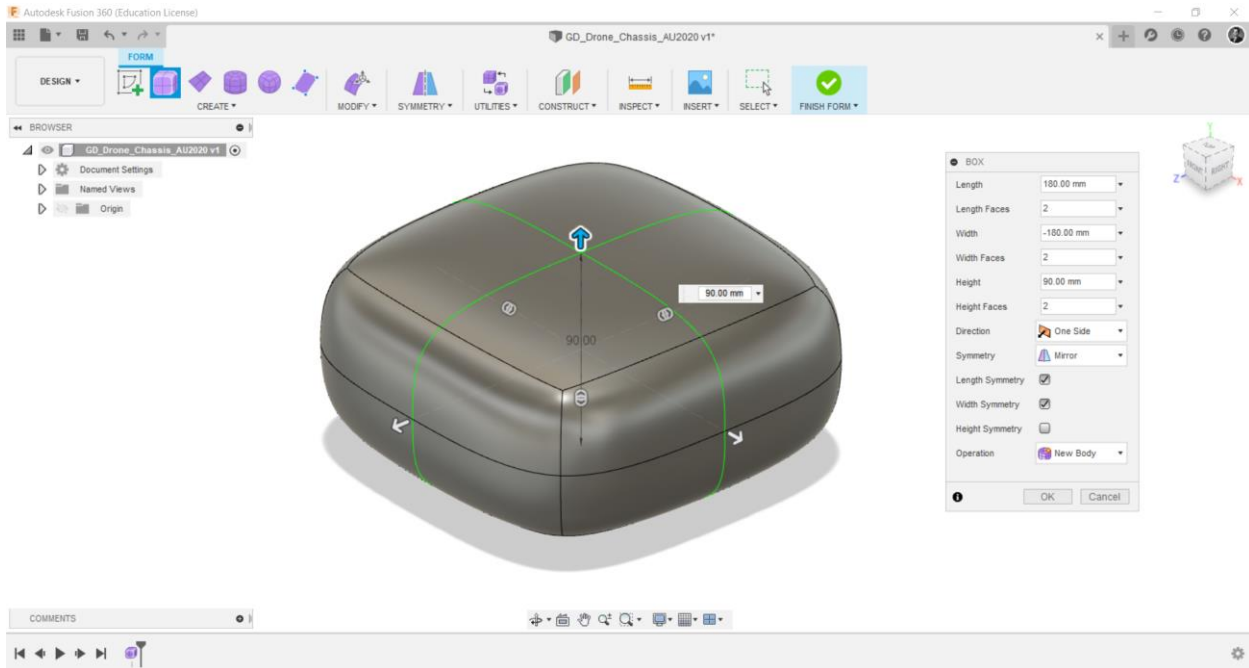
1. After you open the **Fusion 360**
2. Select the **Create Form** Tool



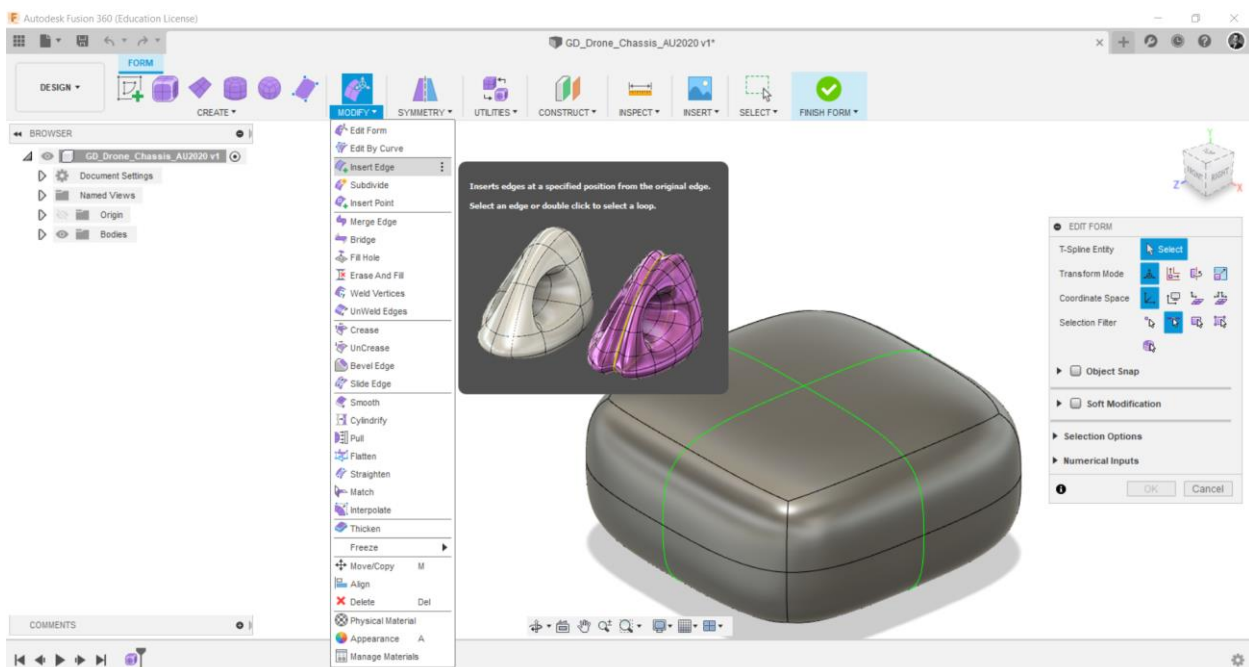
3. After selecting **BOX** tool, confirm that dimensions of the box is **180mm x 180mm x 90 mm**



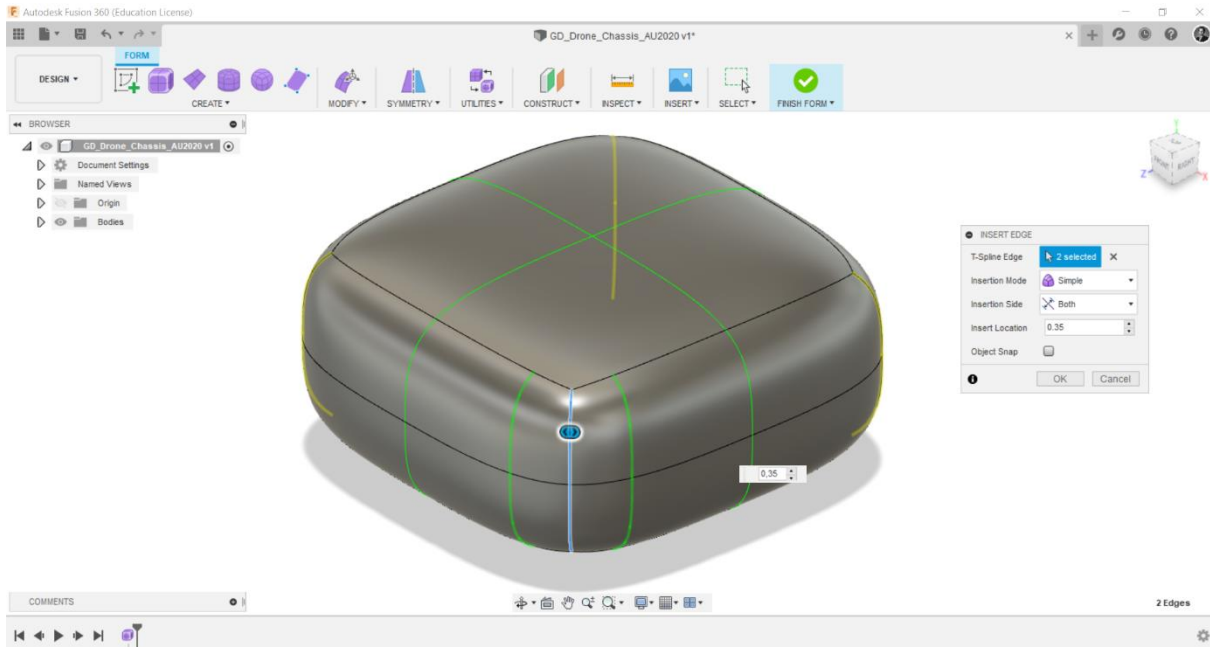
4. You can select the **Mirror** for Symmetry Tab. **Length and Width Symmetry**



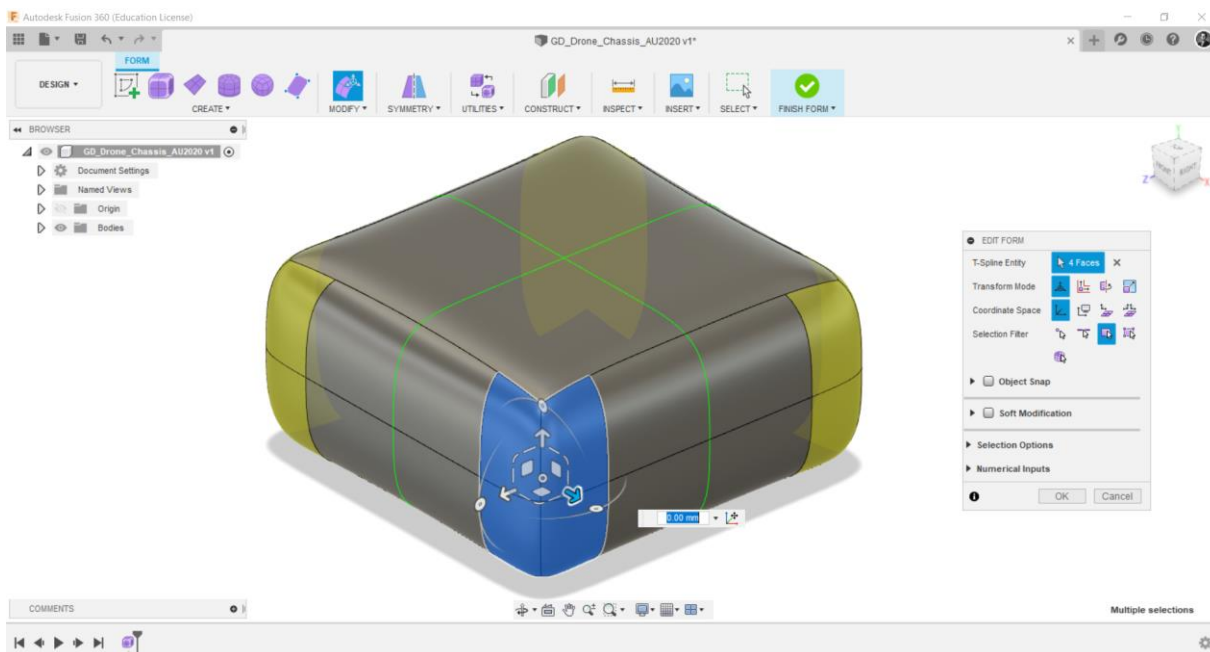
5. To create wings for concept drone chassis, it should add new edges using tool of **INSERT EDGE**.



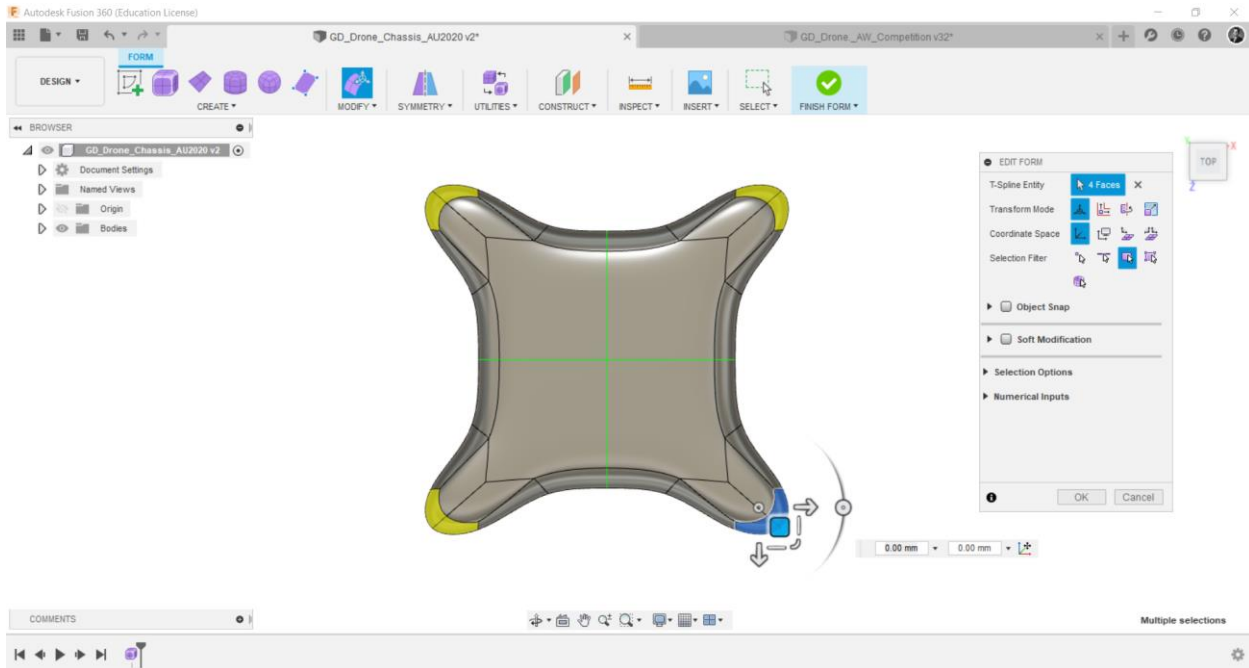
6. You can choose **Both** for *Insertion Side*. Approximately a rate of **0.35** will be the proper location for our modeling.



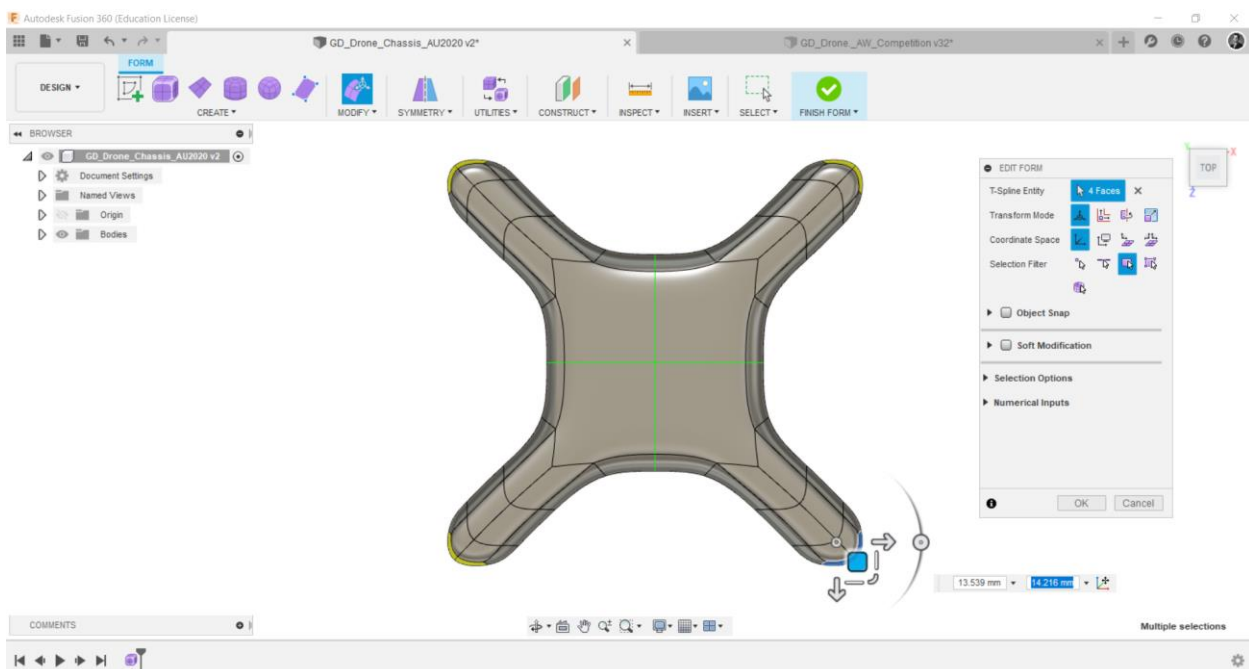
7. After selecting **Edit Form** from toolbar, you can select 4 different faces while holding **Shift** button from keyboards.



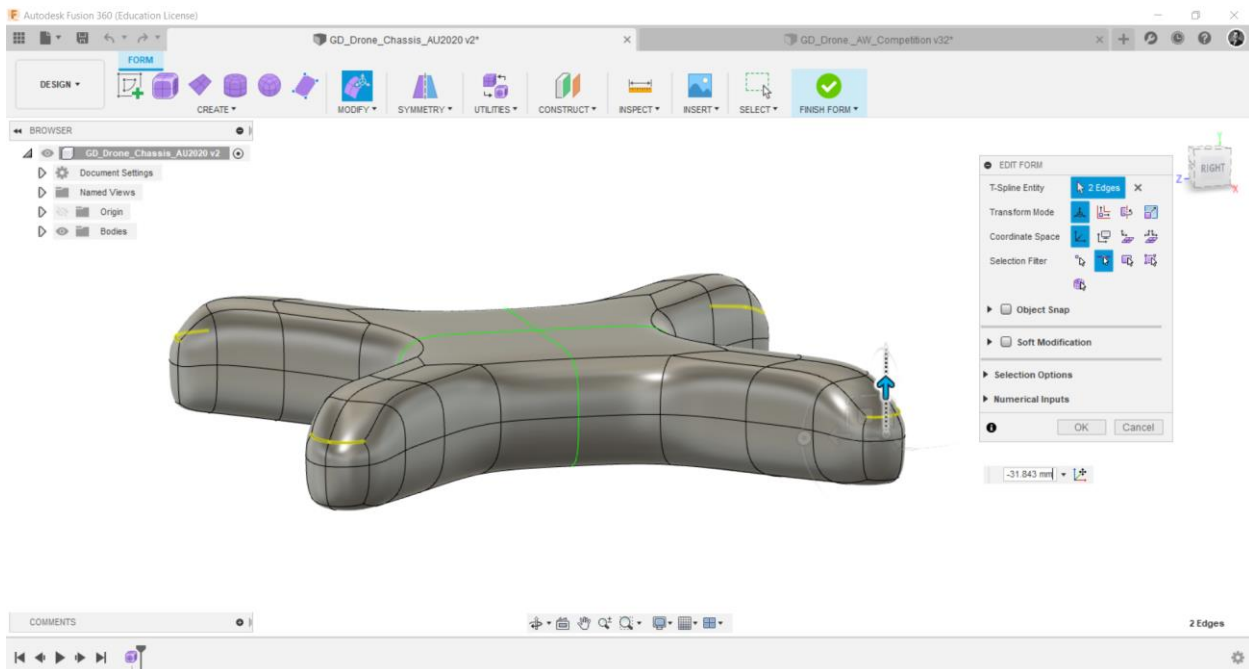
8. To create new faces for wings, you have to *push and hold* the **Alt** button from keyboards. Then you can *slightly drag* selected faces where you want using the manipulator.



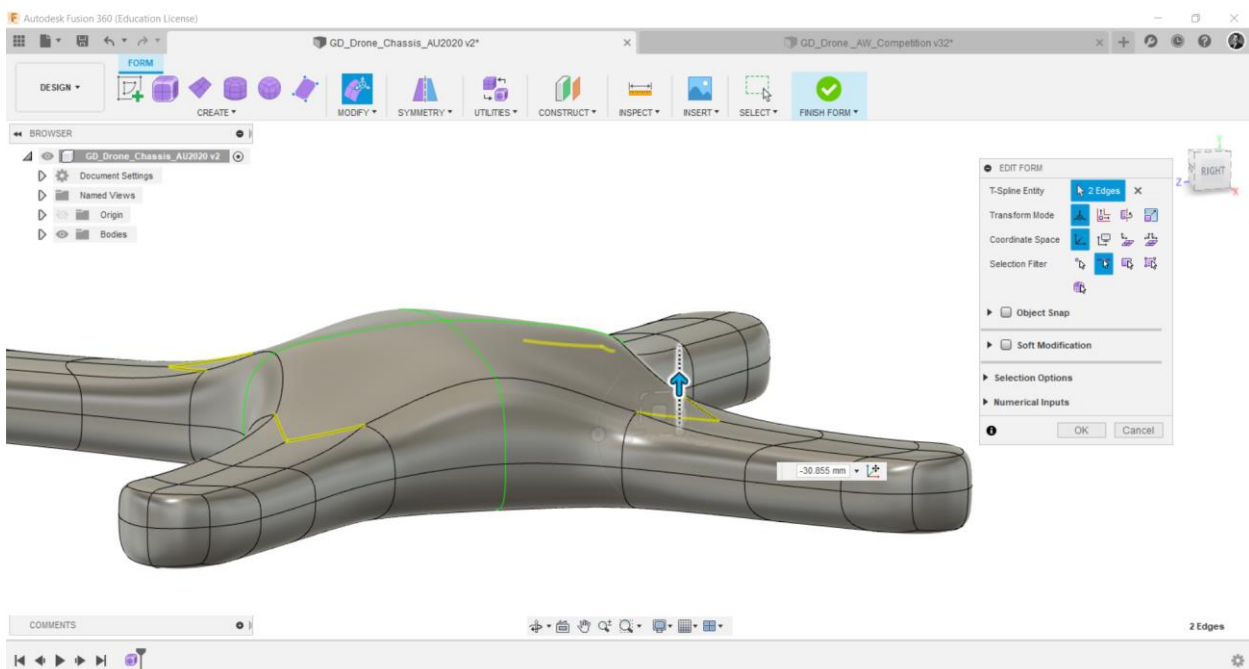
9. Repeating previous steps, you can create **new faces** for concept drone wings. The important thing is that we have to use the *Mirror Symmetry tool* to achieve this design quickly.



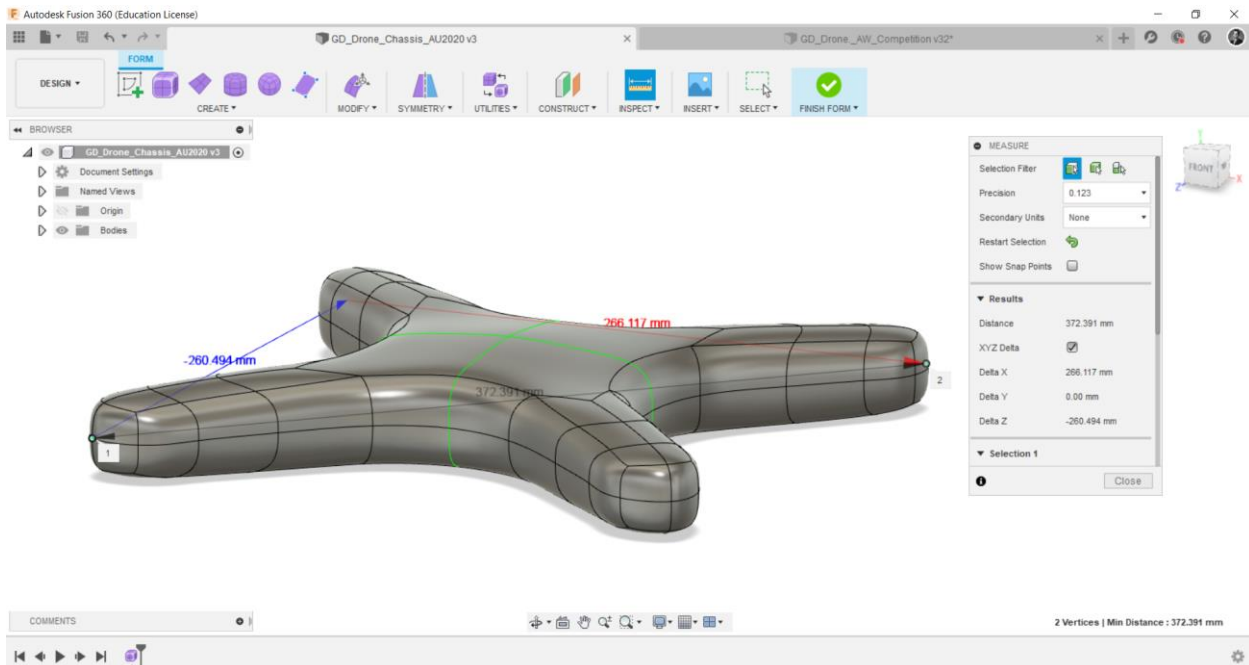
10. In **FORM** Workspace, there are lots of way to design an organic model. If you follow these steps, you can probably reach an approximate model *for concept drone chassis*.



11. Fusion 360 Form workspace offers 5 different **selection filter** in the Edit Form. You can easily select **Edges or Faces** to manipulate them.

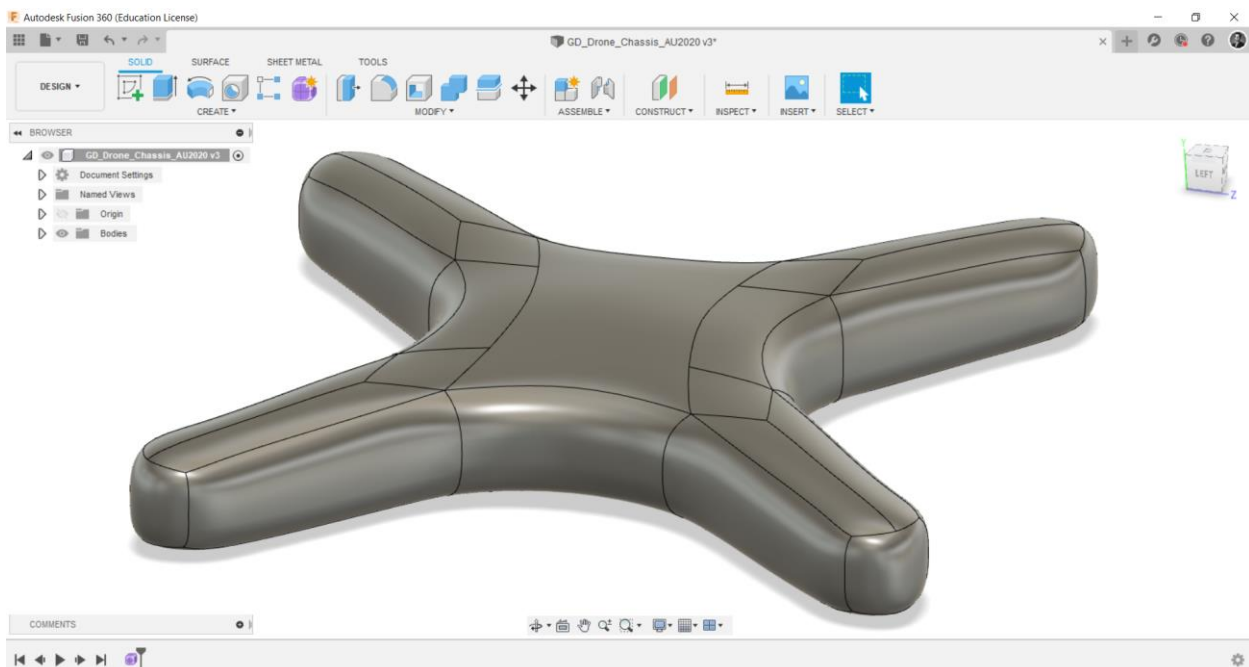


12. After completing *Edit Form*, you can use the **Inspect tool > Measure**. Keyboard shortcut is **I**.



Modeling Exercise; Creating a Drone Chassis using Create Form

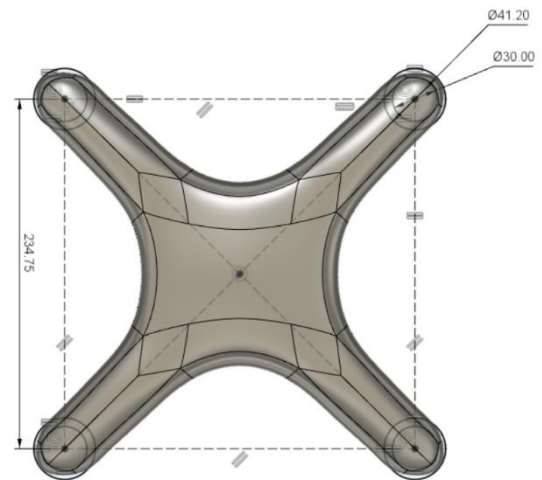
In this Hands-on Lab, we will obtain the necessary components for Generative Design with the concept drone we designed. If you want to access the design files directly, you can download the concept drone file in .f3d format from www.designwagoon.com



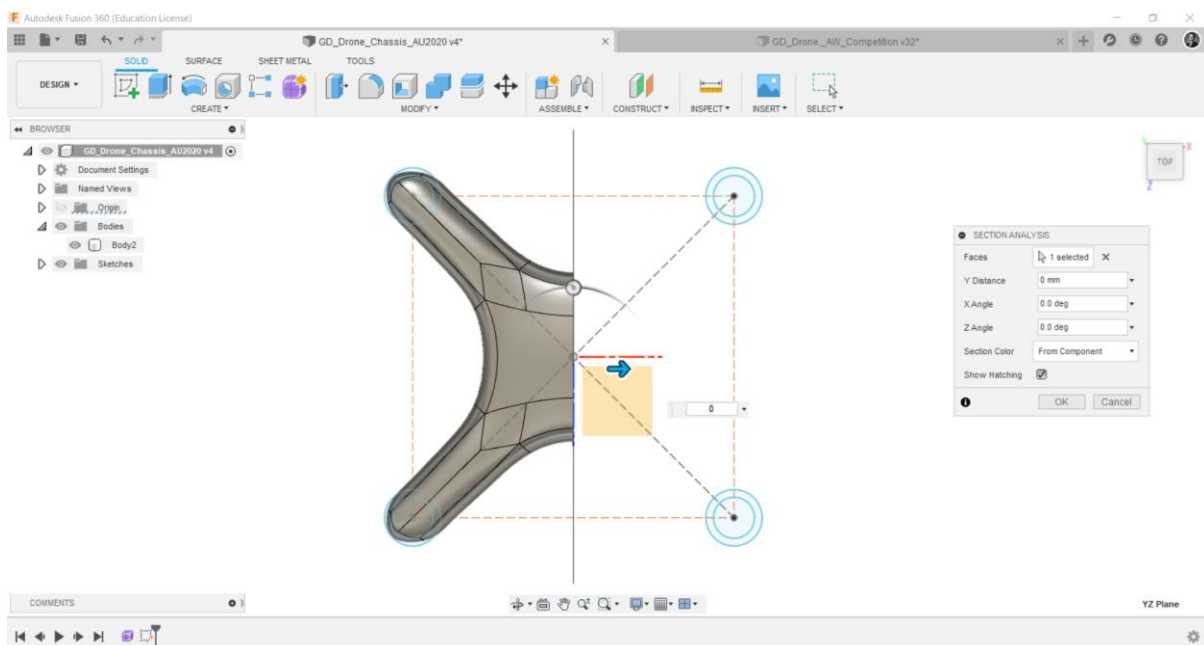
After finishing **Form Modeling**, you can create a Skech.

In this Sketch, you will add different geometries that it helps us to create rotor parts for concept drone.

1. Draw a **Center Rectangle** and use **Equal** tool from Constraints to make a Square
2. Draw two **Circles** the corner of Rectangle
3. Draw Circles the other corners of Rectangle
4. Use **Equal** tool from Constraints and select circles in order
5. Dimensions for there geometries;
Small Circle is 30 mm, Big Circle is 41.20 mm, Square length is 234.75 mm.
6. Notice that the big circle is very close the edge of wing part, like a tangent

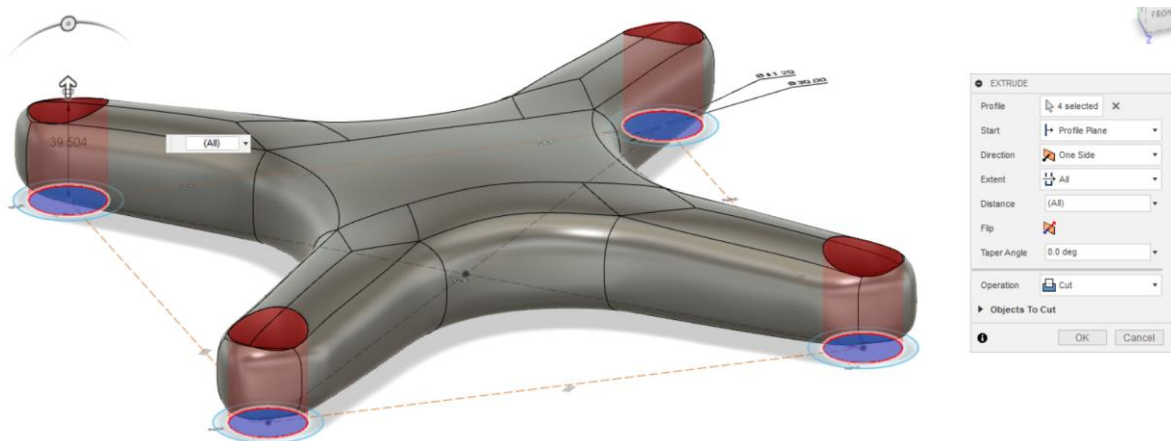


You can use the **Inspect > Section Analysis** tool to check your Sketch while you are working on details of your design.



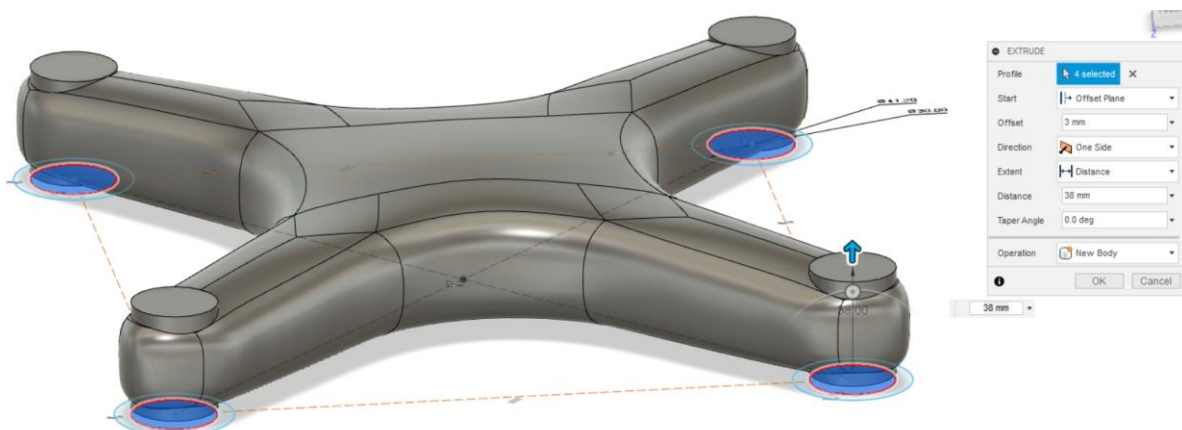
For the next step; you can use **Extrude (E)** Tool to cut the motor regions.

1. Select 4 small circles as **Profile**
2. Start *Profile Plane* and Direction *One Side*
3. Change the Extent section to the **All**
4. Select the **Cut** as Operation



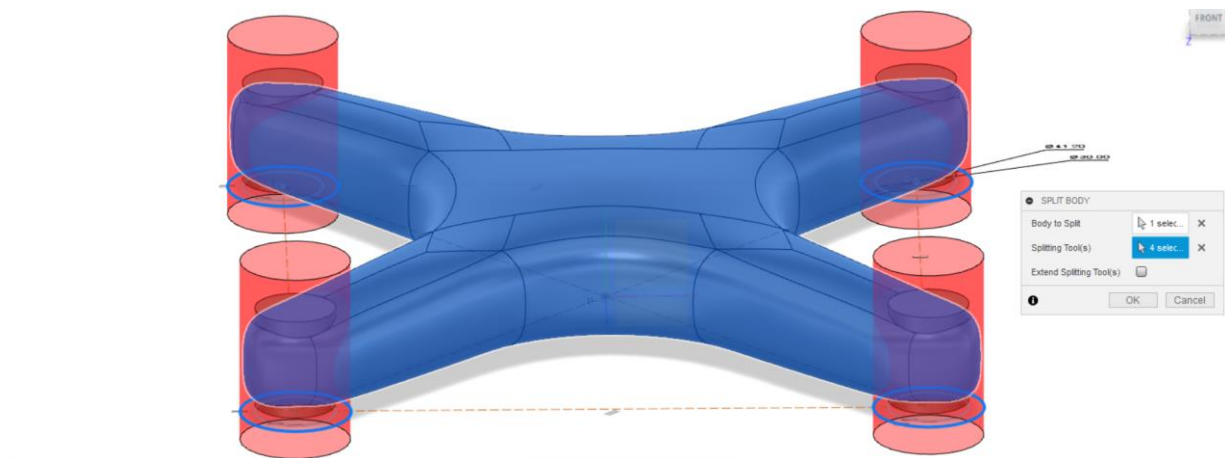
Now, you can create concept brushless dc motors (these parts will be demonstrated as obstacle bodies for our Generative Design Study), follow the next steps to create;

1. Select 4 small circles as **Profile** in Extrude Tool
2. Start *Offset Plane* as 3 mm
3. Change the Extent section to the **Distance** as 38 mm
4. Select the **New Body** as Operation

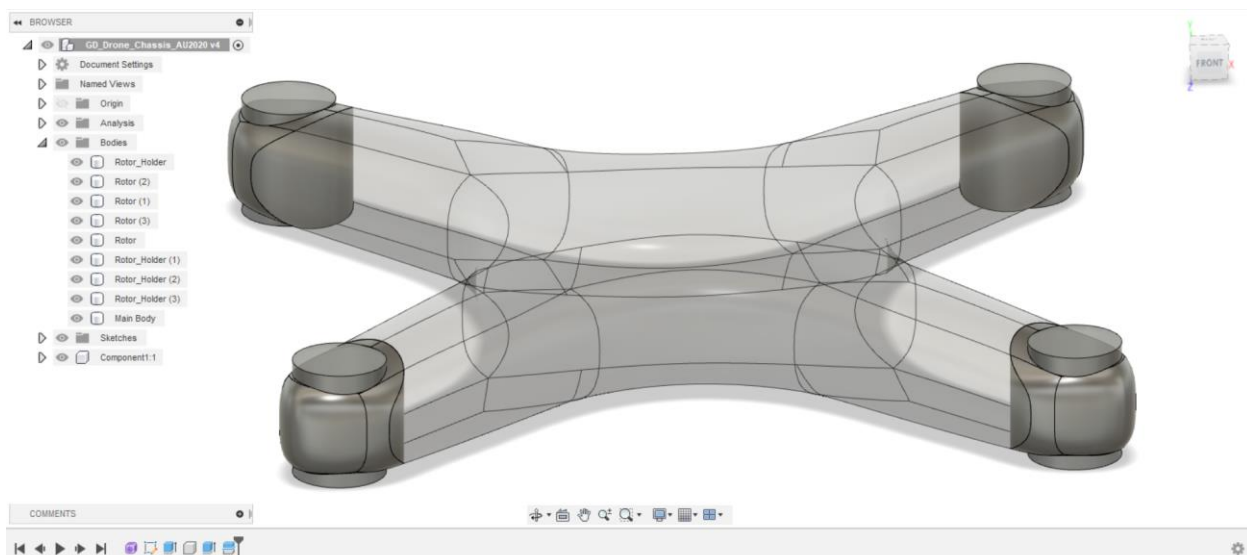


In Fusion 360 Design workspace, there are lots of tools to create and modify the bodies. It could be the best solution to obtain the necessary *"Preserve Regions for Generative Study"* is to use the **Split Body** tool.

1. Select the **Modify > Split Body** from Toolbar
2. Select the Concept Drone Part as **Body to Split**
3. Select Big Circles as **Splitting Tools**



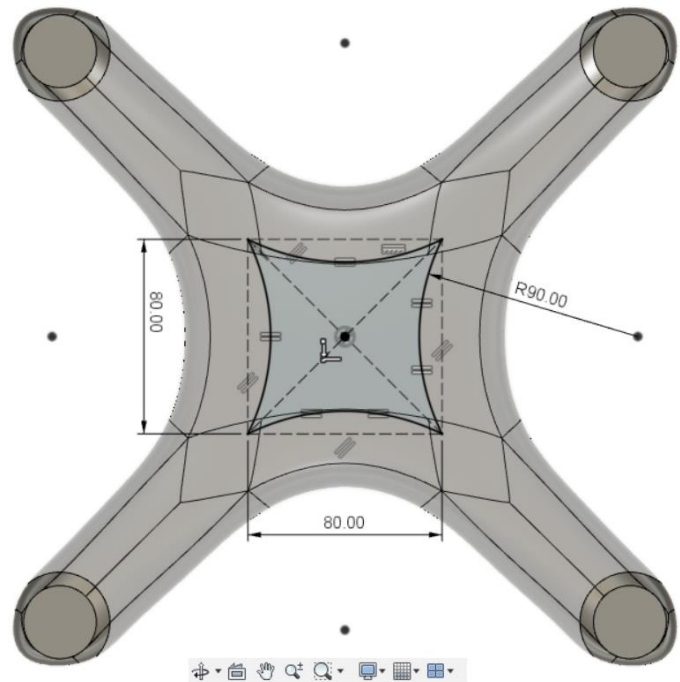
After you obtain 9 different bodies, you can easily change the names. **Double-Click the body** for rename it. If you want to change the opacity of body, you can Right-Click to body, then select the **Opacity Control**.



After finishing the renaming of bodies, you can **Create a Sketch** for new preserve regions that will be used in the *Generative Design* study.

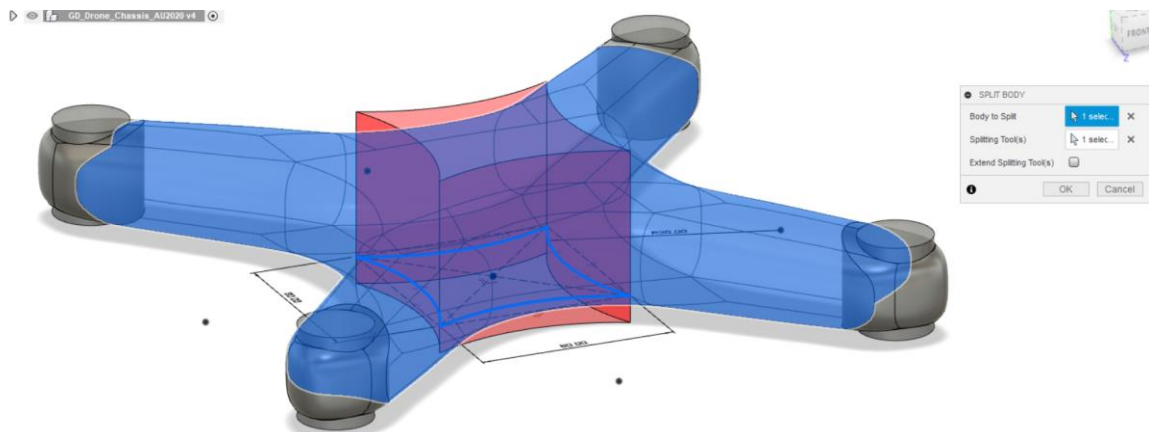
In this Sketch, you will add different geometries that it helps us to create Bottom and Top parts of concept drone. It could be carried battery, motherboard, sensor, camera etc.

1. Draw a **Center Rectangle** and use **Equal** tool from Constraints to make a Square
2. Draw four different **3-Point Arcs** to all edges of the square and use **Equal** tool for them
3. *Square length* is 80 mm and *Arc radius* is 90 mm



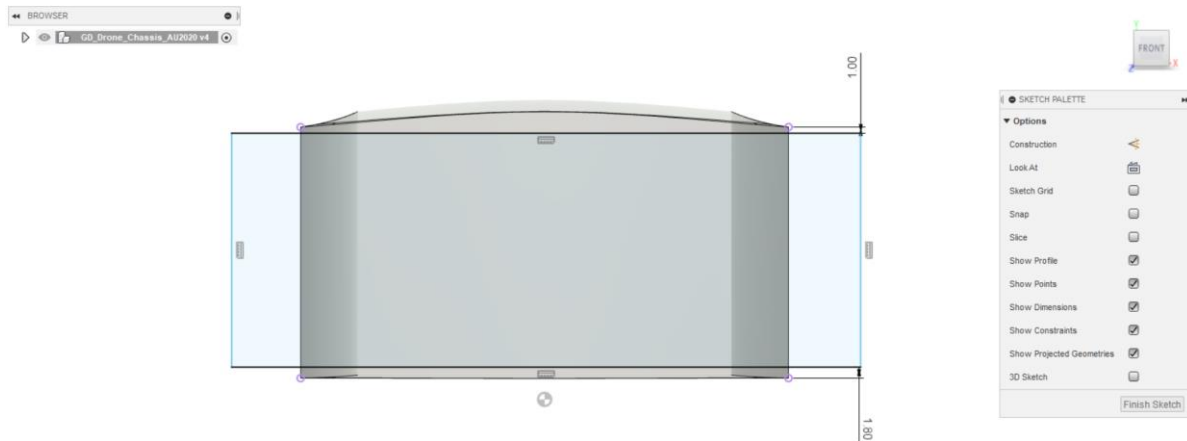
After you select **Finish Sketch**;

4. Select the **Modify > Split Body** from Toolbar
5. Select the Concept Drone Part(Main Body) as **Body to Split**
6. Select Profile that you draw in Sketch as **Splitting Tool**
7. New Small Center body **Copy > Paste** to make an another one



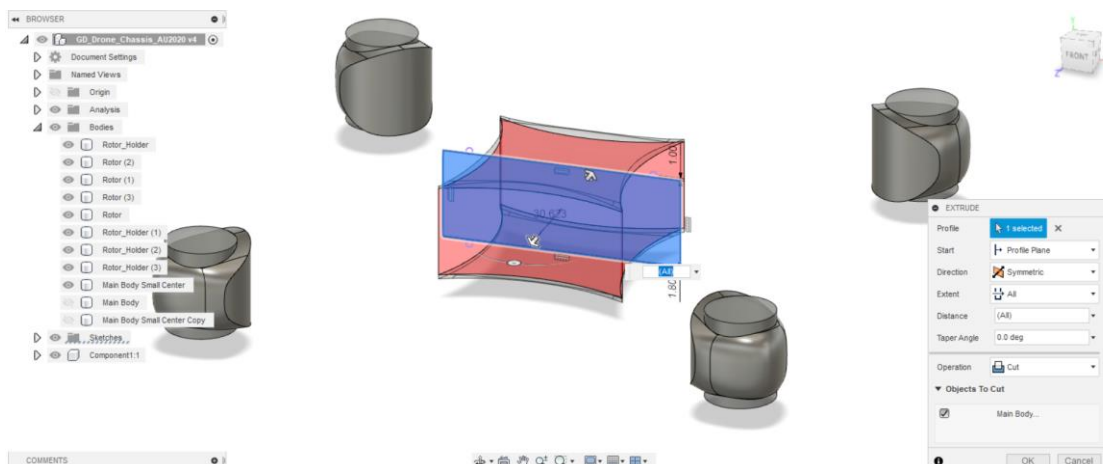
You can easily select different planes to create a Sketch, in this example, it selected XY plane that you can see from Viewcube on the top-right corner.

1. Draw a **Two-Point Rectangle**
2. Use **Dimensions (D)** tool
3. **Thickness of Bottom** part is 1.80 mm and **Thickness of Top** part is 1 mm (Of course, you can change the dimensions of parts whenever you need, [Page 16](#))



For the next step; you can use **Extrude (E)** Tool to cut the center region of concept drone.

1. Select the Sketch Profile that you draw as **Profile**
2. Start *Profile Plane* and Direction *Symmetric*
3. Change the Extent section to the **All**
4. Select the **Cut** as Operation (Notice that *Main Body* and *Main Body Small Center* is **not visible**)



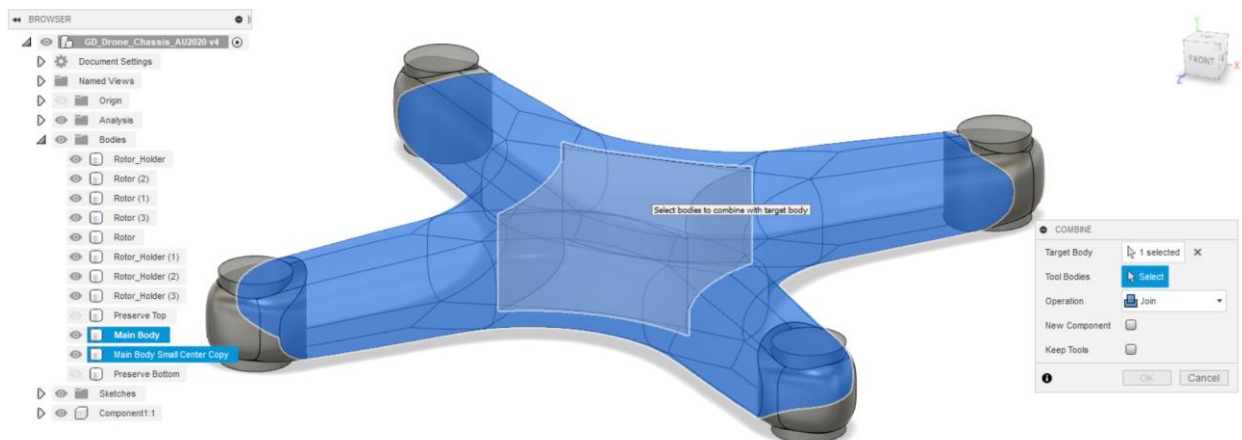
For the next steps;

1. Rename Top and Bottom Parts
2. Double-Click the bodies **Preserve Top** and **Preserve Bottom** (It is important to be well-organized in the Design Workspace)



In the Generative Study, it is not necessary to assign a Starting Shape, but if you'd like to try you can follow the next steps to create the Starting Shape

1. Select **Modify > Combine** from the Toolbar
2. Select *Main Body* as **Target Body**
3. Select *Main Body Small Center Copy* as **Tool Bodies**
4. Choose the **Join** as Operation



If you'd like to change the thicknesses of the Top and Bottom Parts, you can easily use **Offset** Tool from Modify.

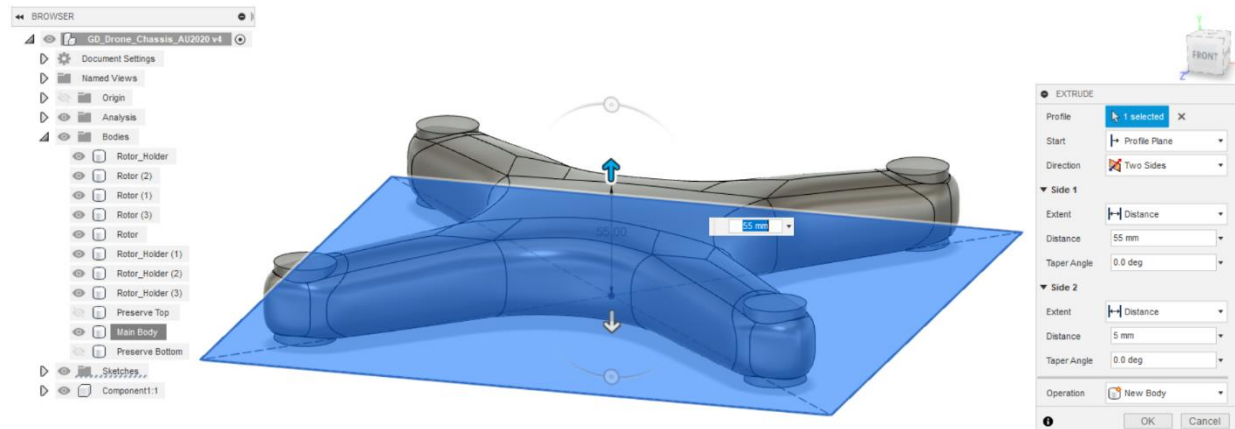
1. Hit the **O**(*Offset Shortcut*) from Keyboards
2. Select **faces** that you want to change the thickness



To prepare the Obstacle Body for Generative Design Study, you can create a box that will bigger than the edges of Concept Drone Body.

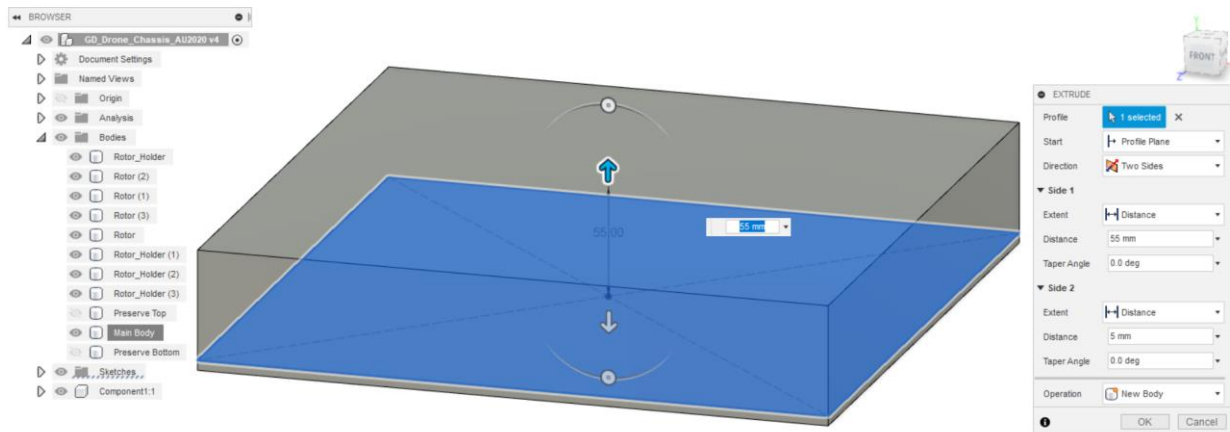
After you create a Sketch bottom plane of the bodies,

1. Draw a **Center Rectangle** and use **Equal** tool from Constraints to make a Square
2. Enter 315 mm for the length of the square using **D** (*Smart Dimensions*) from keyboards



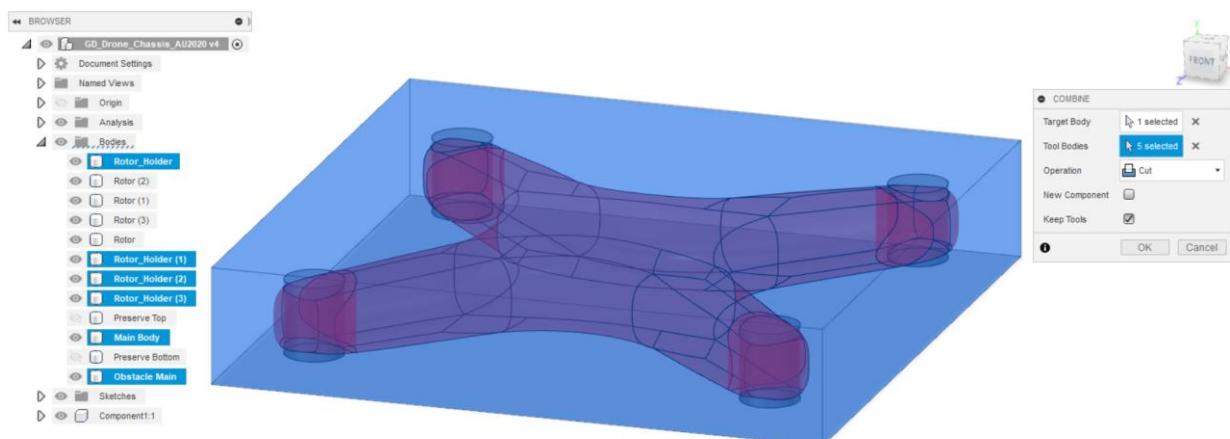
For the next step; you can use **Extrude (E)** Tool to create biggest Obstacle Body for concept drone.

1. Select the Sketch Profile that you draw as **Profile**
2. Start *Profile Plane* and Select **Two Sides** as Direction
3. Enter **55 mm** as Distance of *Side 1*
4. Enter **5 mm** as Distance of *Side 2*
5. Select the **New Body** as Operation



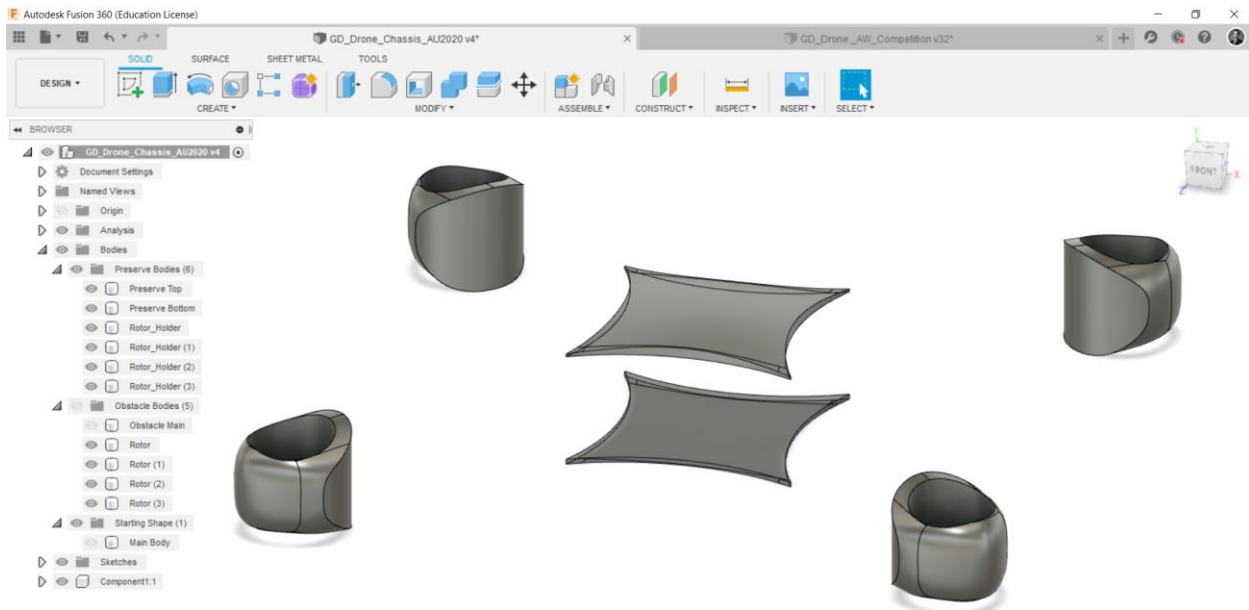
In the Generative Design Study, it is not necessary to assign a Starting Shape, but if you'd like to try you can follow the next steps to create the Starting Shape

1. Select **Modify > Combine** from the Toolbar
2. Select Obstacle Main as **Target Body**
3. Select 5 different bodies which is listed in below as **Tool Bodies**
Main Body, Rotor_Holder, Rotor_Holder(1), Rotor_Holder(2), Rotor_Holder(3)
4. Choose the **Cut** as Operation and Put a checkmark on **Keep Tools**



For the last steps in the Design Workspace;

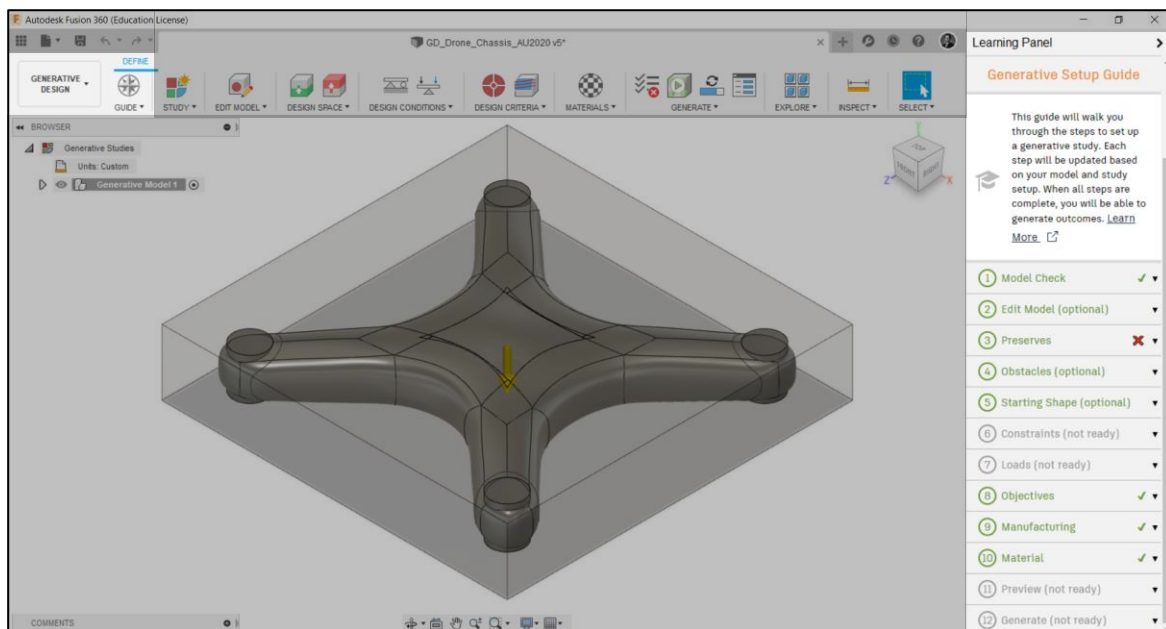
1. **Right-Click the Bodies** from Browser and select the **New Group**
2. You can **rename** the groups as *Preserve Bodies*, *Obstacle Bodies* and *Starting Shape*
3. **Drag and Drop the bodies** related groups to be well-organized before to start our Generative Design Study



GENERATIVE DESIGN

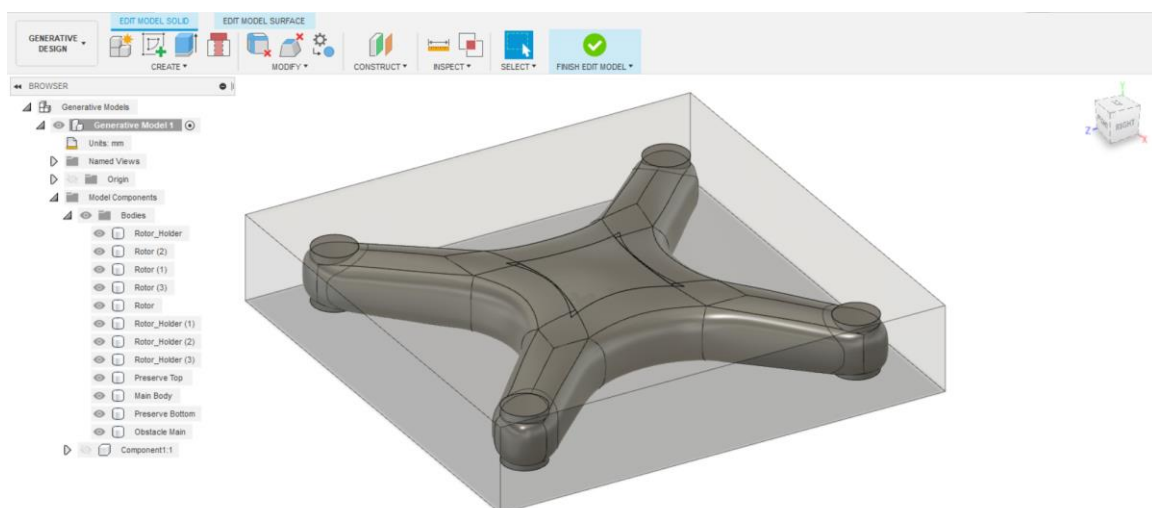
New Generative Design Study

When you enter the Generative Design Workspace in Fusion 360, it will automatically open a new generative design study named as **Study 1**. You can get information from **GUIDE**, there are detailed definitions of all steps for Generative Design. When you complete the assignment of all necessities of Generative Design, you can see the green check icon in every title.



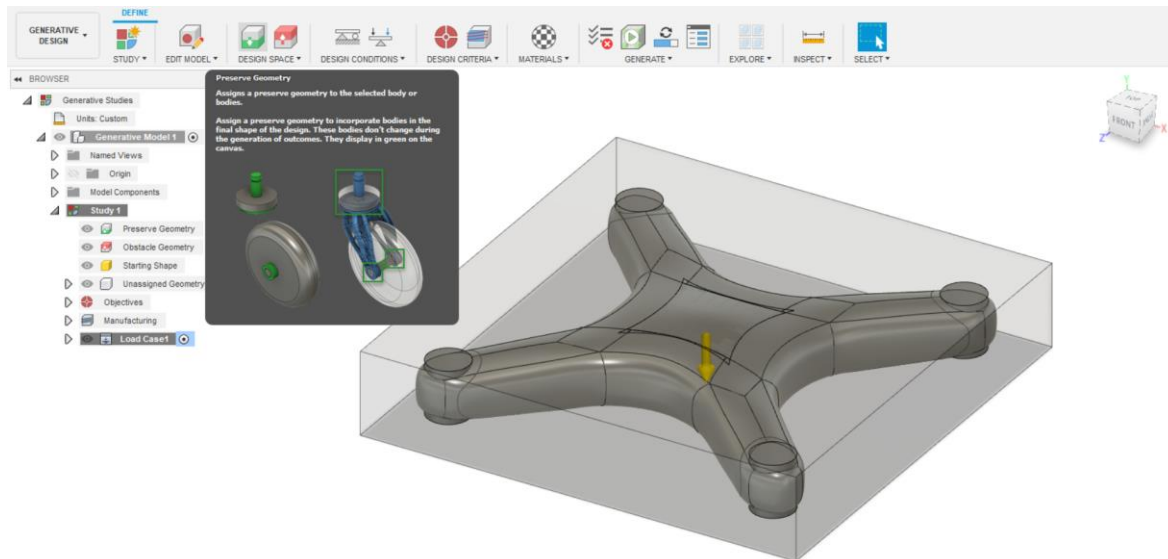
Preparation of the model for Generative Design

In the first study of this hands-on lab, you don't need to use **Edit Model Workspace**. But it enables you to create bodies to represent Preserve, Obstacle and Starting Shape.



Assignment of Preserve Geometries

In Generative Design Study, it should be assigned **Preserve Geometry** that it allows adding Loads and Constraints. Preserve Geometries also will appear in the final shape of the design.

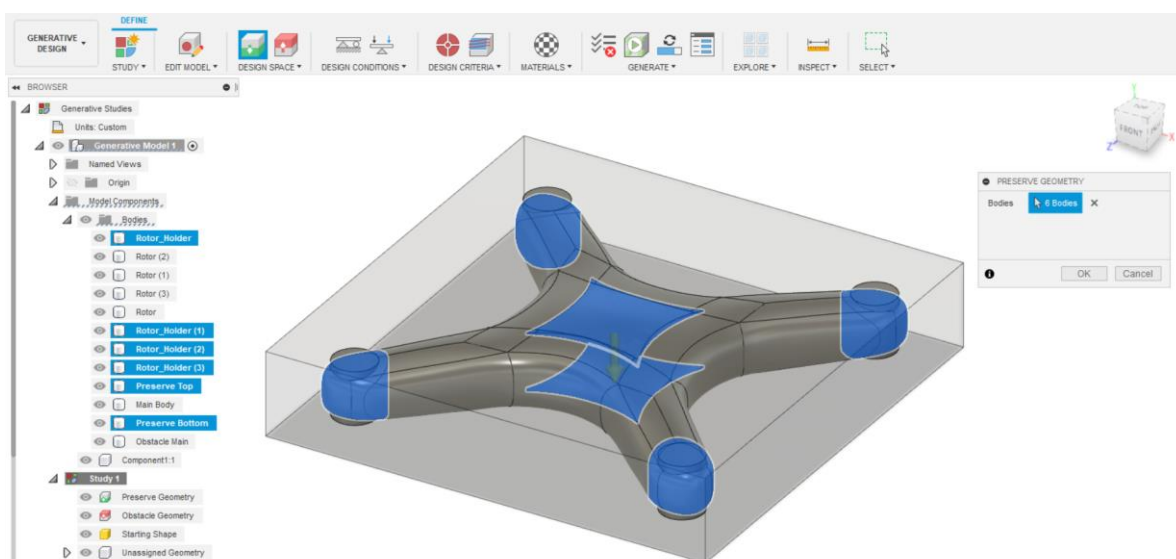


Follow the next steps to assign *Preserve Geometry*;

1. Select the **6 Bodies** that written in below

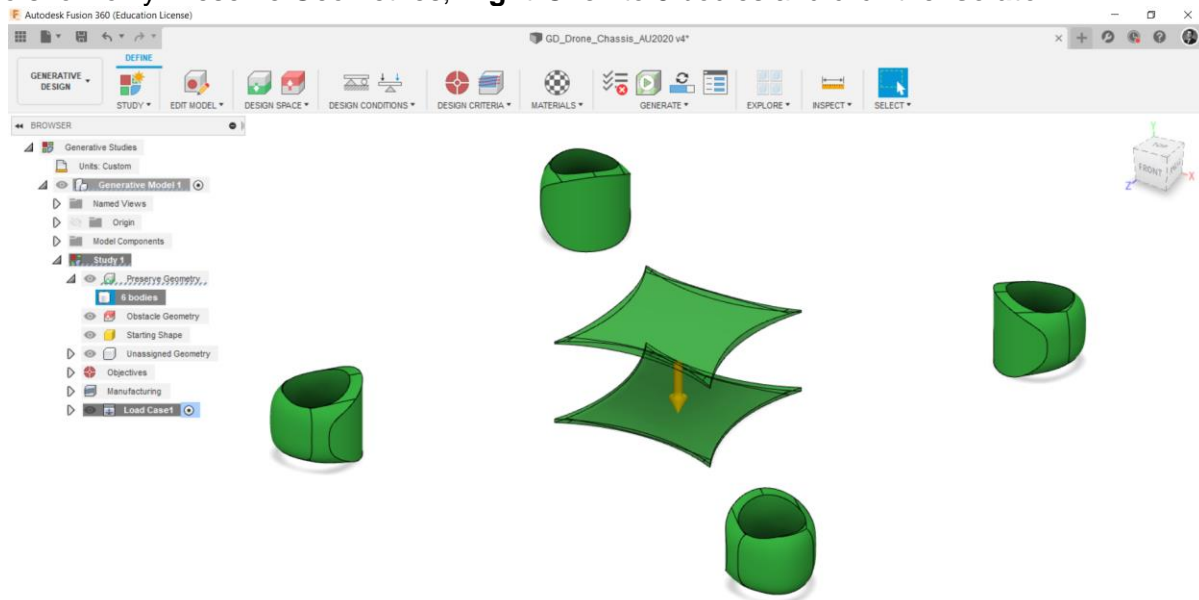
Preserve_Top, Preserve_Bottom, Rotor_Holder, Rotor_Holder(1), Rotor_Holder(2), Rotor_Holder(3)

2. Click the **OK** to assign *Preserve Bodies*



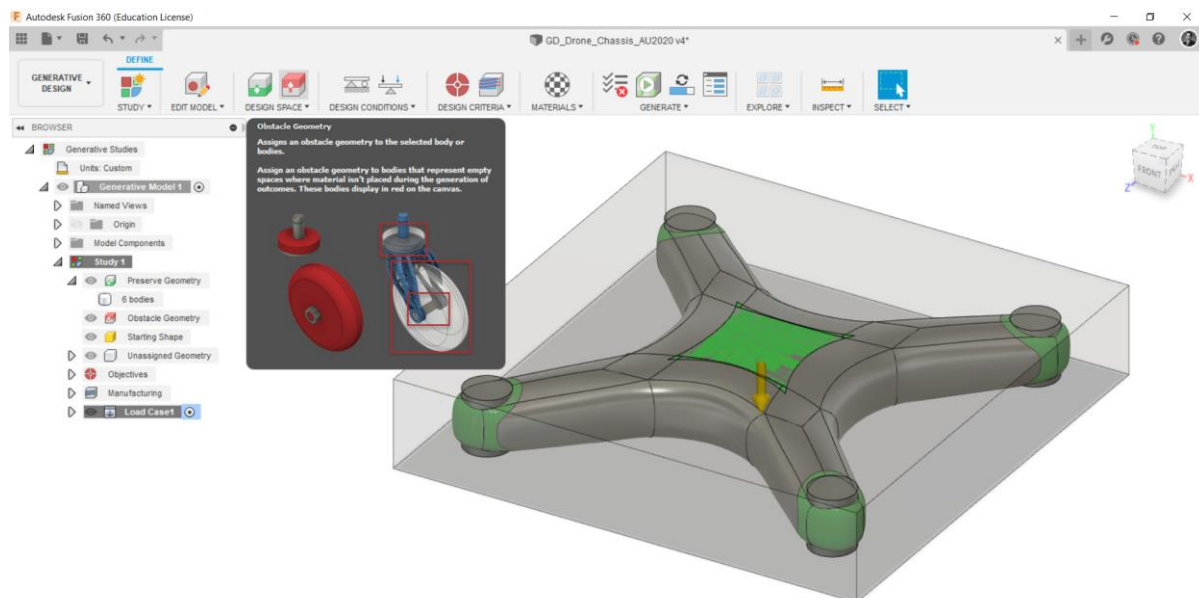
After you correctly assign the preserve geometries, the bodies will appear in the Preserve Geometry Group.

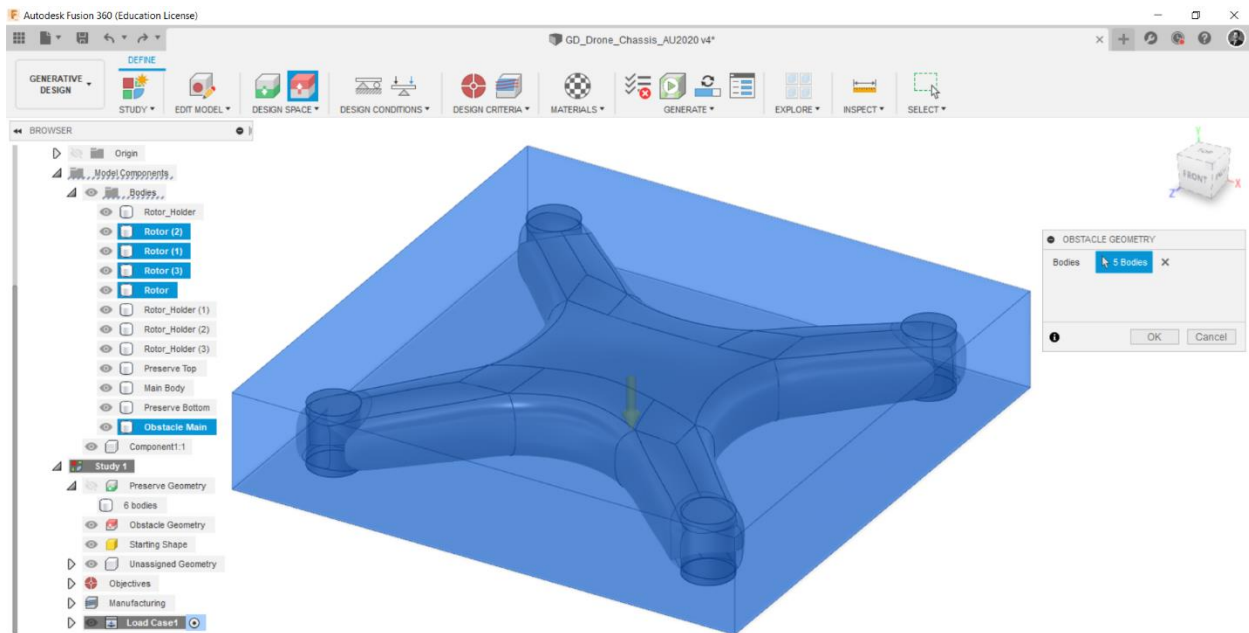
To show only Preserve Geometries; **Right-Click** to 6 bodies and click the **Isolate**



Assignment of Obstacles Geometries

It's not obligatory to add **Obstacle Geometry** in Generative Design Study. But in many cases, it will help you when you need to assign empty spaces where material placed during the generation of outcomes.



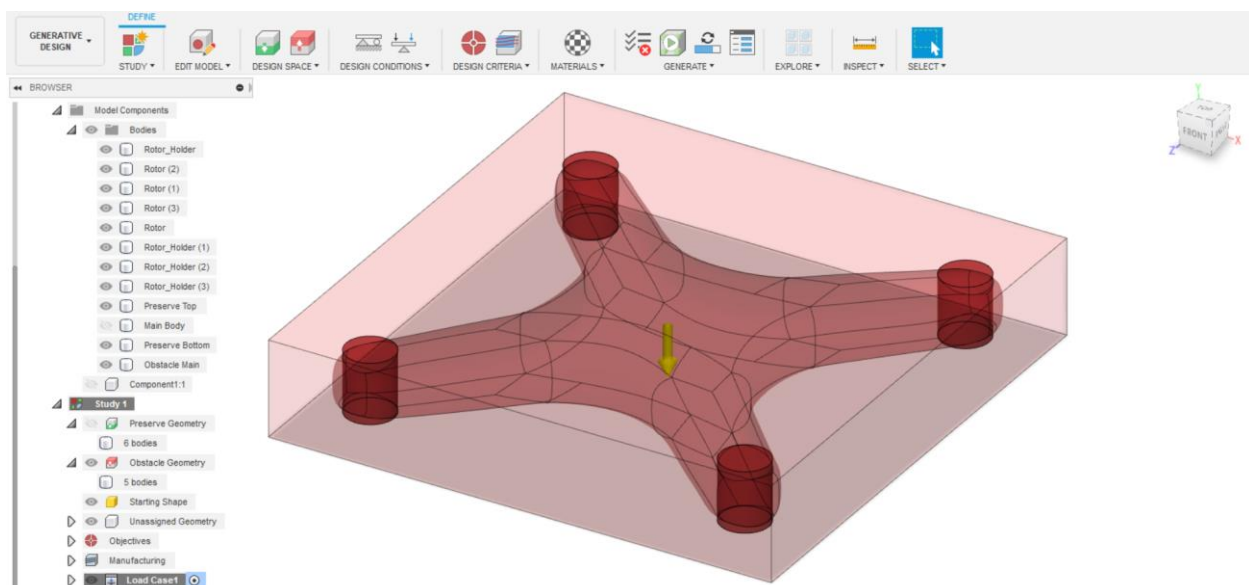


Follow the next steps to assign *Obstacle Geometry*;

1. Select the **5 Bodies** that written in below

Obstacle_Main, Preserve_Bottom, Rotor, Rotor(1), Rotor(2), Rotor(3)

2. Click the **OK** to assign *Obstacle Bodies*

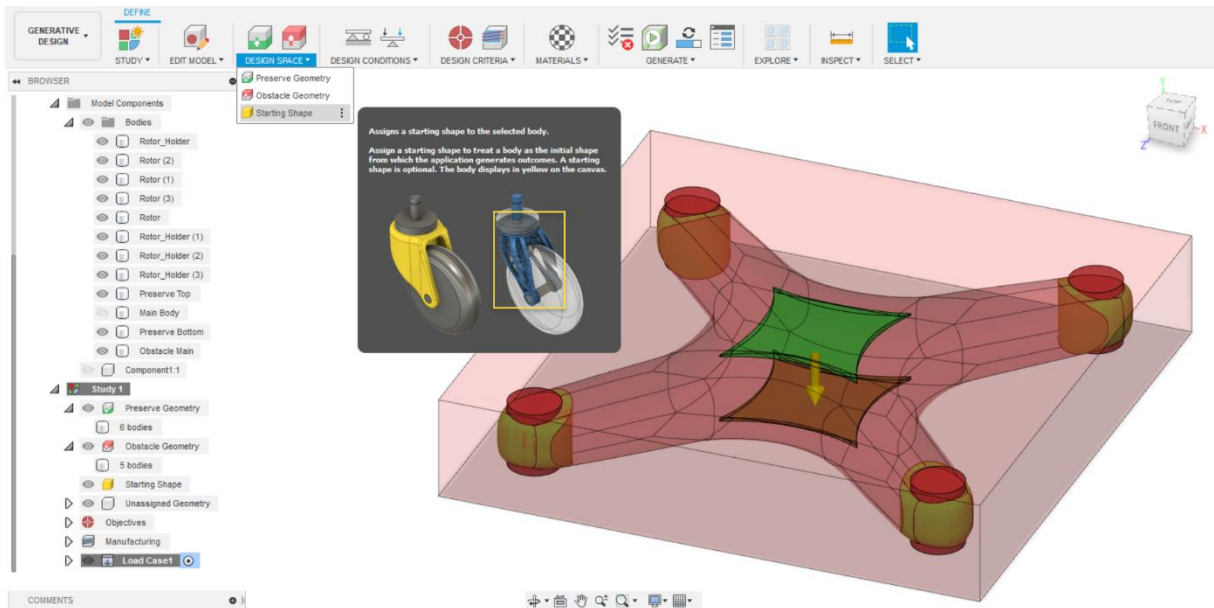


After you correctly assign the obstacle geometries, the bodies will appear in the Obstacle Geometry Group.

To show only Obstacle Geometries; **Right-Click** to 5 bodies and click the **Isolate**

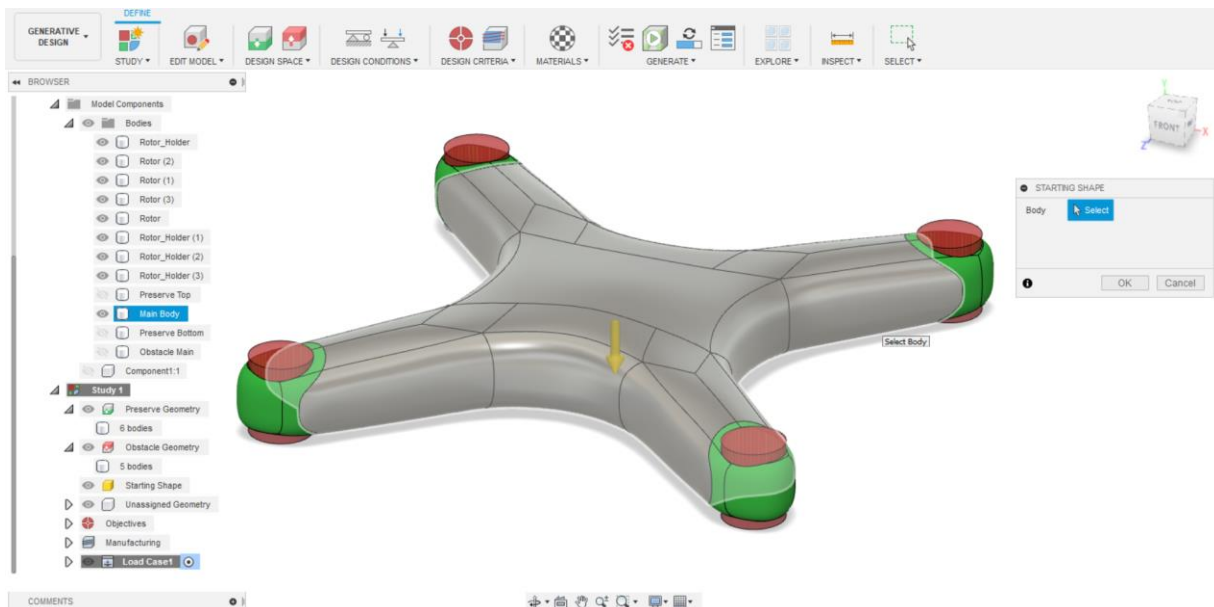
Starting Shape

In Generative Design Study, Starting Shape is an optional tool. You can assign it as initial shape. In this Hands-on Lab, you will explore two different Generative Design Studies, one of which contains Starting Shape and the other one without Starting Shape.

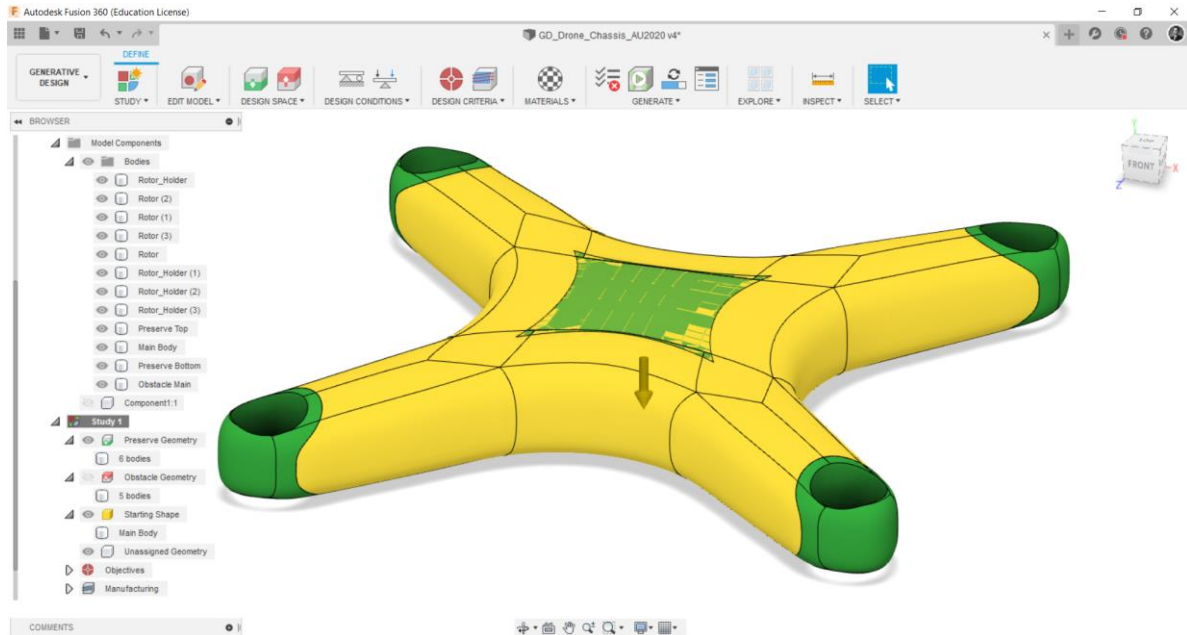


Follow the next steps to assign Starting Shape;

1. Select the **Main Body** as Starting Shape Body
2. Click the **OK** to assign Starting Shape

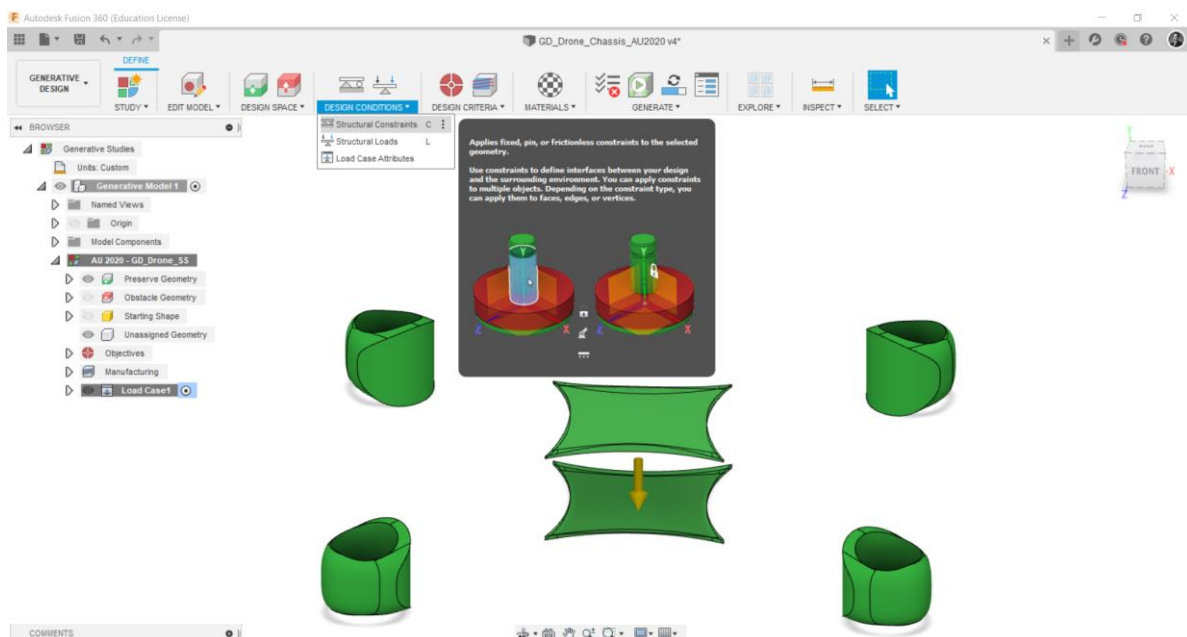


After you correctly assign the Starting Shape, the body will appear in the Starting Shape Group. The **Main Body** will display in yellow on canvas.



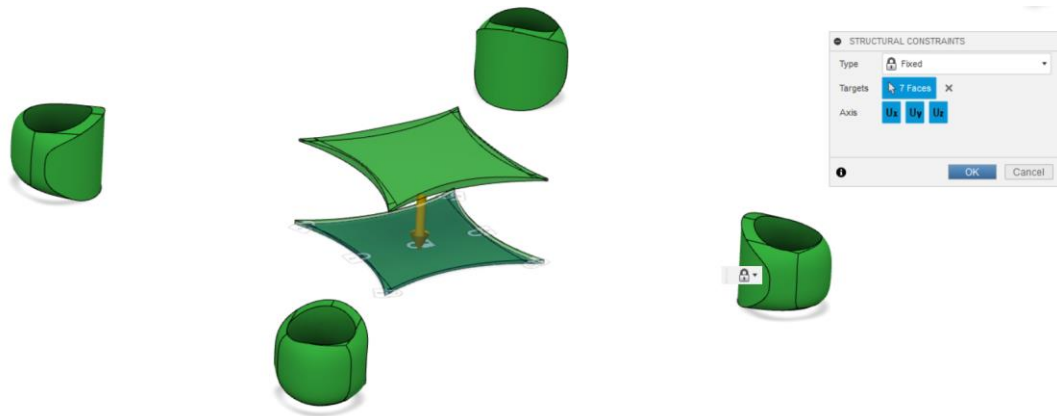
Structral Constraints

In the Generative Design Study, **Structural Constraints** restrict or limit the displacement of the model. In this hands-on lab, you can consider that *Generative Design Study* should create a Concept Drone Chassis in estimated conditions.



Follow the next steps to assign *Structural Constraints*;

1. Select the 7 faces Bottom_Body
2. Click the **OK** to assign Structural Constraints



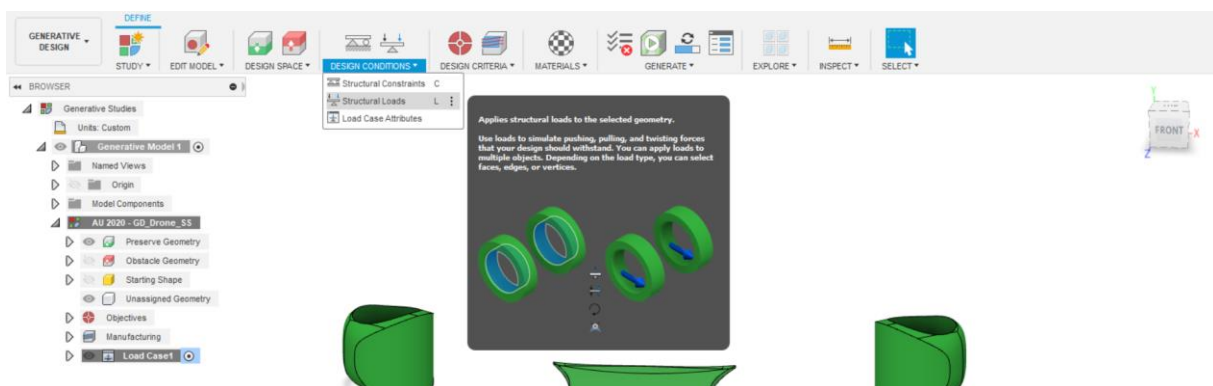
Structural Loads

In this Hands-on Lab, it will be used type of **Force** from *Structural Loads* but there are 4 different Load types available as *Force, Pressure, Moment and Bearing Load in Generative Design Workspace*. You can use loads to simulate pushing, pulling and twisting. Depending on your load type, you can select faces, edges or vertices from multiple objects.

In below, there are several forces given as **Newton (Unit of Force)**, they are just averaged values to create the Drone Chassis, you can make changes as you wish according to your scenario (For different materials, manufacturing methods, scale etc.).

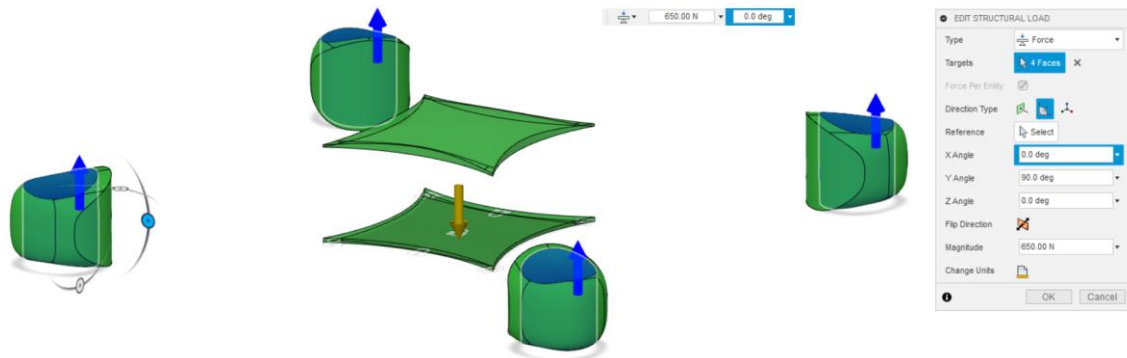
Follow the next steps to assign *Structural Loads*;

1. Select the Structural Loads From Design Conditions (**L** key is the shortcut)



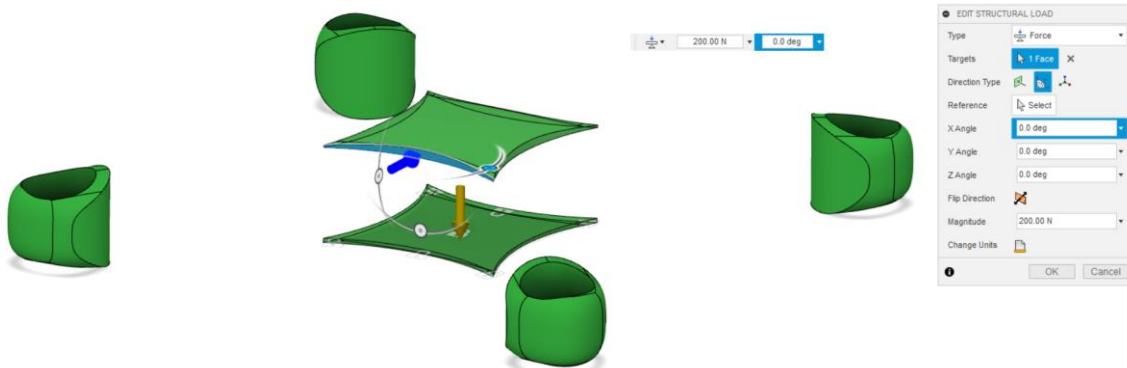
2. Select the **4 faces** inside of the Rotor Parts as **Targets**

3. Enter the 650 N as **Magnitude** as shown in below



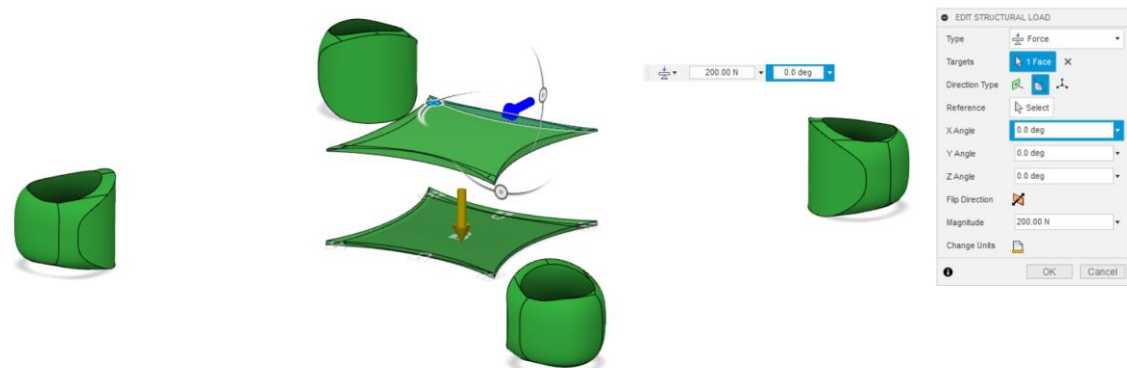
4. Select the face of Preserve_Top (Notice that all screenshots are from the same view, you can check the viewcube)

5. Enter the 200 N as **Magnitude** as shown in below



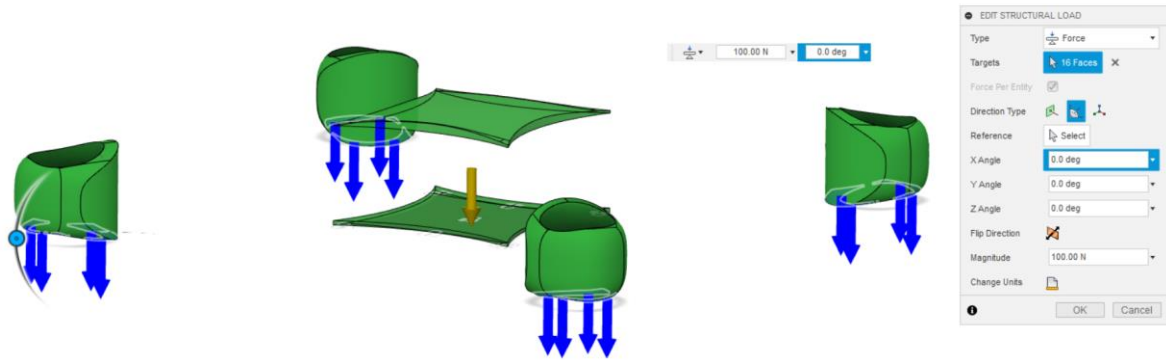
6. Select the opposite side face of Preserve_Top

7. Enter the 200 N as **Magnitude** as shown in below



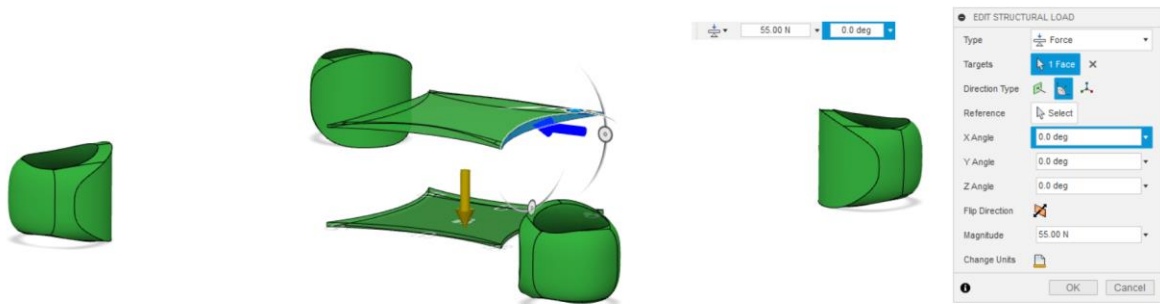
8. Select the bottom faces of Rotors

9. Enter the 100 N as **Magnitude** as shown in below



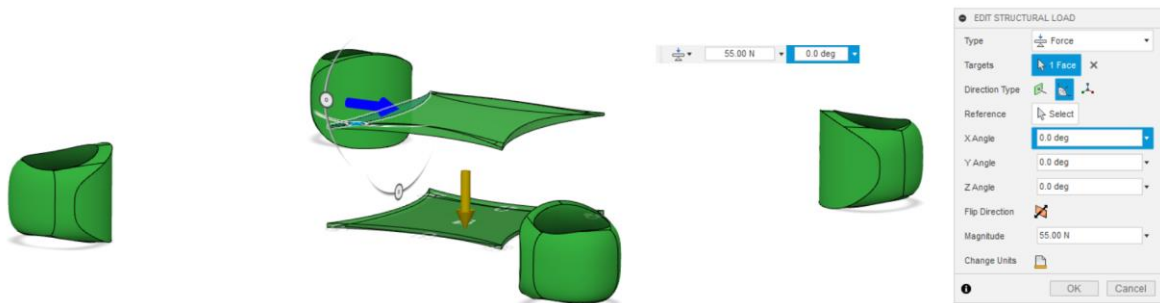
10. Select the face of Preserve_Top

11. Enter the 55 N as **Magnitude** as shown in below



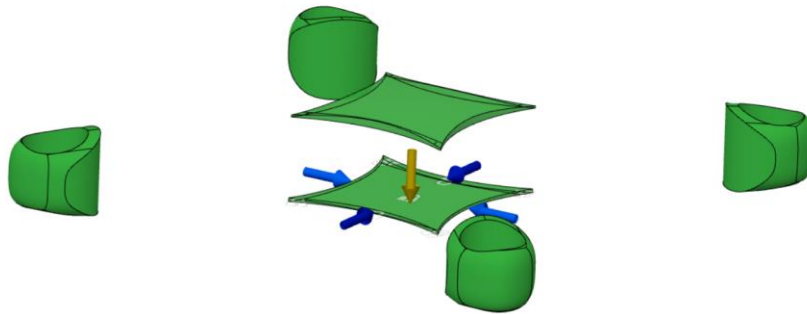
12. Select the opposite side face of Preserve_Top

13. Enter the 55 N as **Magnitude** as shown in below



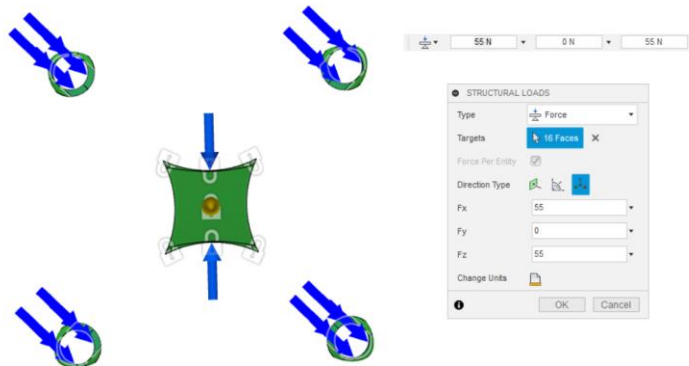
14. Select the 4 faces of Preserve_Bottom in 2 steps

15. Enter the 200 N to each as **Magnitude** as shown in below (Notice that you can change the Constraints place for these Structural New Loads, and also you can change the loads action on bottom side, it's up to your case)



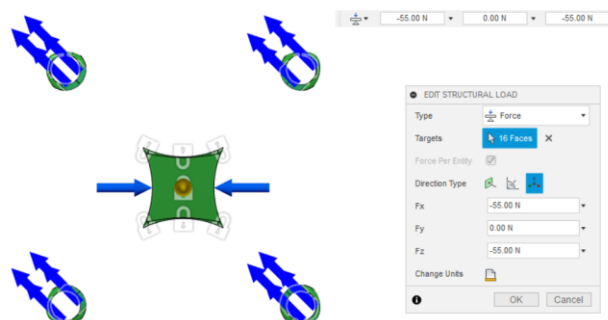
16. Select the bottom faces of rotors

17. Enter the F_x ; 55 N, F_y ; 0, F_z ; 55 N as **Magnitude** as shown in below



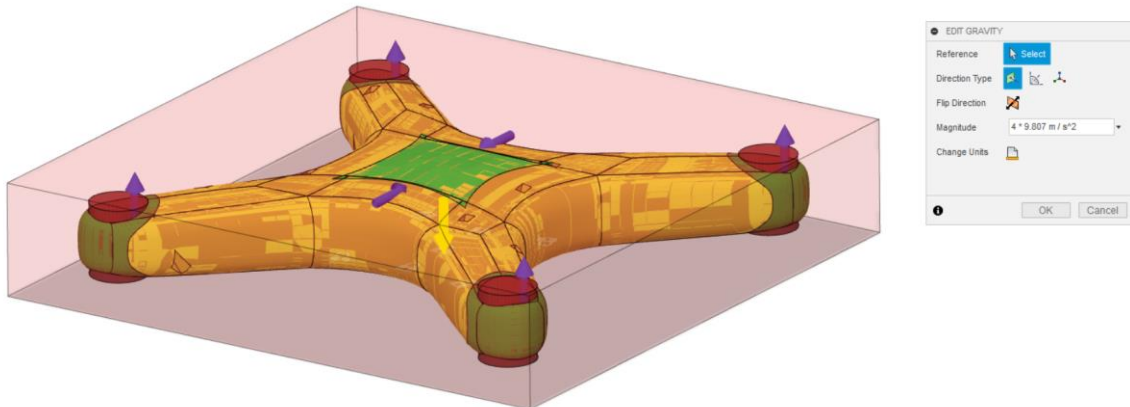
18. Select the bottom faces of rotors

19. Enter the F_x ; -55 N, F_y ; 0, F_z ; -55 N as **Magnitude** as shown in below



20. Select the Gravity from Load Case 1

21. Enter the $4 \times g$ as **Magnitude** as shown in below (Notice that **Gravity** only affects the mass of the model, you're free to change of your case up to $10 \times g$ etc.)



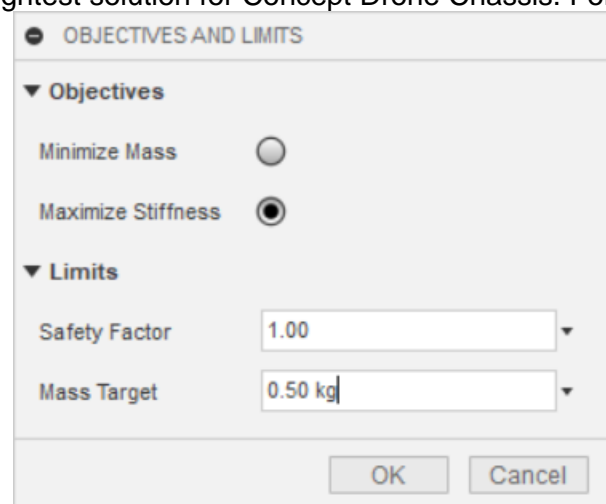
Objective Limits

In this hands-on lab, we would like to reach the lightest solution for Concept Drone Chassis. For this aim, you can easily choose the Minimize Mass as Objectives. In general, it's proper to enter a value of 2 for Safety Factor on Limits.

If you'd like to reach more detailed design outcome, you can enter a Mass Target after you determine from **Right Click to Body in Browser > Properties**.

For the Generative Design Study with Material of *Titanium 6Al-4V*;

- 1- Enter the **Safety Factor** Value as 1.00
- 2- Enter the 0.50 kg as **Mass Target**



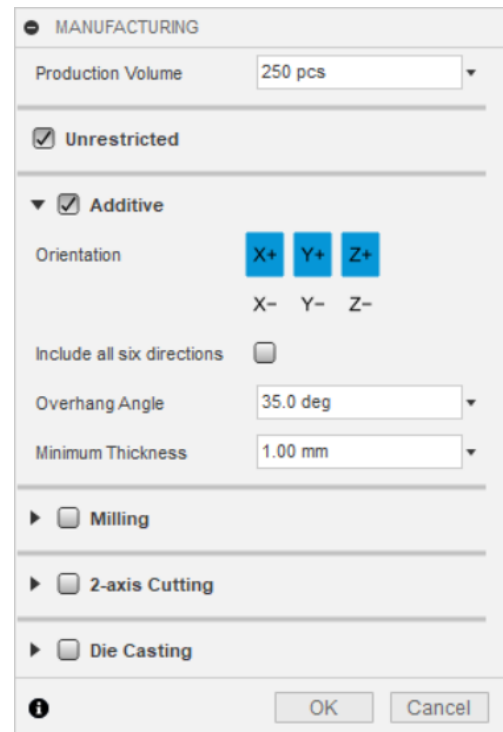
Manufacturing

You can Select the **Manufacturing Tool** from Design Criteria. It specifies the manufacturing constraints for the design process. There are 5 different options available as *Additive, Milling, 2-Axis Cutting, Die Casting and Unrestricted*. In this hands-on lab, it will be chosen **Additive manufacturing and unrestricted method**, but, of course, you can try other methods for concept drone chassis.

Follow the next steps to assign *Manufacturing Method*;

1. Put a checkmark on **Unrestricted**
2. Put a checkmark on **Additive**
3. Select **X+, Y+, Z+** for Orientation
4. Enter the **35 Degree** to Overhang Angle
5. Enter the value of **1.00 mm** to Minimum

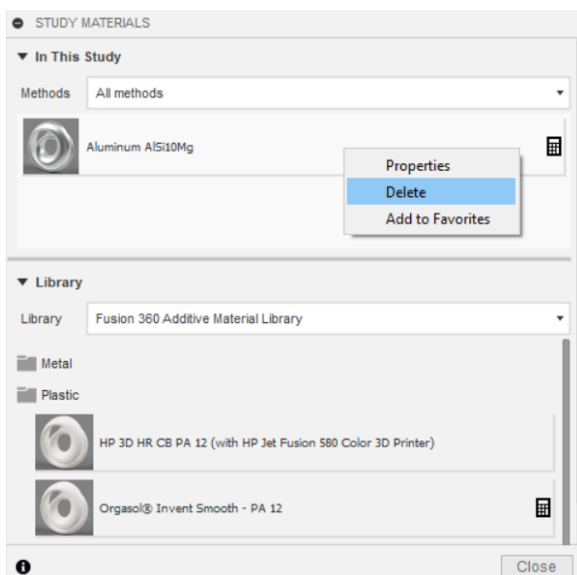
Thickness



The MANUFACTURING dialog box shows the following settings:

- Production Volume: 250 pcs
- ☒ Unrestricted
- ☒ Additive
 - Orientation: X+, Y+, Z+ (selected)
 - Include all six directions: ☐
 - Overhang Angle: 35.0 deg
 - Minimum Thickness: 1.00 mm
- ☐ Milling
- ☐ 2-axis Cutting
- ☐ Die Casting
- Buttons: OK, Cancel

Choosing Materials



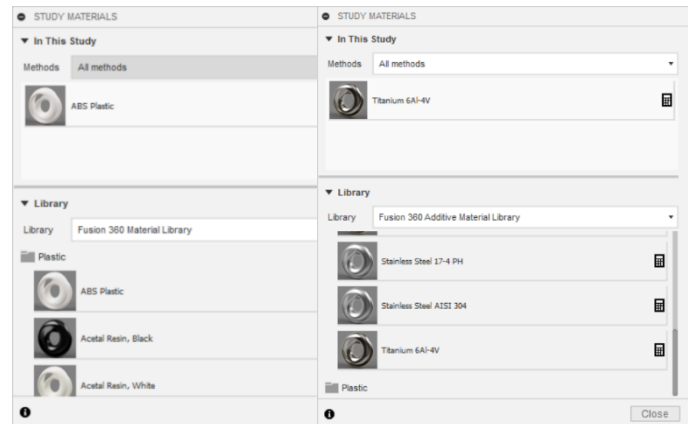
The STUDY MATERIALS dialog box shows the following settings:

- Methods: All methods
- In This Study: Aluminum AlSi10Mg (with context menu: Properties, Delete, Add to Favorites)
- Library: Fusion 360 Additive Material Library
 - Metal
 - Plastic
 - HP 3D HR CB PA 12 (with HP Jet Fusion 580 Color 3D Printer)
 - Orgasol® Invent Smooth - PA 12
- Buttons: Close

You should select at least one material for your **Generative Design Study**. Fusion 360 offers Aluminum AlSi10Mg as default but you can *delete* it from in this study section.

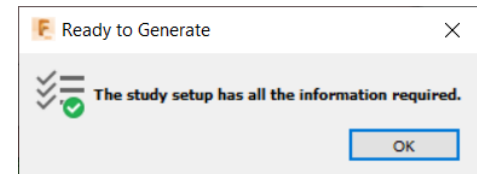
In this hands-on Lab, it will select two different materials as Plastic and Metal. But feel free to choose different materials for your cases.

- 1- Select the **ABS Plastic** from Fusion 360 Material Library
- 2- Drag & Drop to in this Study Section
- 3- Select the **Titanium 6Al-4V** from Fusion 360 Additive Material Library



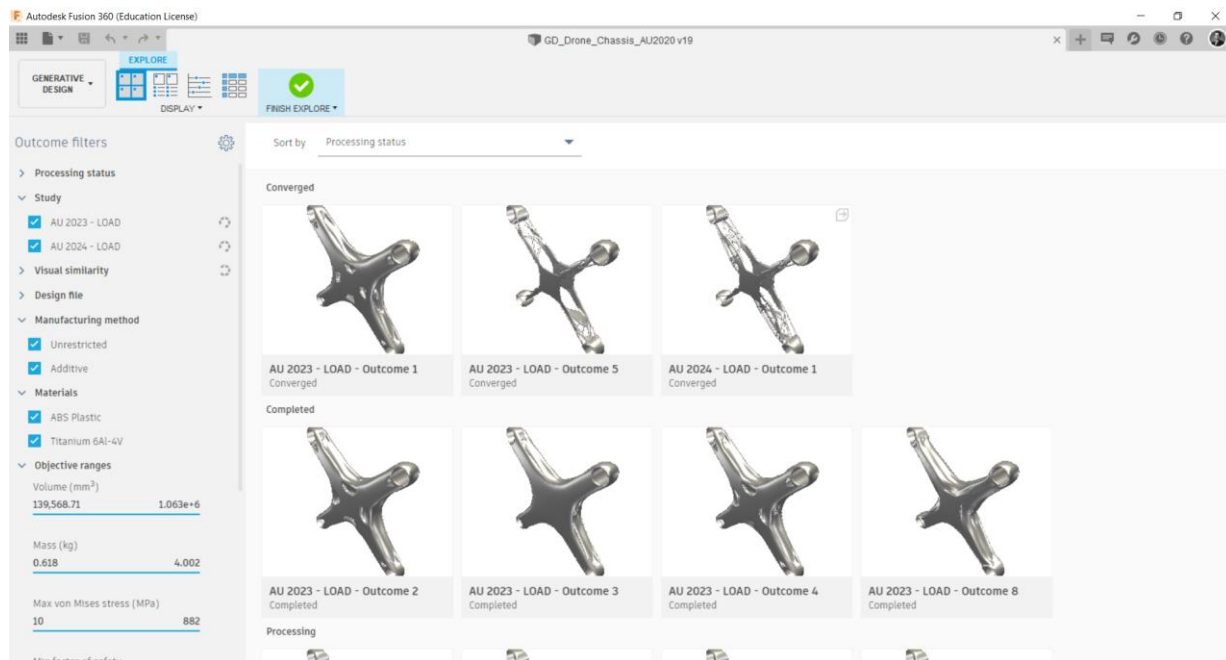
Pre-Check and Generate

Pre-Check tool ensures to the setup meets requirements to generate outcome. When you see the Green Check icon in the Pre-Check tool, it's all good and you're ready to **GENERATE!**

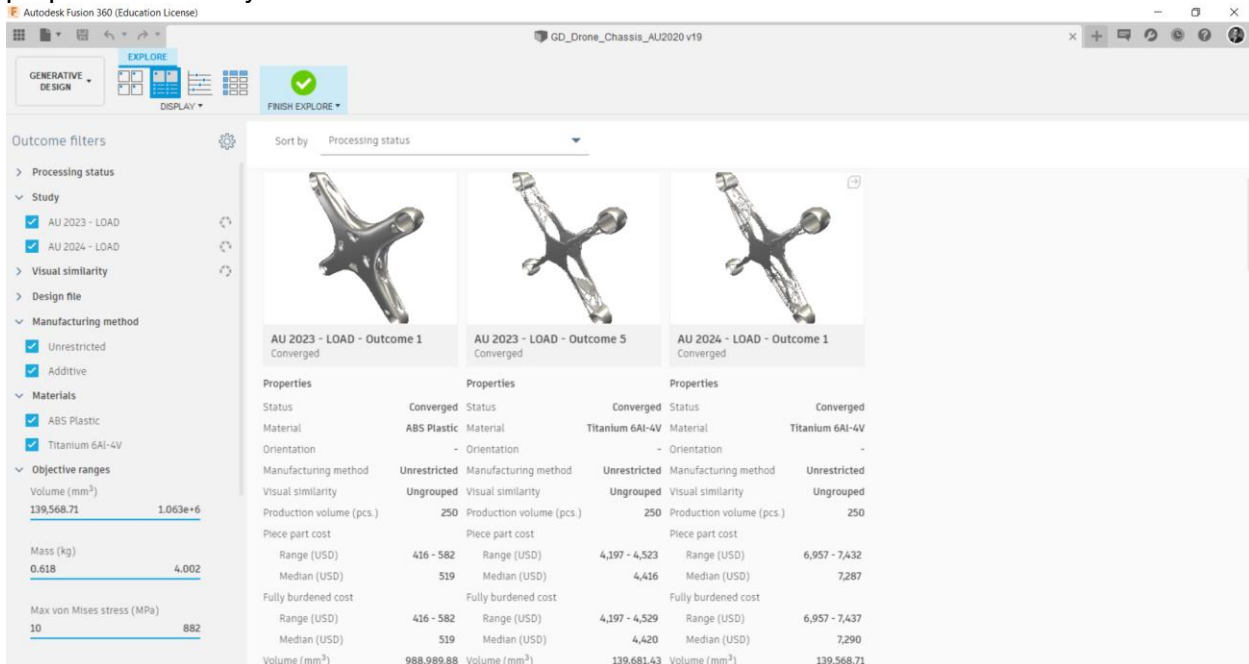


Exploring Generative Design Outcomes

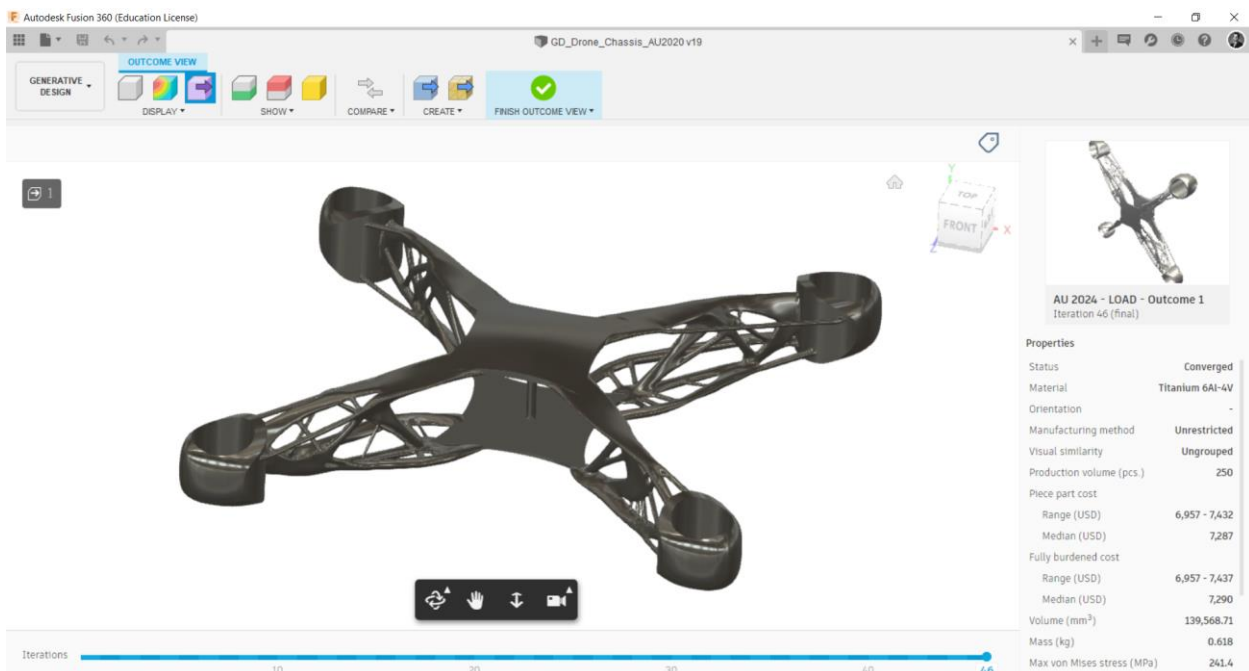
Fusion 360 offers us a detailed Explore page which contains many outcomes. You can easily change the objective ranges from Outcome Filters and you will see only outcome thumbnails that you need for your necessary.



When you switch the **Properties View** from Display, you can quickly take a look detailed properties for every outcomes.



Outcome view offers 3 different Display view as **Model view**, **Stress View** and **Design Preview**. Also, there is very useful tool to modify your outcome as **CREATE** tool. Design From Outcome tool create a **3D Design** which you can edit, from the current outcome's iteration.



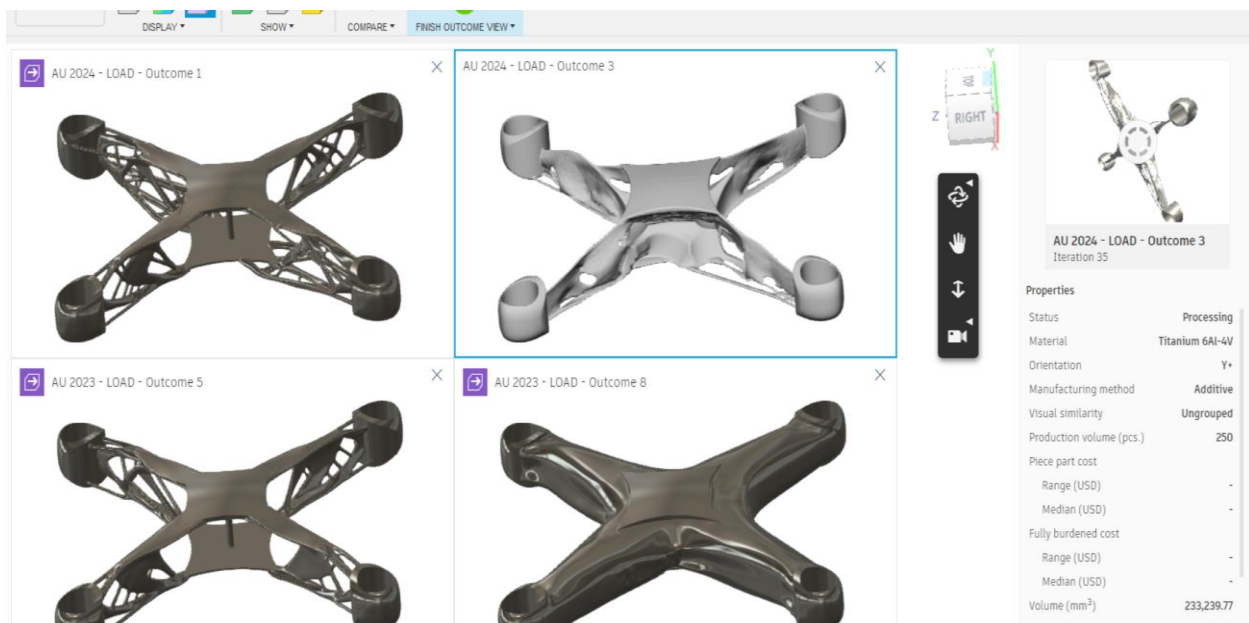
Details of the Scatter Plot View

If you want to take a look all outcomes in the same table, Scatter Plot View will be the best tool for you. You can change the axis like Volume, Mass, Min Factor of Safety etc. And colors represents materials which used by Generative Design Study.



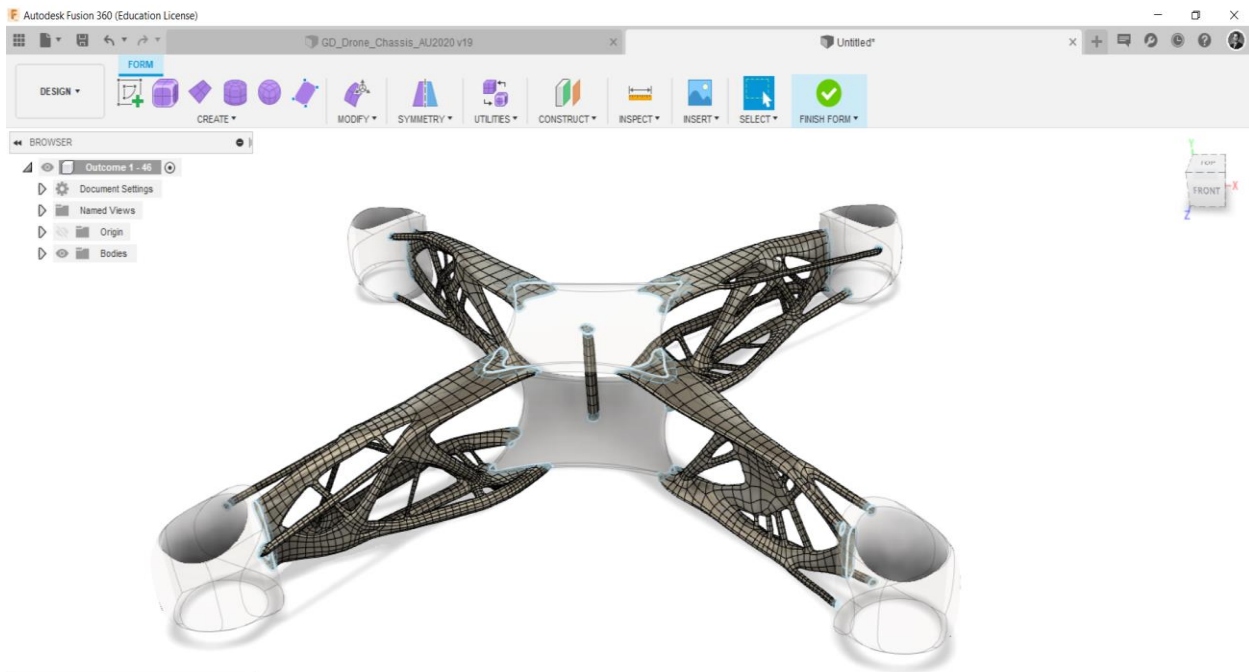
Comparasion View

You can compare up to **four outcomes**. It will be useful for you to compare *outcomes as visual similarity, stress views, and other details at the same time*.



Design from Outcome

You can easily modify your selected outcome design from your **Generative Design Study**. At the beginning of the hand-out, we started creating a *box*, and now, that's the result of the **Hands-on Lab**.



I hope this hand-out and hands-on Lab will contribute your work. **All the best!**