

E3.7/E3.7A COLLABORATIVE COMPUTER-AIDED ENGINEERING ON THE FUSION 360 PLATFORM

SUMMARY

I) Area of Study

Collaborative Computer-Aided Engineering of Mechanical Systems

II) Learning Objectives

By completing this lab experiment, students will be able to learn about

a) Functions of a modern CAE integrated platform

Overview

Integrated all-in-one system

Cloud system and file management, file sharing functions, team collaboration

b) Basic Principles and Concepts in CAE

Part Design

Static Stress Analysis

Part Assembly



Figure 1. Completed E-scooter Assembly.

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1. INTRODUCTION

The world is moving towards Industry 4.0, a key feature of which is a digital backbone that integrates the different functions and activities in an organization. Fusion 360 is a platform that serves the mechanical engineering industries in Industry 4.0. It comprises a comprehensive and well-integrated suite of systems for a range of engineering activities and provides support for collaboration between different functions within an organization, from product coceptualisation to design, simulation, manufacturing, and production. Fusion 360 offers a digital framework for team-based ideation, collective innovation, and project management. This is realized through a friendly user interface, which enables a seamless transition between its CAD capabilities (modeling, drawing and rendering) and downstream applications mentioned above.

In this lab, students are to take the CAD model of a mechanical device (an E-scooter), collaborate to complete its design and decide on the design selection. They will learn and appreciate the range of functionalities of a modern integrated CAE platform, and how CAE software has evolved over the years to be more collaborative and powerful. They will also learn the concept of project management and be cognizant of the trends in a digital economy. Equipped with this knowledge, students will be able to embrace and drive technological changes in our industries in the future.

2. OBJECTIVES & SCOPE

The objective of this lab is to expose students to the collaborative and integrated environment of a CAE system, Fusion 360, including and beyond the individual activities such as modeling and analysis. Modeling and analysis are required here, but students are to work in a team, sharing data and making decisions on the platform. Specifically, the team is given the parts of a complete e-scooter except for the deck board. Each member of the team is to design one board and analyse its load-bearing capacity and share the information in the system. The team will then confer and choose the best board to complete the scooter assembly.

3. IMPORTANT NOTES

The Fusion 360 platform is cloud-based and registration for a user account is mandatory to carry out the lab tasks. A week before the lab session, the lab administrator will send an email to invite students to register for Fusion 360. Students are to register for an account within 1 day upon receipt of the invitation, and an email acknowledgement is required. Students will work in teams of 3-4 and will be given 1 week to complete the exercise. Students may also collaborate remotely via online communication. More information on Fusion 360 is available online, such as courses in <https://help.autodesk.com/view/fusion360/ENU/courses/>. Students are strongly encouraged to access these online resources to complete the assignments.

4. FUSION 360 PLATFORM REGISTRATION

Autodesk, the vendor for Fusion 360, provides students with a free one-year single-user access to Autodesk software and services for educational purposes. Fusion 360 is an all-in-one system that includes 3D modeling, simulation, manufacturing, social and collaborative applications. Students can obtain access to Fusion 360 via the following procedure.

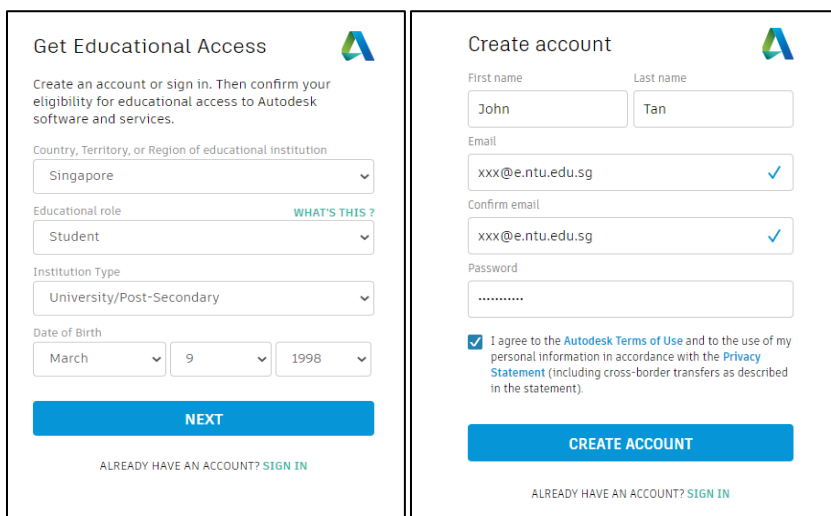


Figure 2. Autodesk registration page.

- i. Create an account:
 - 1) On the Get products page, click on “Get Started” (<https://www.autodesk.com/education/edu-software/overview?sorting=featured&page=1>).
 - 2) Follow the on-screen instructions to enter the basic information about your school and yourself. Registration must be done with student’s NTU email.
 - 3) Check email to verify registration.
- ii. Confirm eligibility:
 - 1) Sign in to the newly registered account (<https://www.autodesk.com/education/edu-software/overview?sorting=featured&page=1>).
 - 2) Choose “Nanyang Technological University” in the school drop-down list and verify that all the information is correct. *(Ensure that name is written as in matriculation card)*
 - 3) If your name is Tan Ah Beng, please use First name: Tan, Last name: Ah Beng. The order of name is important in the authentication process.
 - 4) Submit a photo of your NTU Matriculation card.

iii. Download Fusion 360:

- 1) Once logged in, go to <https://www.autodesk.com/education/free-software/>. Select “Get product” on the Fusion 360 panel followed by “Access”. Install the application once the file is downloaded.

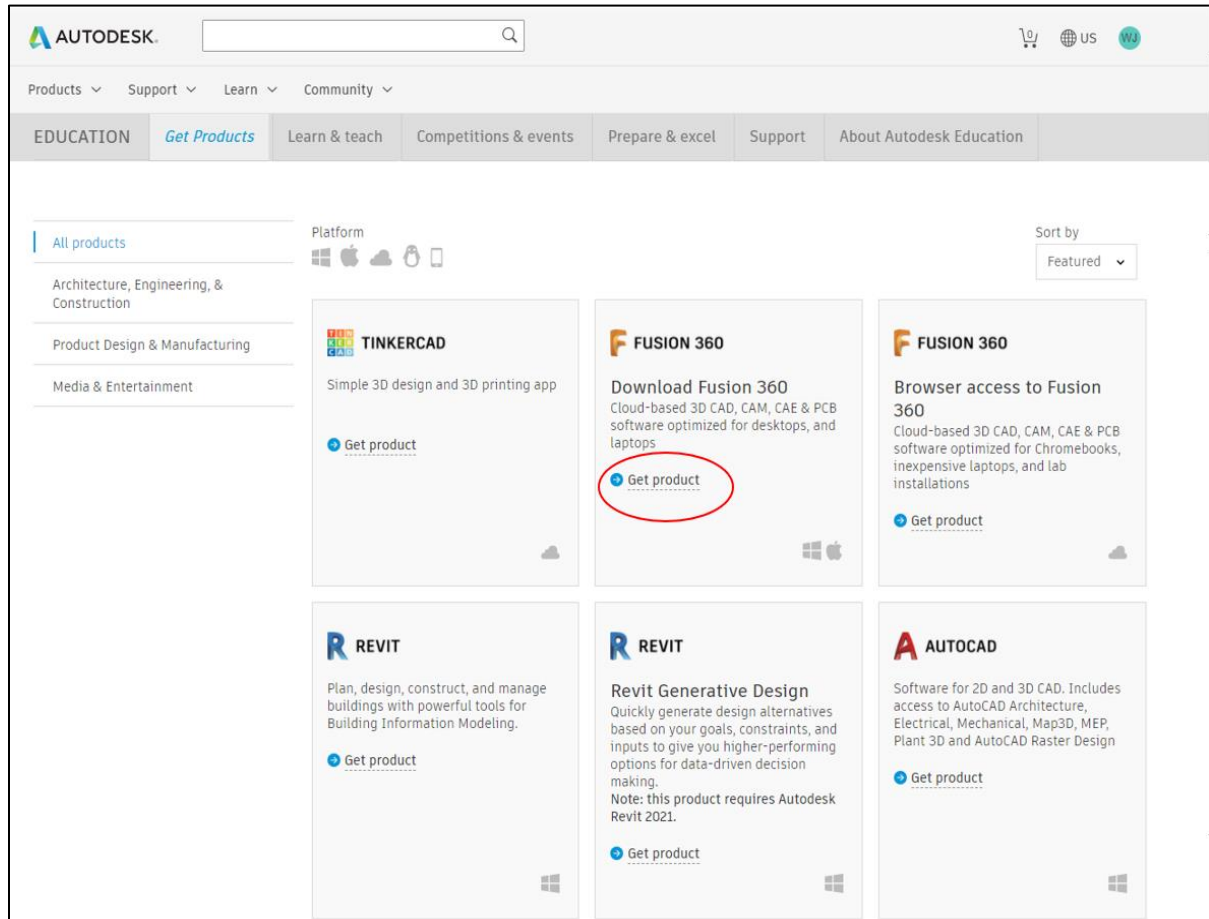


Figure 3. Fusion 360 download page.

5. GETTING STARTED

In Fusion 360, users can join teams. In their teams, users can create projects, share design progress, simulation results and comment on each other's work. In this exercise, students are assigned to a team based on their lab session. They then have access to the team's project data.

- i. Switch to the name of the team based on your lab session by clicking on your name on the top left-hand corner. Contact the Lab technicians if you do not see the name of your team.

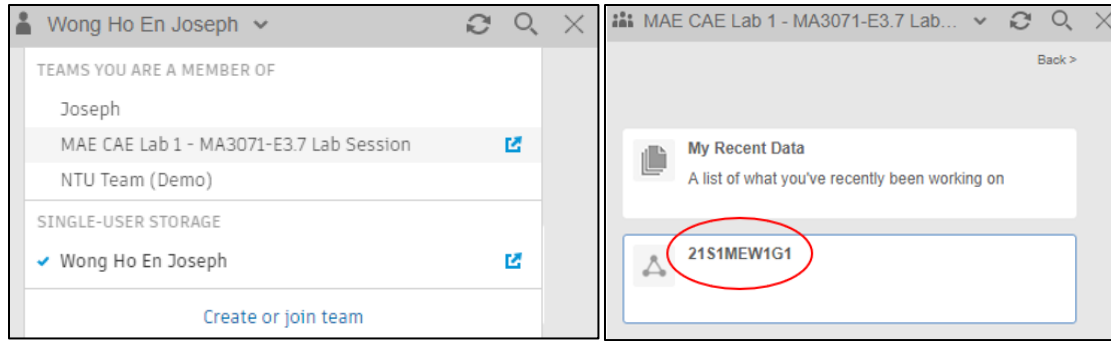


Figure 4. Teams and project panel.

- ii. Each student will have been added to a “project” based on their lab groups. Click on the name of “project” (e.g. “21S1MEW1G1”) and save the file as “Name_Deck”. (e.g. “JohnTan_Deck”).

6. BASIC FUNCTIONS



Figure 5. Fusion 360 Taskbar.

Fusion 360 provides a variety of workspaces located at the top left-hand bar, shown in Figure 5. Users can toggle between different workspaces such as design, render, simulation and drawings. Functions on the taskbar are arranged according to the sequence of use from left to right.

Canvas Selection		Modeling Commands	
Ctrl + C Command + C	Copy	R	2-point Rectangle
Ctrl + X Command + X	Cut	A	Appearance
Hold Shift + Hold Middle Mouse Button	Orbit	C	Center Diameter Circle
Hold Shift + Click then Hold Middle Mouse Button	Orbit around point	E	Extrude
Hold Middle Mouse Button	Pan	F	Fillet
Ctrl + V Command + V	Paste	H	Hole
Ctrl + Y Command + Y	Redo	J	Joint
Ctrl + Z Command + Z	Undo	L	Line
Roll Middle Mouse Button	Zoom	I	Measure
		M	Move
		D	Sketch Dimension

Figure 6. Common Fusion 360 shortcuts & commands.

Figure 6 shows the basic shortcuts and standard commands in Fusion 360. A full list can be found at <https://www.autodesk.com.sg/shortcuts/fusion-360>. Students are advised to familiarise themselves with the basic commands before coming for this exercise.

Task 1: Modeling of E-scooter Deck

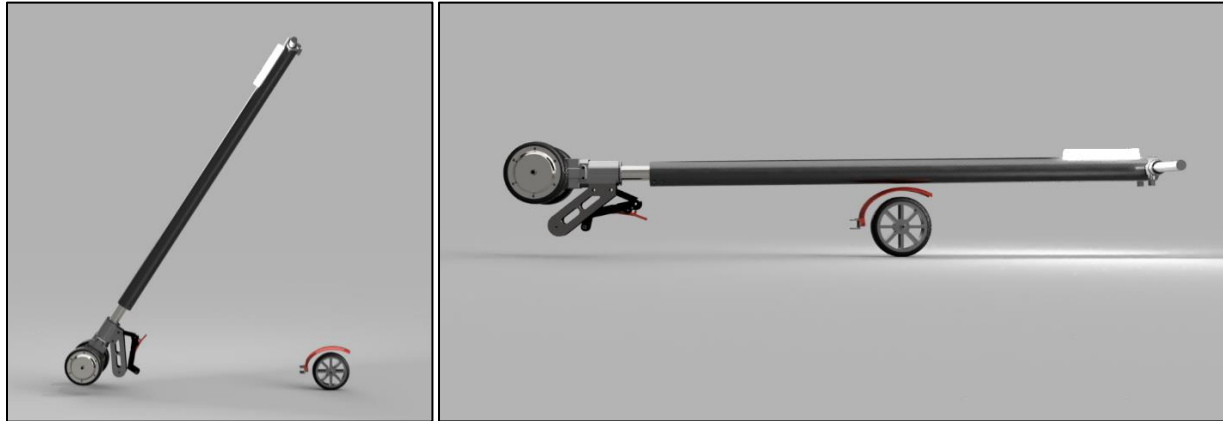


Figure 7. Foldable E-scooter Main Assembly.

In this exercise, students are required to complete the foldable E-scooter as shown in Figure 7 by creating the missing deck and performing static stress analysis before inserting the deck into the main assembly. The main assembly of the E-scooter can be found in the student's lab group folder titled "E-scooter Main Assembly".

1. Sketching of the deck:

Click on the Sketch icon on the left of the Taskbar, create the sketch of the deck board (Figure 8) using lines, splines, and other shapes, using the dimensions shown (values in millimeters). Figure 9 shows a close-up view of the positions of the mudguard holes with the required dimensions.

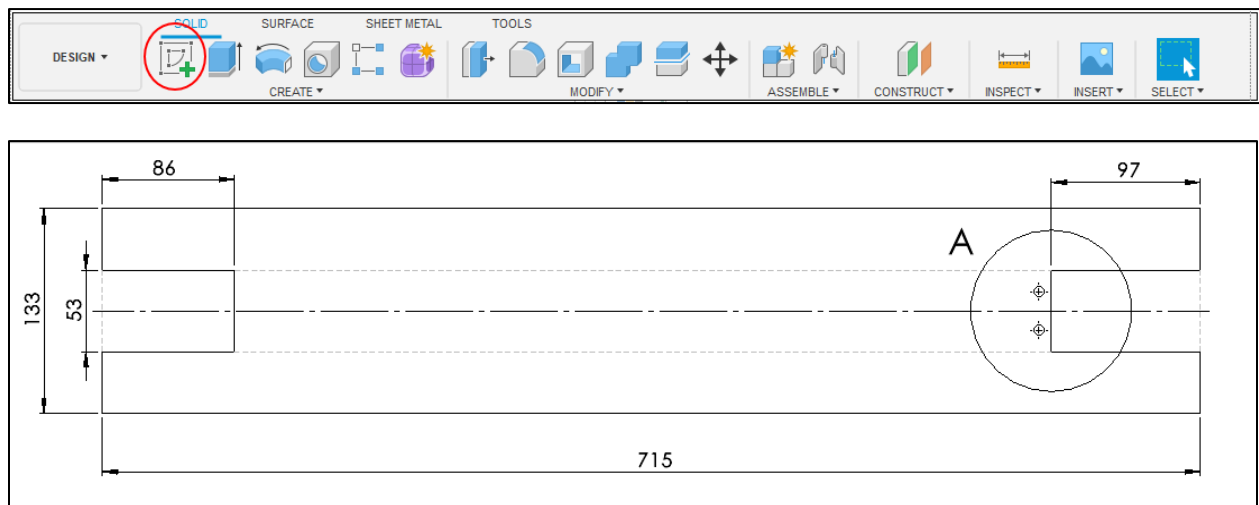


Figure 8. Taskbar (Top) & Top view of the deck board (Bottom).

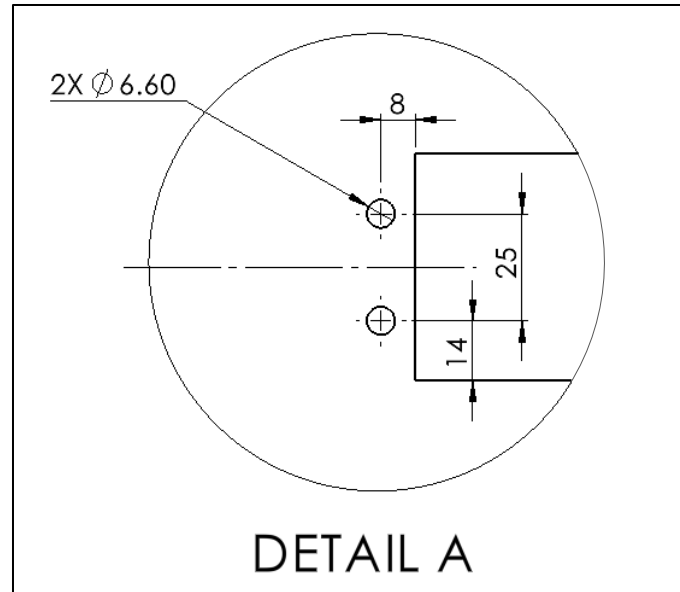


Figure 9. Detailed view of mudguard holes.

2. Extrusion:

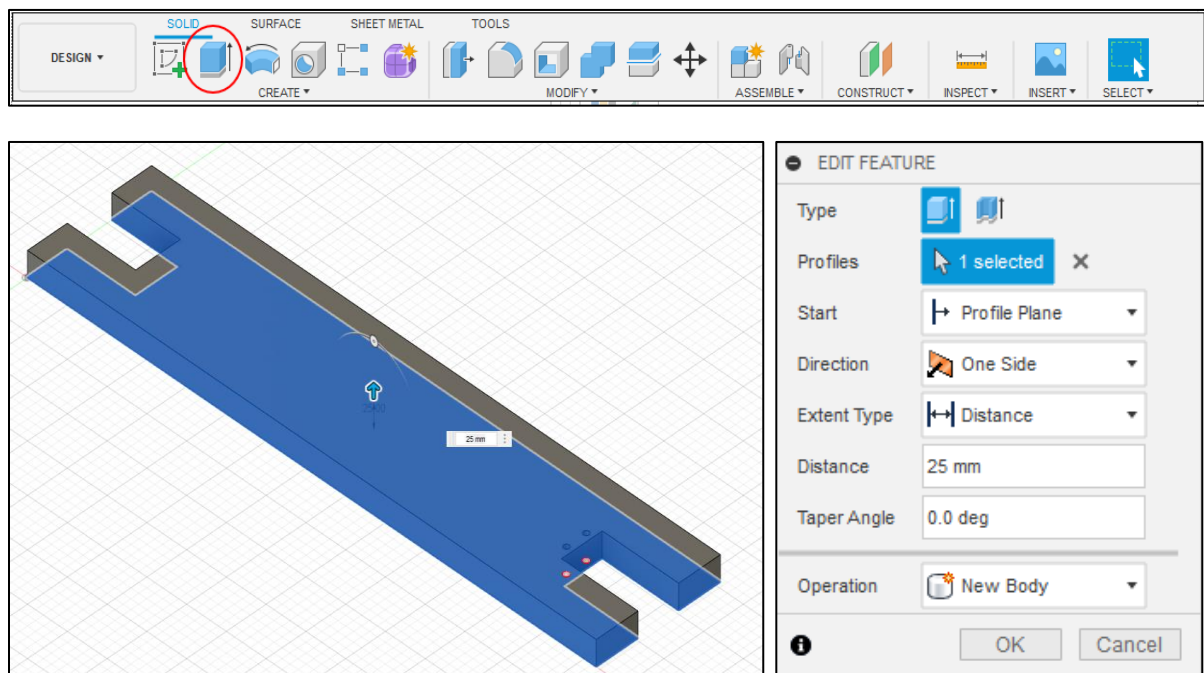


Figure 10. Taskbar (Top) & Extrusion of the deck.

Select the completed sketch (but exclude the two circles) and then use the Extrude function to extrude by 25 mm. Ensure 'Operation' is set to type 'New Body'. The result is shown in Figure 10.

3. Creating holes for shafts

On the plane perpendicular to the deck board, sketch 3 holes using the parameters (Figure 11).

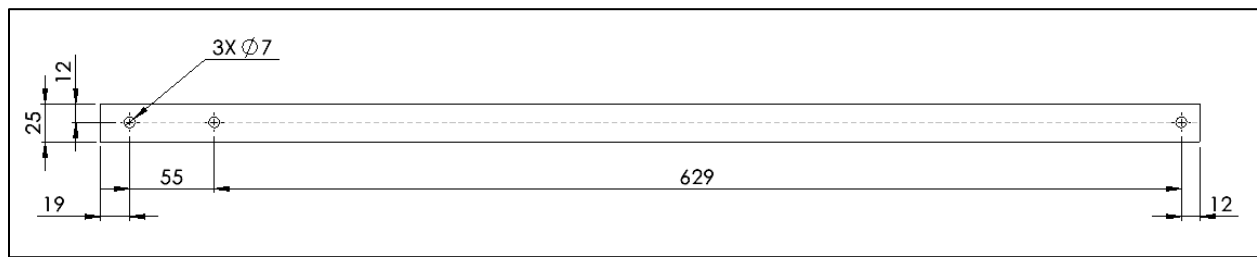


Figure 11. Front view of the deck.

Next, using the Extrude function as in step 2, select the faces of the three circles and cut through the entire board. Ensure 'Operation' is set to type 'Cut' (Figure 12).

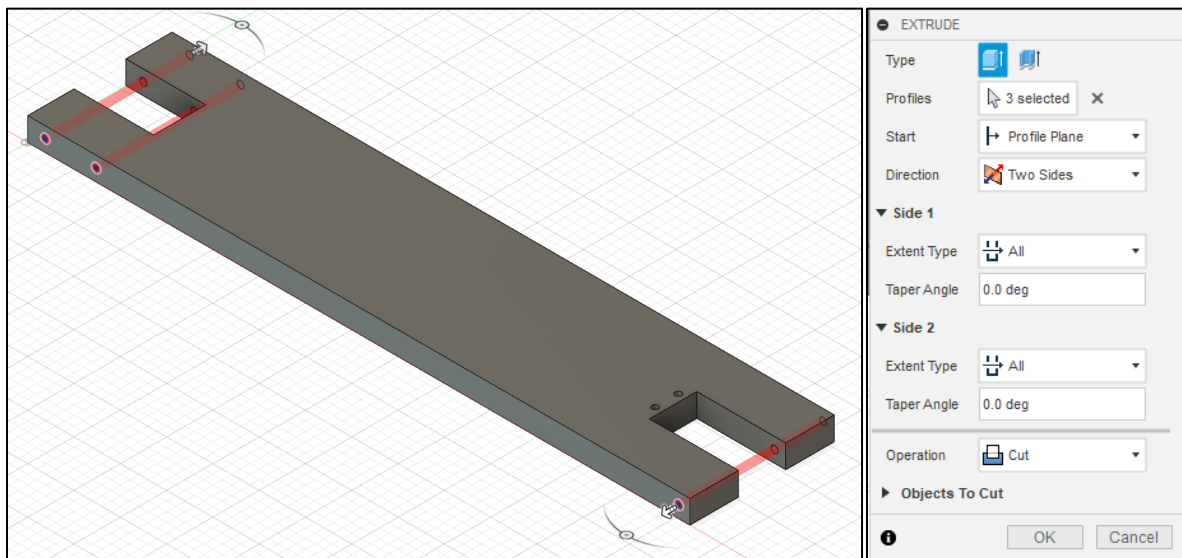


Figure 12. Cut Extrusion of shaft holes.

4. Changing material of the deck

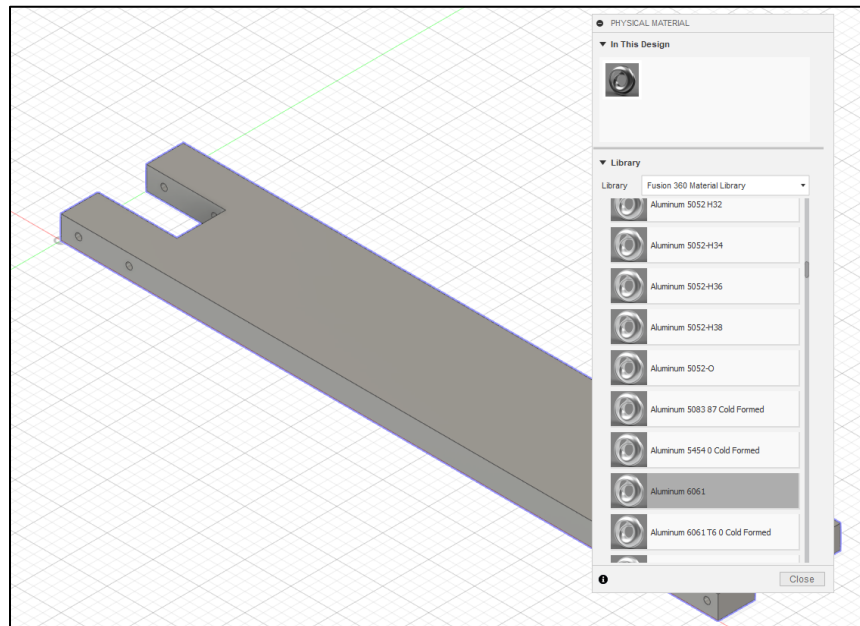


Figure 13. Specify the material of the deck.

You need to specify the material for the deck. E-scooter decks are often constructed with aluminium alloys. For this exercise, use Aluminium 6061. To change the material of an object, right-click on the body and select “physical material”. In the Fusion 360 Material library, under the “Metals” folder, click and drag “Aluminium 6061” onto the deck (Figure 13).

5. Optimization

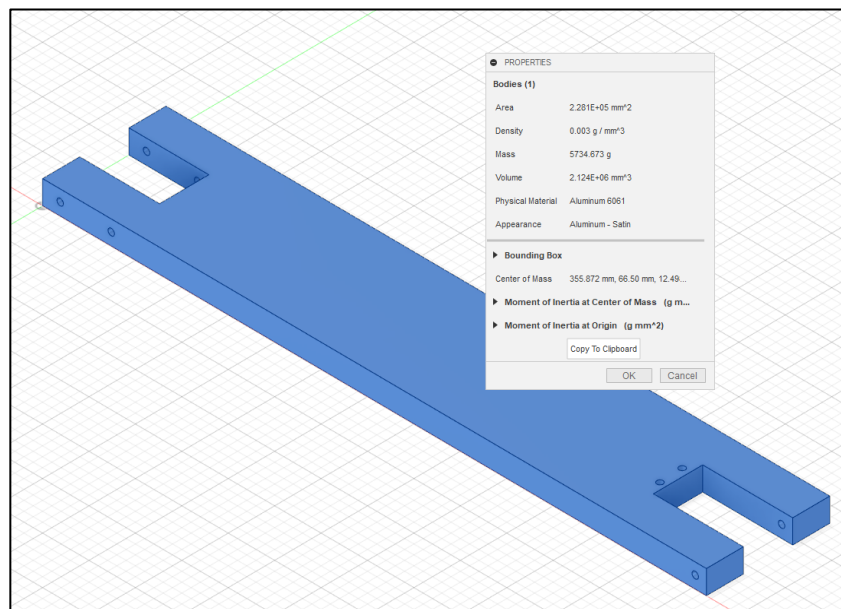


Figure 14. Checking the volume of the deck.

This model of the deck is too bulky and heavy. Its current volume is $2.124 \times 10^6 \text{ mm}^3$ (Figure 14). Students are required to modify the design to reduce the **volume to less than $1 \times 10^6 \text{ mm}^3$** . This may be done using different methods, a few of which are shown below. Students are encouraged to explore the various methods to create their own design but should spend no more than 30 minutes on this task.

To check the deck's volume, right-click on the body and select "Properties".

Possible Optimization Methods:

a. Shell

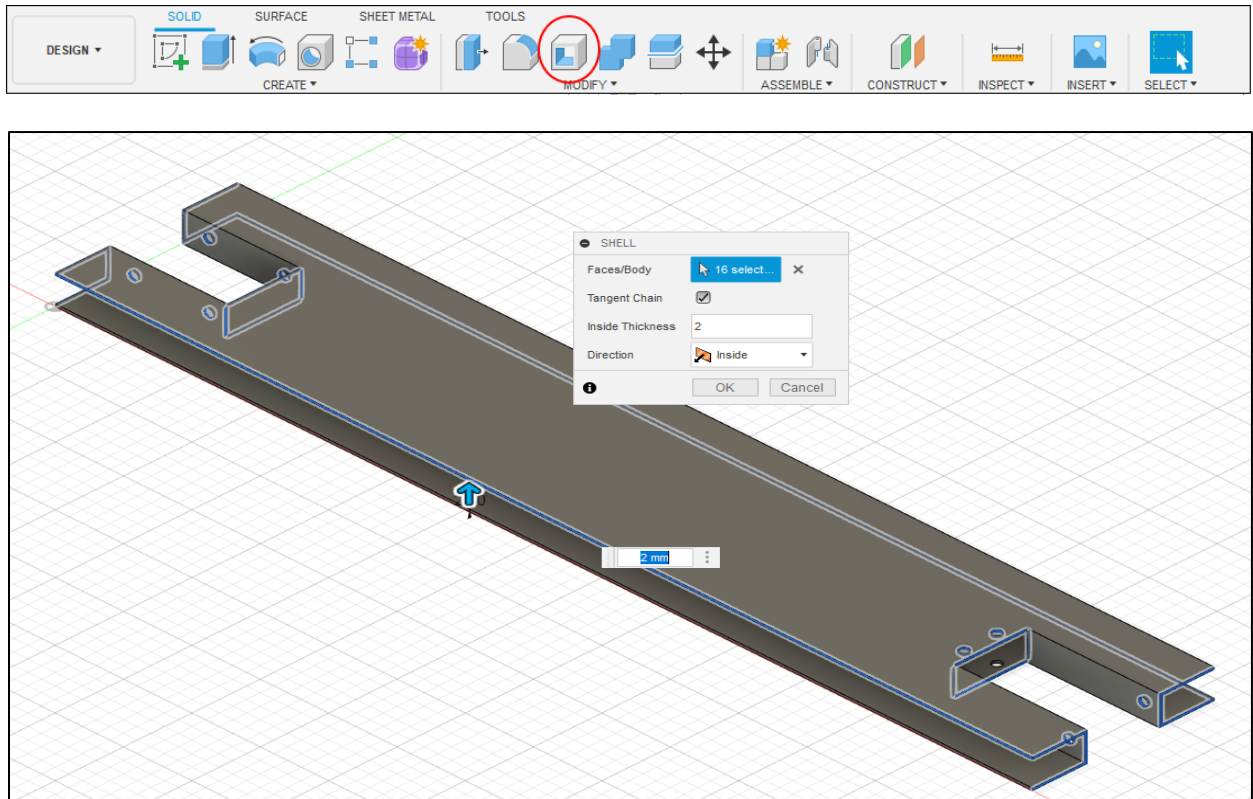


Figure 15. Taskbar (Top) & Shell material from the deck (Bottom).

The shell function can be used to hollow a solid model. This can significantly reduce the weight of the deck board. To hollow a body, select the shell function and click on the entire body. Faces can also be selected to be removed. Figure 15 shows a possible outcome.

b. Sketch and Cut extrude

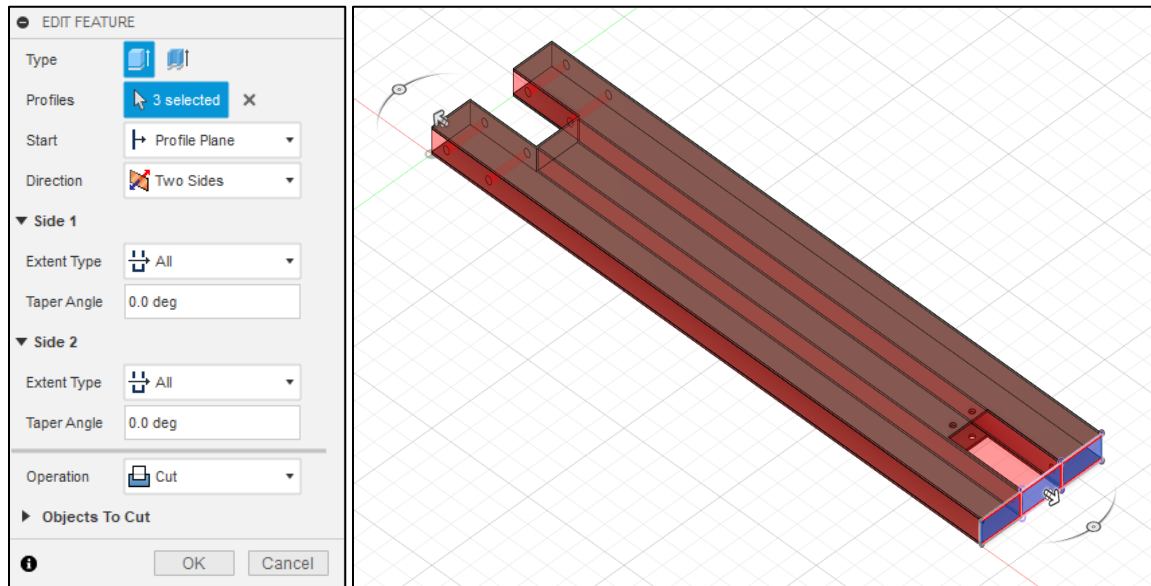


Figure 16. Cut Extrusion to hollow the deck.

Similarly, material volume can be removed by sketching the desired shape of the cut at a plane. The profile of the sketch can be extruded to cut material away from the board, as shown in Figure 16.

c. Chamfer

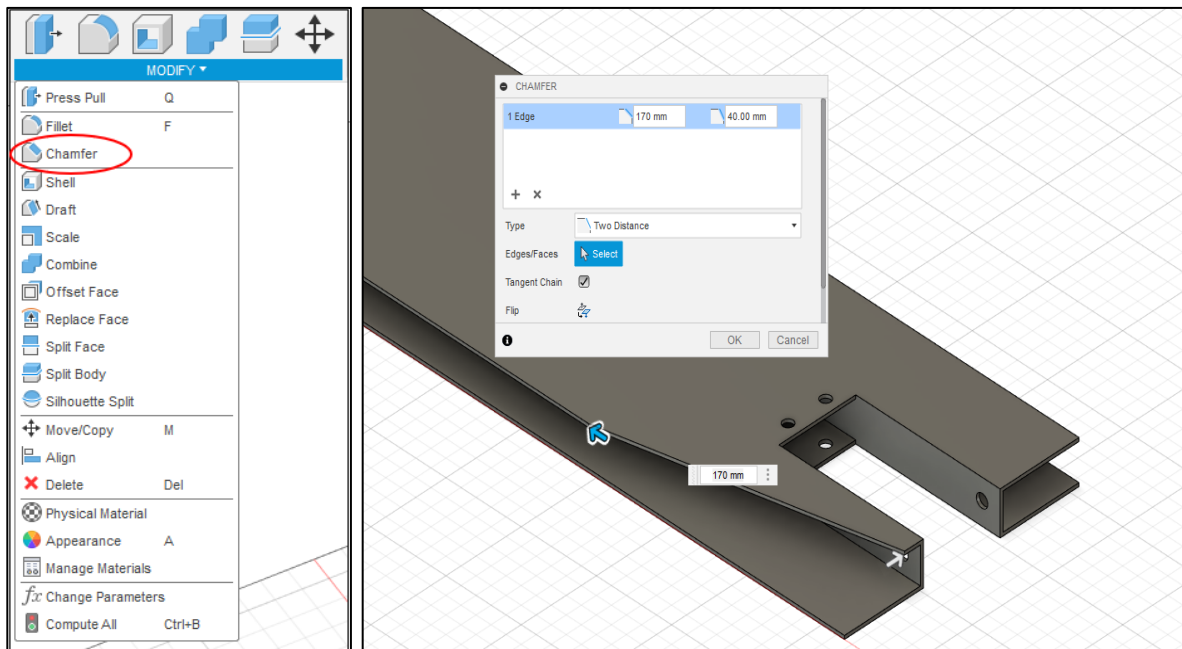


Figure 17. Chamfering edges of the deck.

A chamfer can be used to further remove material from the edges (Figure 17). Select the desired edges of the board and enter corresponding values for the distance of chamfer from each side of the edge.

d. Fillet

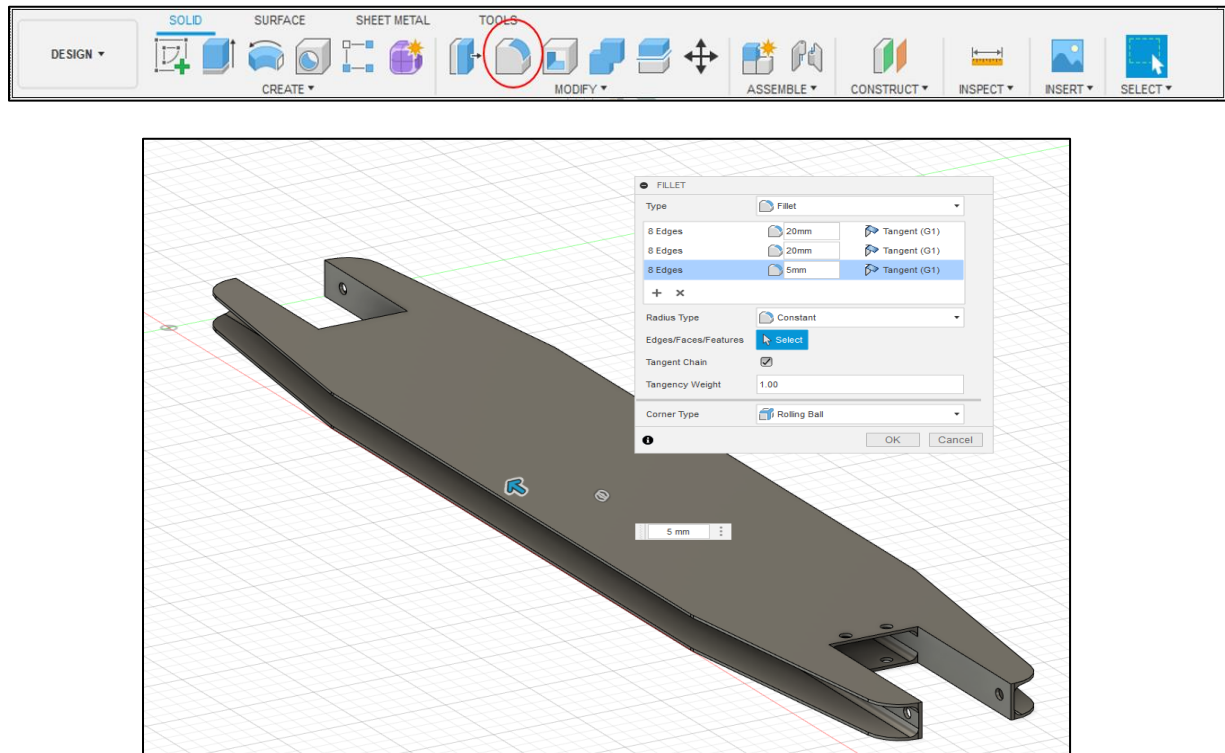


Figure 18. Taskbar (Top) & Fillet of round corners of the deck (Bottom).

The fillet function can be used to round off sharp corners. Select the desired edges to fillet and enter the radius of the fillet. See Figure 18.

e. Extrusion – adding additional ribs and support

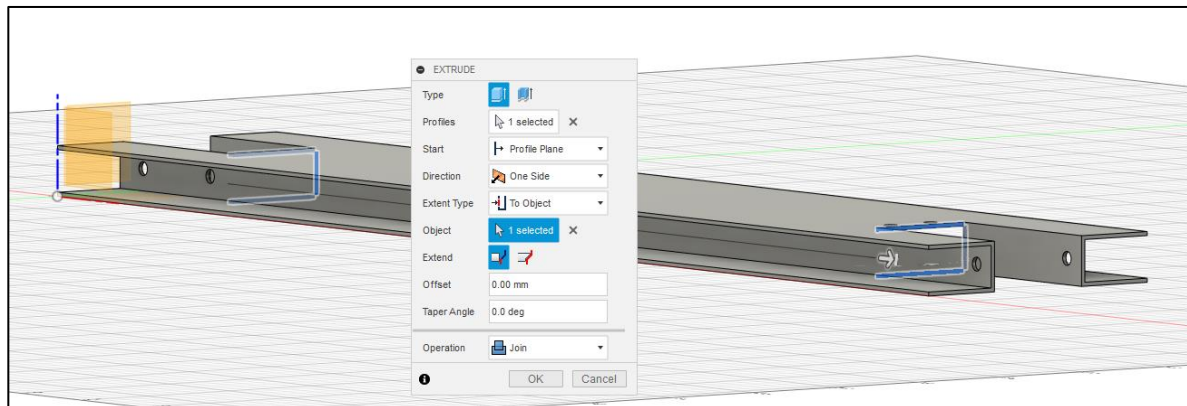


Figure 19. Extrusion of ribs in the deck.

Extrusion can be used to add ribs or supports to improve the deck's ability to withstand heavier loads. A face or sketch can be selected and extruded, as Figure 19 illustrates.

Task 2: Simulation

Once the design of the board is completed, you are to analyse its ability to withstand the load of a person of roughly 80 kg. This is to be done using finite element analysis available under the “Simulation” module. There are four preparatory steps: (1) define the geometry, which is the board that you have designed, (2) apply the constraints, which define how the board is jointed to its supporting structure and constrained, (3) apply the load which is assumed to be a distributed load, based on the default load settings in Fusion 360 and (4) generate the finite element mesh for the board. Once these are set, apply the simulation, upon which you can visualise graphically the results in terms of the deflection of the board and the stress distribution.

Procedure:

1. Under the Workspace tab at the top left-hand corner, select “Simulation”. Next, select Static stress and click create study. We will now analyze how the board will respond under a distributed load of 800N (roughly a person weighing 80 kg).
2. Under Study materials, select Aluminium 6061.
3. To set structural constraints, select the cylindrical areas of the front and back shaft holes. Under the type of constraint, select “pin” (Figure 20).

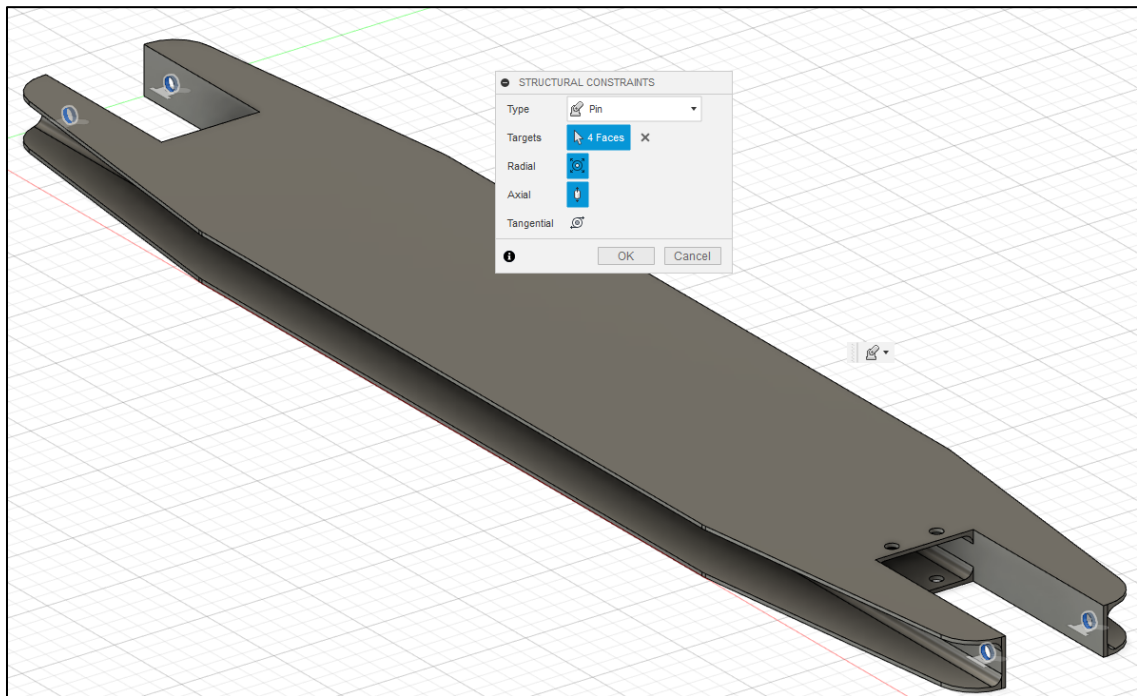


Figure 20. Setting Pin constraints at 4 corner shaft holes (in blue).

4. To set the load on the structure, select the top surface of the board and set the magnitude to 800N. In this exercise, the load set will be the default distributed load in Fusion 360. See Figure 21.

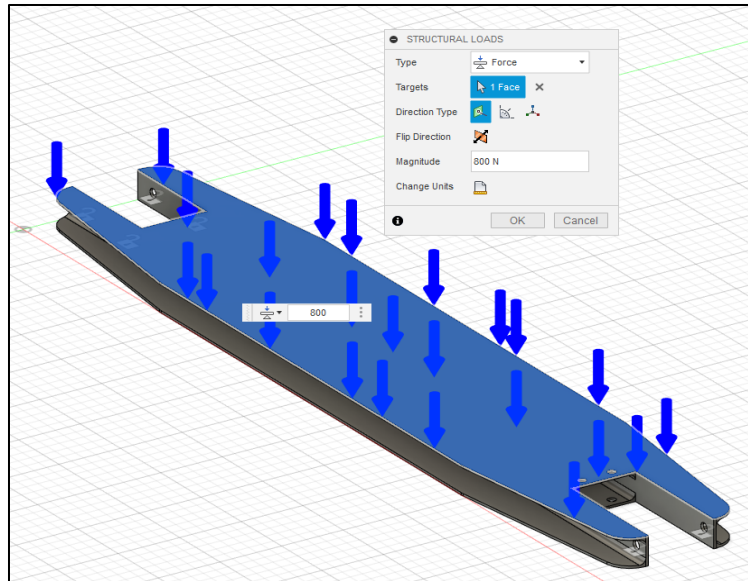


Figure 21. Applying a distributed load of 800N.

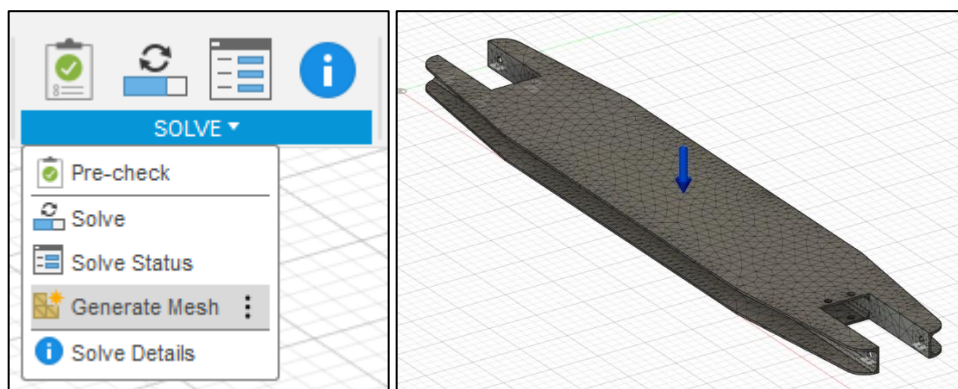


Figure 22. Generating Mesh of the deck.

5. Next under the solve section in the taskbar, select “Generate Mesh” (Figure 22).
6. Click on Solve and wait for the simulation results.
7. Save the deck file in the group Folder as “Name_Deck”. (e.g. “JohnTan_Deck”)

Task 3: Result Analysis and collaboration

The results can be visualized as a colour plot of the geometry for the stress distribution and the deflection (Figure 23). You should analyse these results and determine if the board can withstand the given load.

You should then consider these results together with the factors of total weight and aesthetic of the deck to make your choice of the best board from the different designs of your team.

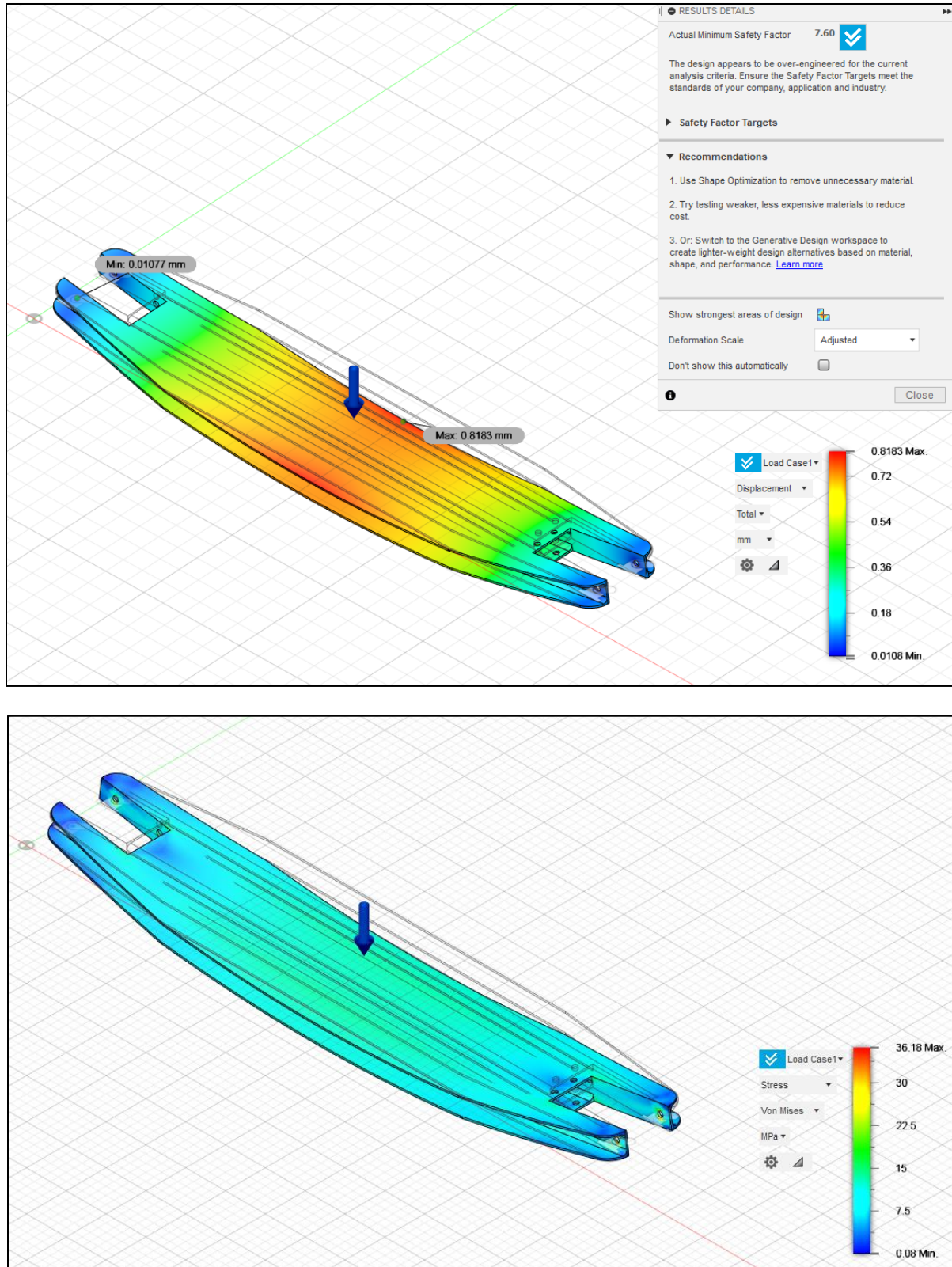


Figure 23. Displacement (Top) & Stress (Bottom) simulation results.

Procedures:

1. Fusion 360 allows users from the same group to view each other's designs and simulation results. Open each member's design and comment on one advantage and one disadvantage of their board design. Add your name after your comment. (Comments can be added in the bottom left corner)
2. Discuss and then choose one design from within your group for the final E-scooter main assembly. These factors should be taken into consideration: **Maximum displacement** under a distributed load of 800N, **volume of the deck, design, and aesthetic of the deck**.
3. As a group, provide a short write-up on the reasons for the choice. Leave the write-up in the comment section of the selected deck.
4. Save the selected deck file in the group folder as "*FINAL_Name_Deck*" (e.g. "FINAL_JohnTan_Deck").

Task 4: Assembly into the main E-scooter

Here you are to assemble the board to the other parts of the scooter that have been provided.

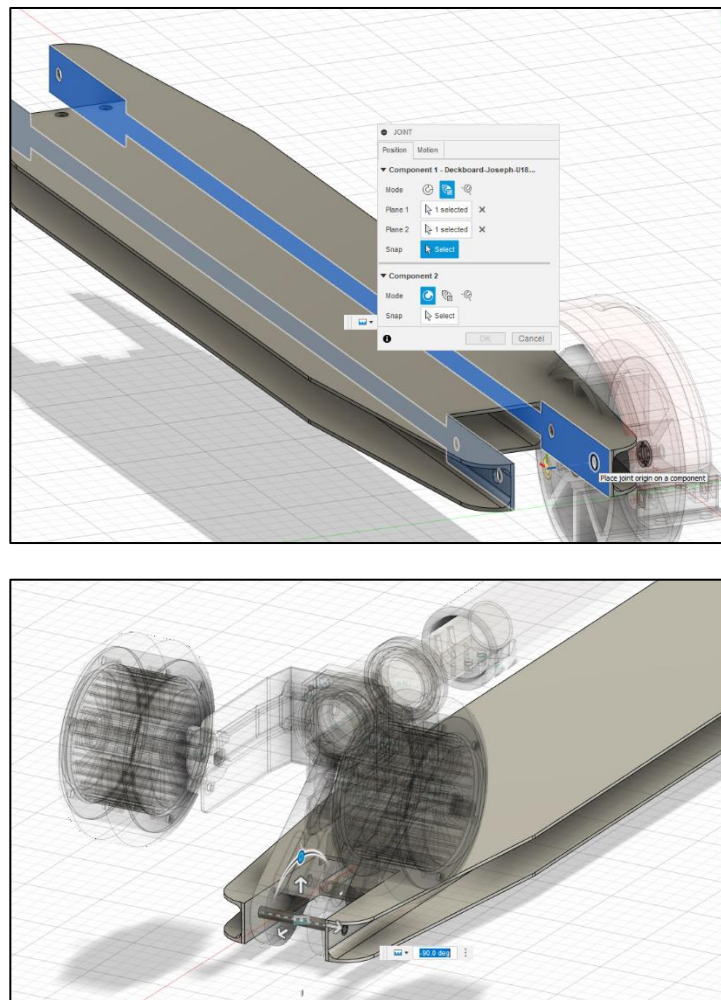


Figure 24. Jointing the center axis of shaft hole (Top) to shaft (Bottom).

Procedures:

1. Open the “E-Scooter Main Assembly” file in the group folder.
2. Next, on the left panel, right-click on your board design and select “Insert into current design”.
3. Once inserted, under “Assembly”, select “Joint”. Set mode to “Between two faces” and select the central axis of the front shaft holes as “Component 1”. Next, select the center axis of the front shaft of the deck as “Component 2”. Set motion to “Rigid”. (See Figure 24)
4. Use the join function again to assemble the rear mudguard. Select the face of one of the holes on the mudguard as “Component 1” and the corresponding hole of the deck as “Component 2”. Set motion to “Rigid”. (Figure 25)

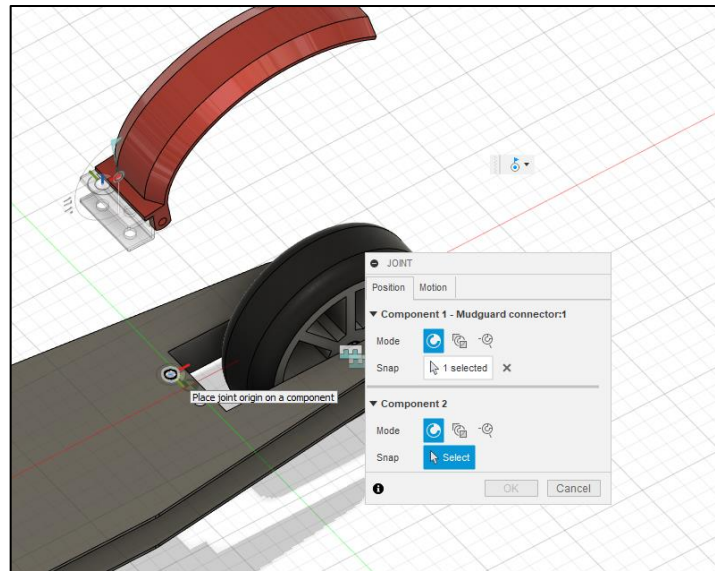


Figure 25. Jointing mudguard to the deck.

5. Use the join function again to assemble the rear wheel. Set mode to “Between two faces” and select the central axis of the shaft of the rear wheel as “Component 1”. Next, select the center axis of the back shaft of the deck as “Component 2”. Set motion to “Rigid”. (Figure 26)

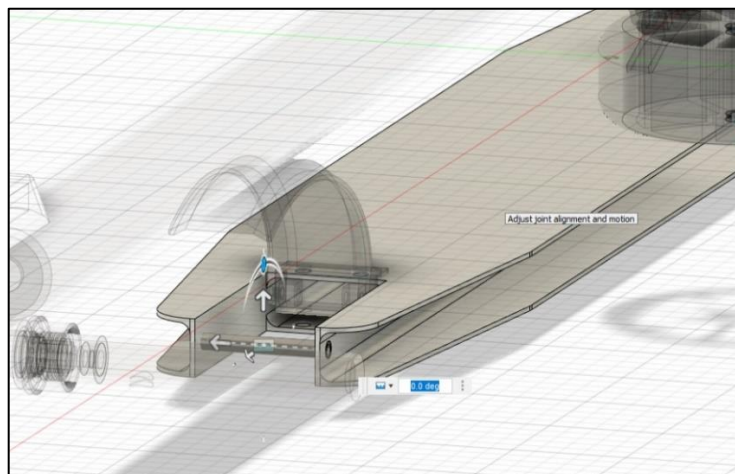


Figure 26. Jointing the center axis of the shaft to the shaft of the wheel.

6. Repeat step 3 to assemble the center shaft holes of the deck to the hinge bracket of the E-scooter. Select the center axis of the shaft as “Component 1” and the center axis of the shaft holes on the deck as “Component 2”. Set motion to “Rigid”.
7. Under “Assemble” click on “New Contact Set”. Select the Folding DA component and the deck.

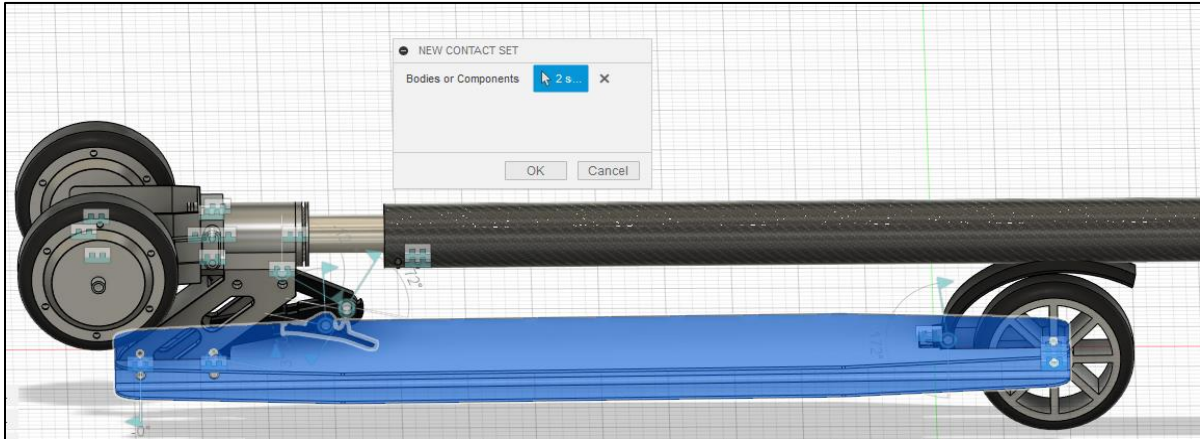


Figure 27. Adding contact points to components.

8. Right-click on the body of the deck and click “Ground”. The assembly of the scooter is now complete. Click and drag on the handle to animate the folding motion of the E-scooter. Save the file as “*GroupName_E-scooter_Main*”.

Task 5: Submission

At the end of the session, ensure that the group folder has the following files for submission:

1. **Every student** to submit their deck model saved as “*Name_Matriculation_Deck*” in their group folder. The selected model for the assembly to be saved as “*FINAL_Name_Matriculation_Deck*” instead.
2. **Every student** to comment on one advantage and one disadvantage of each group member’s deck. Leave your name on your comment.
3. A short write-up on the reason(s) for the selected deck **per group**. The comment should be made in the file of the selected deck.
4. One final E-scooter Assembly with the selected deck **per group**. File to be saved as “*GroupName_E-scooter_Main*”.
5. **Every student** to comment on your own board and on what you have learned in this exercise and suggest improvements to this exercise that you like to see. Leave your name in the comment.