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SCHOOL OF ENGINEERING

MNFG604

A Reverse Engineering Project

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Summary

The Report coves step by step analysis on how a mini quadcopter is dismantled and remade on a CAD software in this case Creo Parametric 8.0. The designed CAD models are made with the objective of replicating the original design of the outer body and other internal components along with their original measurements.

The analysis covers various aspects of the reverse engineering process. The report includes the ways the measurements were taken to replicate the original measurements. It describes the techniques used to replicate the original design and styling which is hard in objects such as this. There are few problems that are highlighted that one might face while reverse engineering the part and some suggestions are presented describing what could be the problem and few ways to overcome them, further details on how to assemble all components together virtually.

This virtual representation of reverse engineered parts can help understanding the product better and redesign them.

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Introduction

In recent years CAD software's have widen the horizon of possibilities for designers and creators to develop a variety of new designs that are hard to express on paper or machine. The current Generation of CAD Software's provide a great variety of advantages in form of part analysis to check its behaviour under different parameters. CAD along with AI and machine learning can produce features like topology optimization which can help develop designs that can be more effective in terms of material saving, strength etc.

Not just design a lot of machining processes for advanced manufacturing largely depend on the CAD technology. CAM (Computer Aided Manufacturing) is advanced manufacturing process that not only manufactures products or parts a lot of manufacturing industries depend on it for production of industrial parts like moulds, gears, nozzles etc. CAM includes processes like CNCs and 3D printing that cannot be used without having a virtual form of the product to decide the machining or printing paths.

This makes CAD a valuable tool even for Reverse Engineering all the parts can be made and tested for fits, tolerances and other factors virtually. In the current assignment the objective of the assignment was to reverse engineer any product with electronics in It on a CAD a software- CREO Paranematic 8.0 . The product selected was a mini quadcopter which was first taken apart by removing the 8 external screws 4 at he end of the wing and 4 at the centre area of the drone. Then propellers are removed from the motor shaft that are joined due to tolerance. After removing the propellers, the Guards can be pulled out and finally the top part of the drone is free to remove which give us access to the four motors on the bottom case and the circuit board is fixed to the Upper case by two screws.

This gives us all the parts in the drone that need to be made on CAD using their actual dimensions of the parts. The ways to measure the dimensions varies from part to part. Since the size of product is small most dimensions can be measured with easy using a Vernier calliper. But in scenarios certain lines or structures could be hard to dimension. In such scenarios Parts like propeller guard, and circuit board were made by using their images. Which was aligned on a plane with the maximum length and width, then using them a projection are made to get the shape and measurements of required parts. Using this various parts are made for the project some of which are just for the sake of reference to understand their position during and after assembly process.

Reverse Engineering

It is essentially a process where any product or object is opened and researched to determine all the parameters and constituents that was needed to make it.

The object that can be reverse engineered can be of any nature let it be electronical, mechanical, chemical or biological. For the current project the product being reverse engineered is a Mini Quadcopter which consists of electronics and motor that allows it fly when proper signal is provided.

The quadcopter in question consist of very few parts but the main challenge is designing its outer body that is very stylish in nature making it hard to design the body.

To start of the project the first part to be designed was the propeller guard.

Propeller Guard-

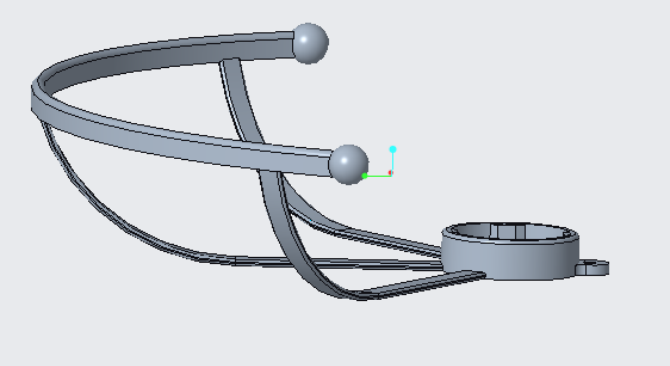


fig1

Function of propeller guard is to protect the propellers from damage in case of crash.

The part has a less steps but it takes time to get It right.

Construction-

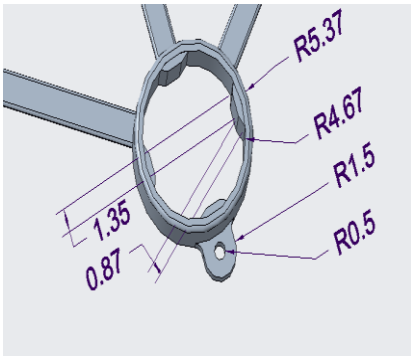


fig 1.1

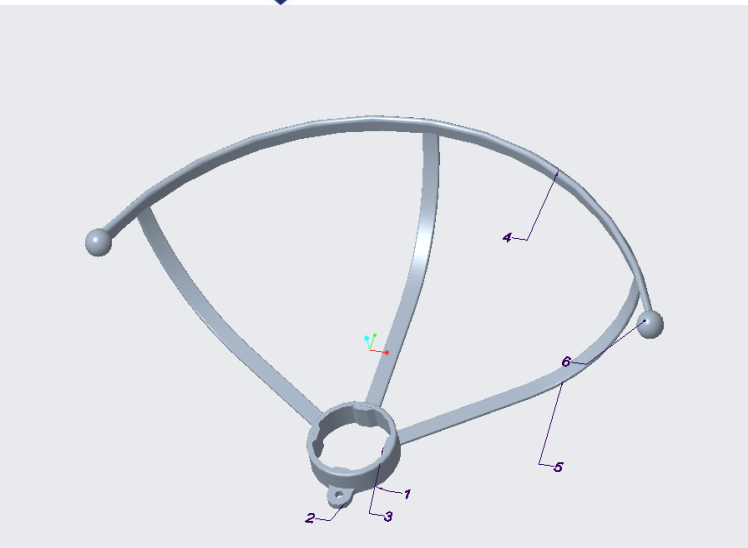


fig 1,2

- Select a plane and extrude the object shown in fig1.3 taking dimensions from fig1.1. The extrusion needs to be done in a series so portion **1** is extruded to a height of **3.1 mm**, portion **2** extruded to a height of **0.8mm** and portion **3** to a height of **3mm** (***None of the extrusions are symmetric***).

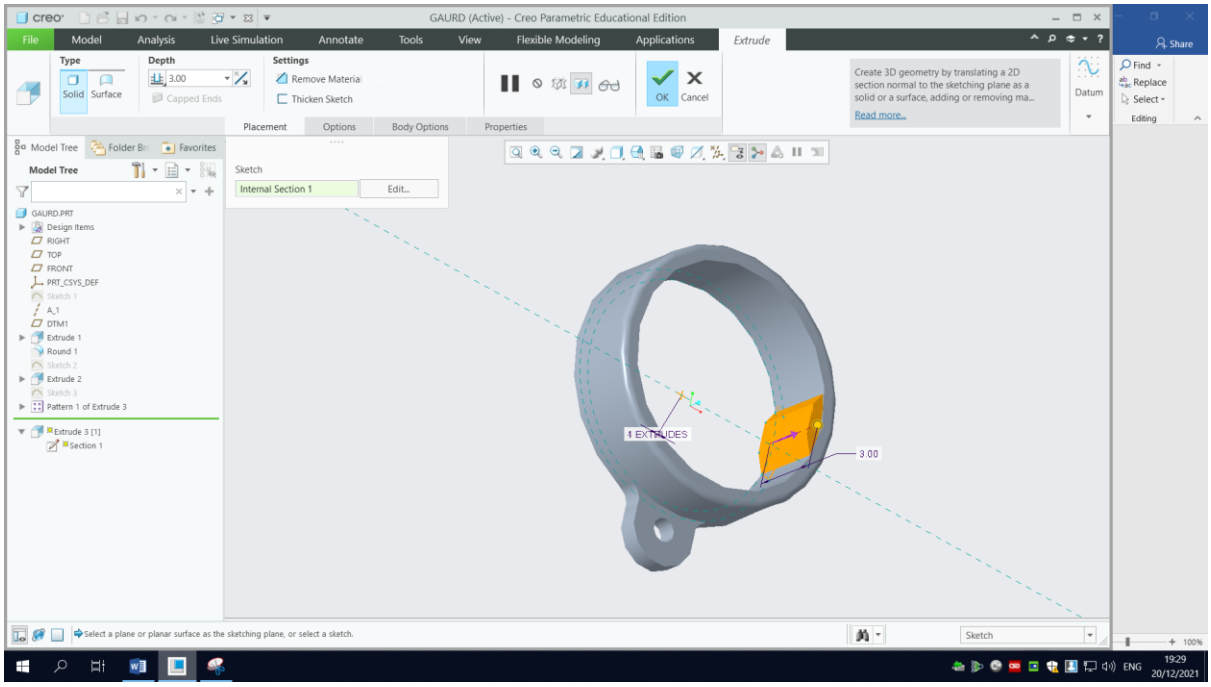


fig1.3

- Now use the 

on portion **3** using Axis pattern with **1st direction members** being **4** and **angle**- **90** as shown in fig 1.4

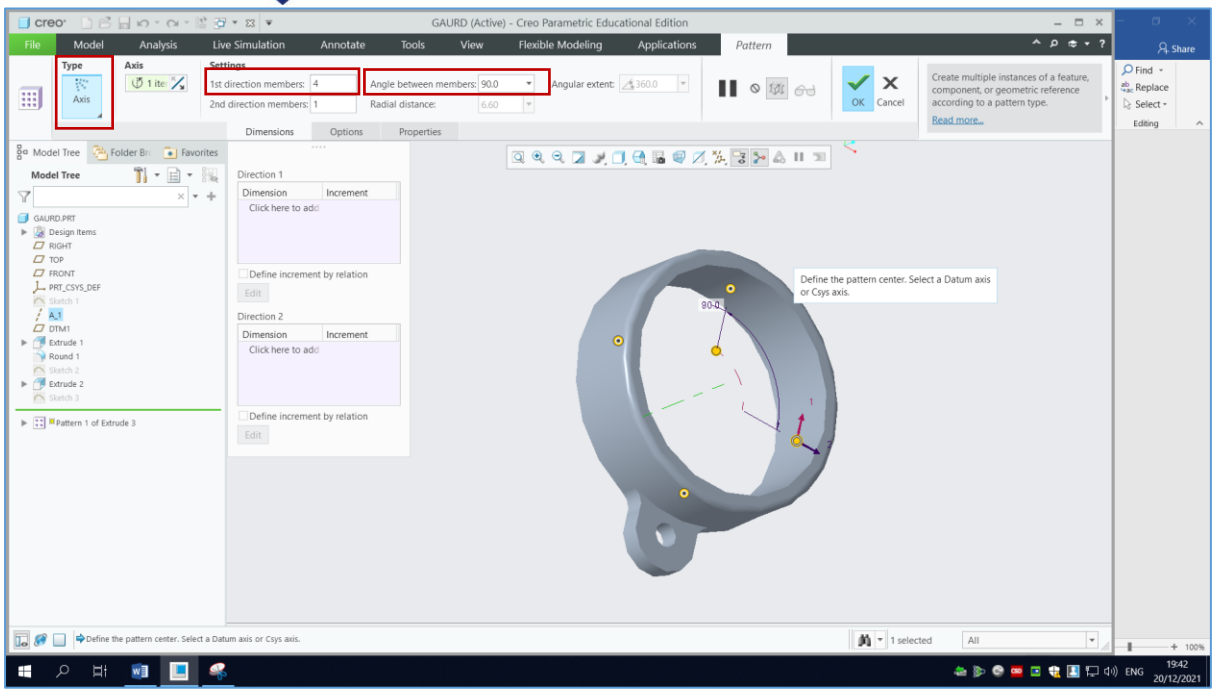


fig1.4

- Make a plane using front datum plane as reference and offset it to 13.7mm as shown in the fig 1.5.

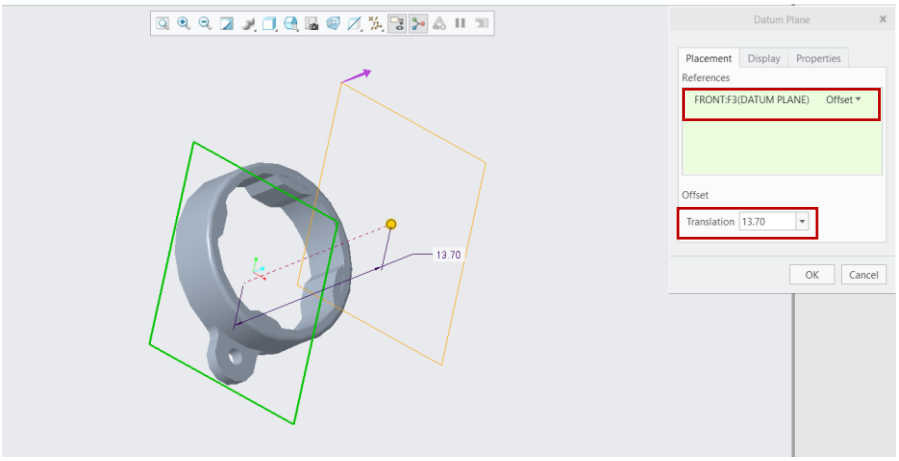


fig1.5

- Now select the projected plane as sketch surface. Sketch the extrude pattern referring the dimensions in fig 1.6 and extrude it to a height of **2mm** towards the front datum plane to make portion **4**.
- Taking one of the ends of portion 4 and sketch as shown in fig1.7 and revolve it using Revolve to make portion **6** and then mirror it using Mirror function.
- Draw the sweep section as shown in fig 1.9.
- Use Sweep the function to produce the portion **5** using the sketch from fig1.10.

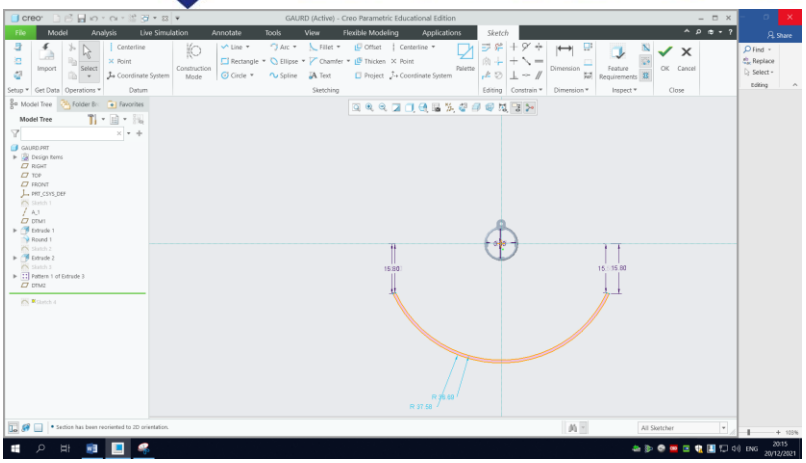


fig1.6

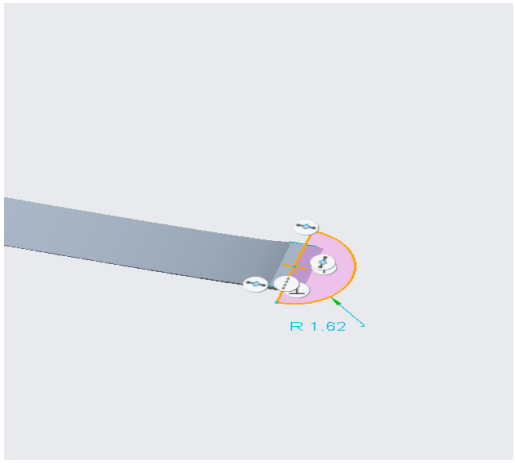


Fig1.7

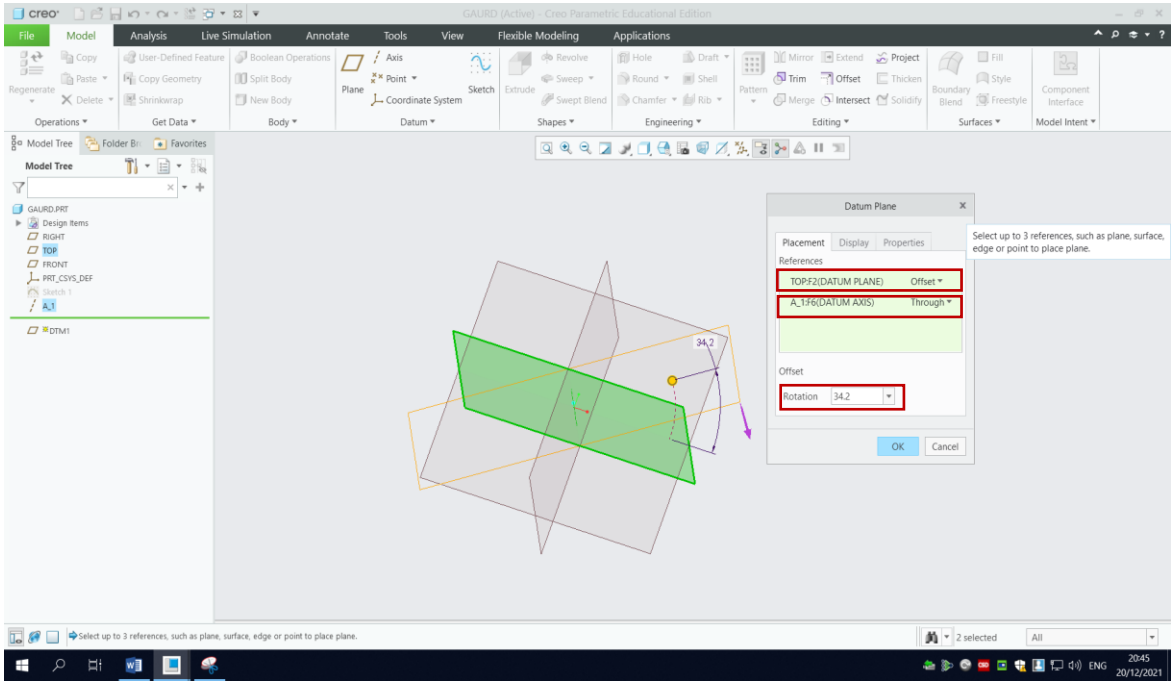


fig1.8

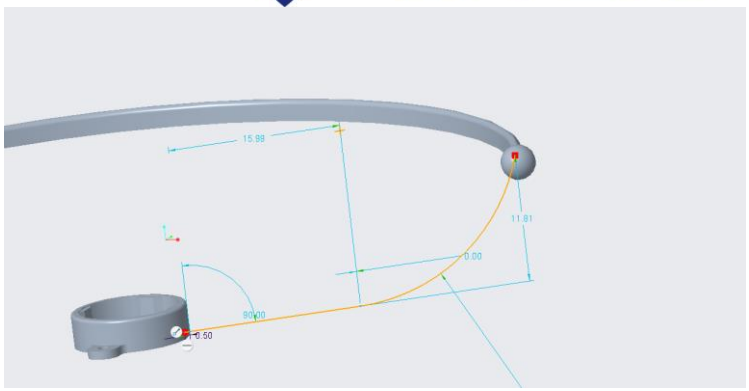


fig1.9

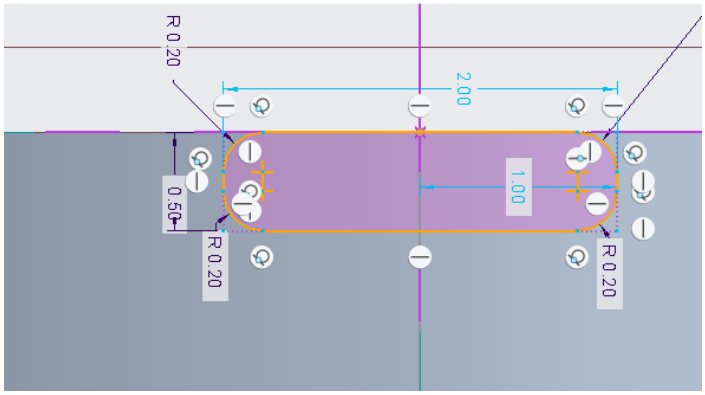


fig1.10

- Using the pattern function 

make **3** members at an angle of **56** as shown in fig1.11.

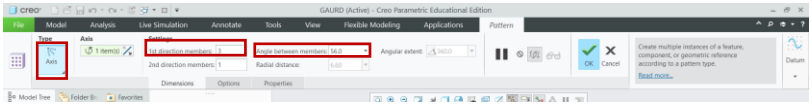


fig1.11

Propeller-

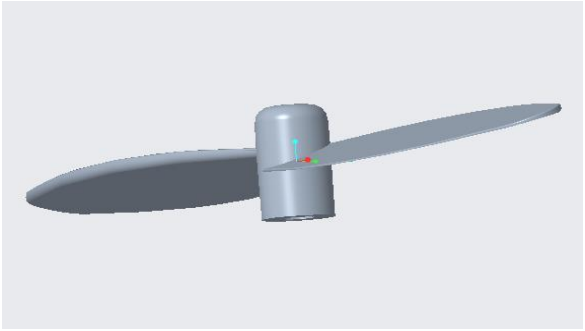


fig2

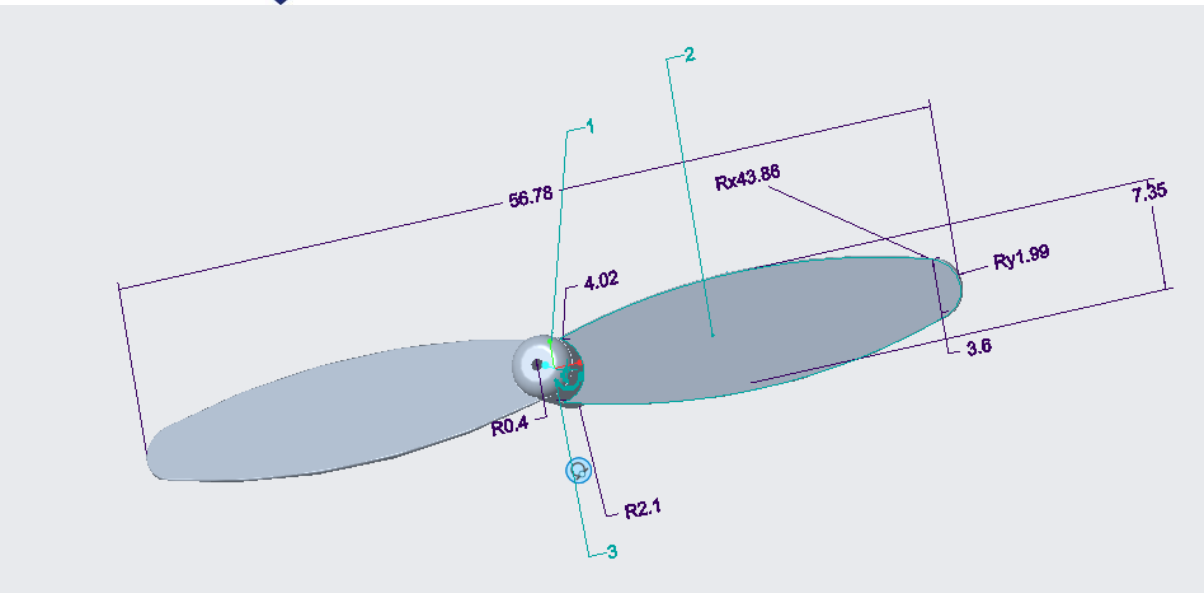


fig2.1

- Start with extruding a cylinder of height of **7mm** for portion **1** use the dimensions from fig2.1 and then round by **1mm**.
- Make an angular plane at angle of **20** as shown in fig2.2.

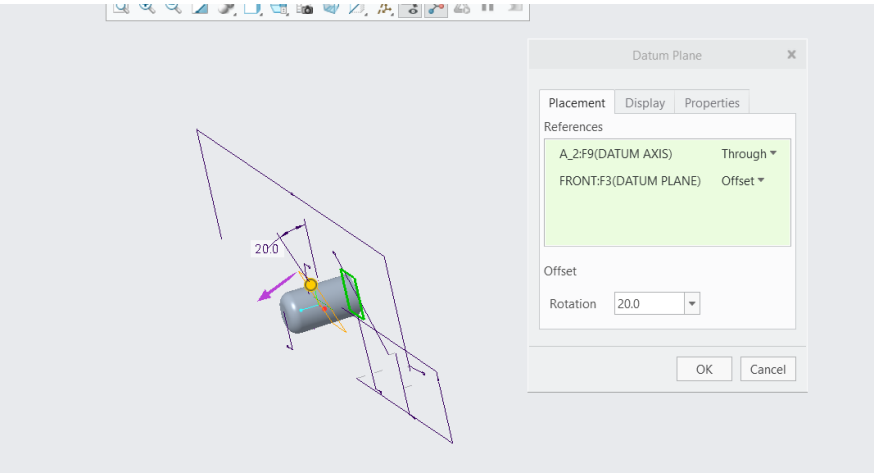


fig2.2

- Now select the new plane and sketch ad per dimensions shown in fig2.3 and extrude it to a height of **0.8mm** symmetrically

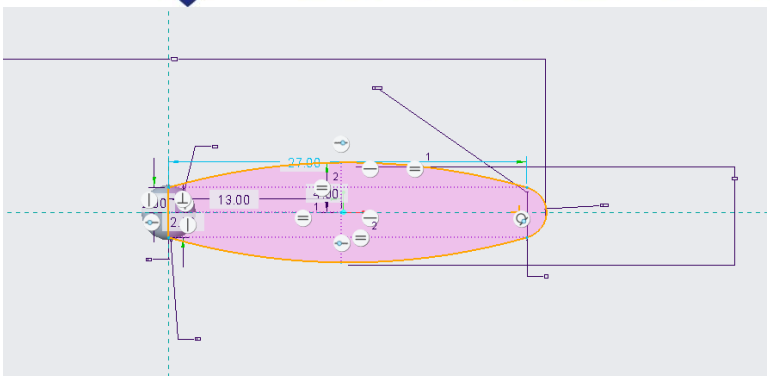


fig2.3

- Create another datum plane as shown in fig2.3.
- Now add a sweep path along the width of the propeller on the new plane as shown in fig2.4
- Create a sweep section as shown in fig2.4 and sweep the section using 

to get the shape and finish the propeller.

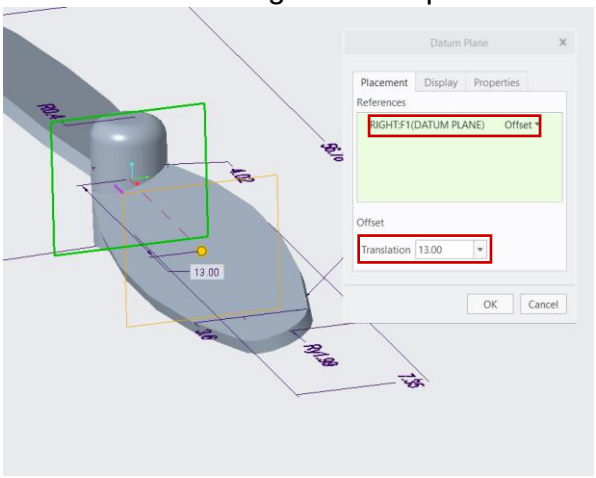


Fig2.3

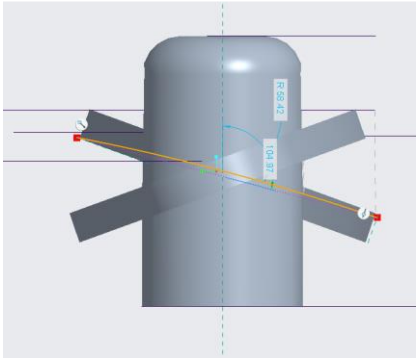


Fig2.4

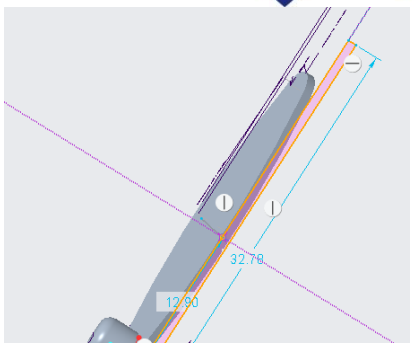


fig2.5

- Now use the pattern tool to replicate the part as shown in fig2.6 and repeat it to copy the sweep removed portion which will finish the portion**2**

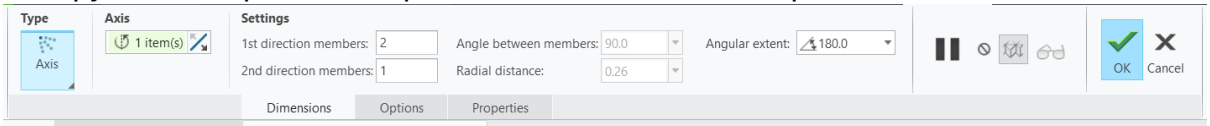
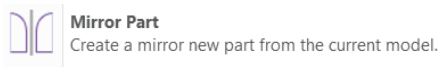


fig2.6

- Now round sharp edges to get desirable shape and then finally make a hole as per dimensions in fig 2.1 to finish the propeller.

There are two types of propellers used so one is made and the other type is made by saving a mirrored copy of this propeller go to **File>Save As> Mirror Part.**



Battery-

- On a datum plane an **18.5X25 mm** rectangle is made and extruded symmetrically to a height of **8.5mm**.
- Then **4** edges are chamfered to **3.5mm** and **1mm** as shown in fig3.1
- Then the body is rounded to get a suitable shape

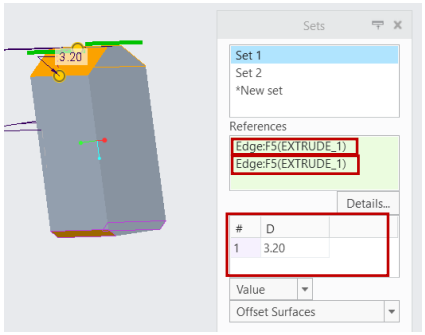


fig3.1

Motor-

It is an **assembly** of **3** parts **motor casing**, **shaft** and **back cover**.

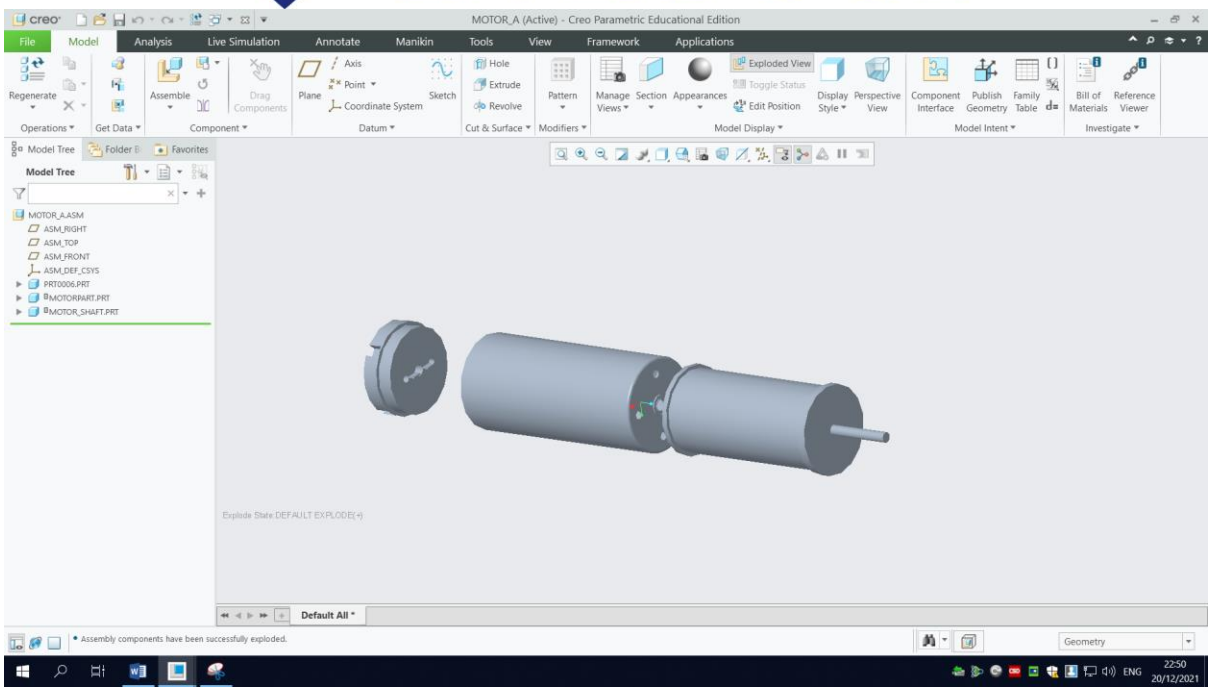
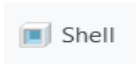


fig4

Motor Casing

- A rectangle is made of dimension **16X3.6mm** and revolved.
- Then using the shell tool 

0.2mm tick shell is made as shown in fig4.1.
- Then on the solid surface a hole is made of dia **1.6mm**.

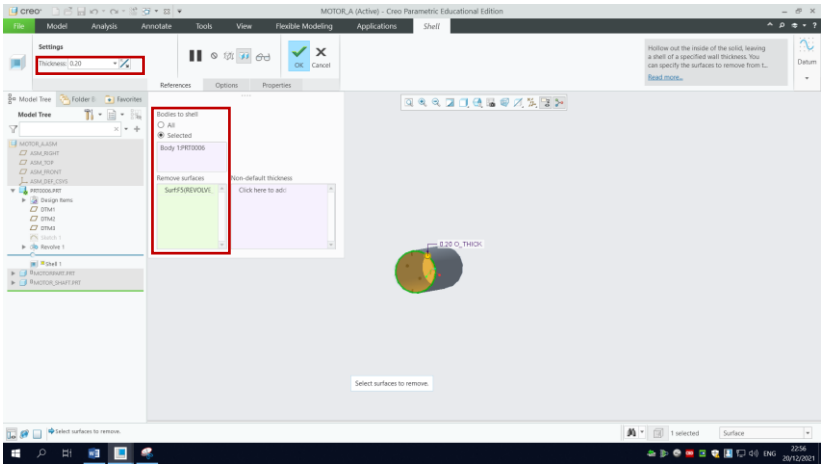


fig4.1

Shaft-

It is simply made by revolving the section shown in fig4.2.

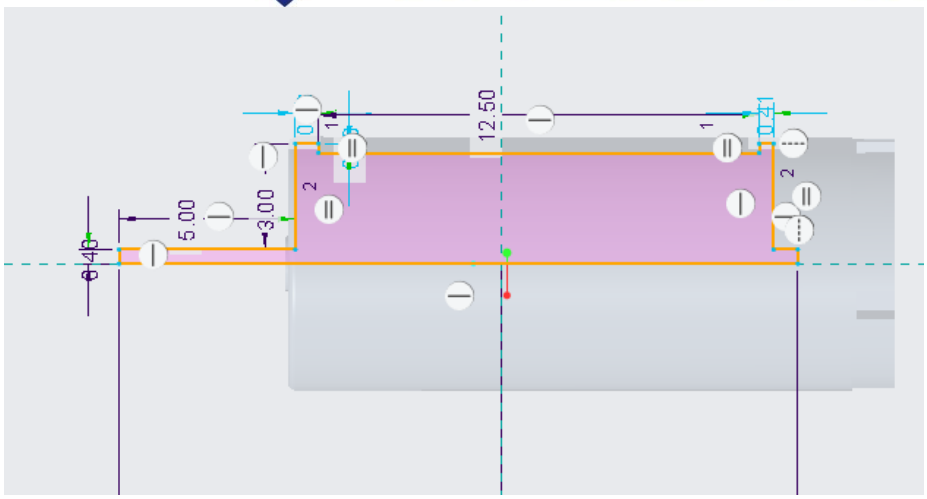


fig4.3

Back cover-

It is simply made by drawing as per shown in fig4.4 and extruding it to a height of **2.3mm**

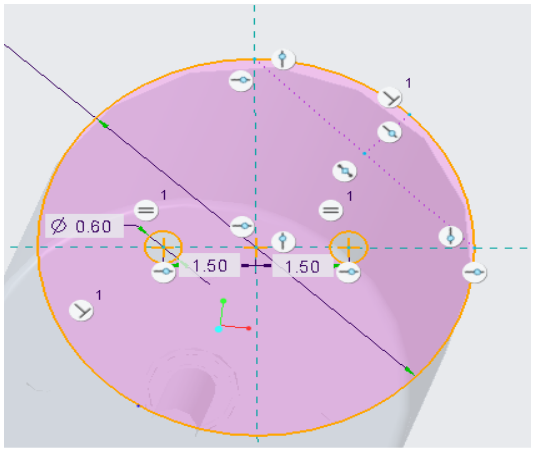


fig4.4

Circuit Board-

It is made by inserting an image of the circuit board and using it as reference to draw which is then extruded to a height of **1.1mm**.

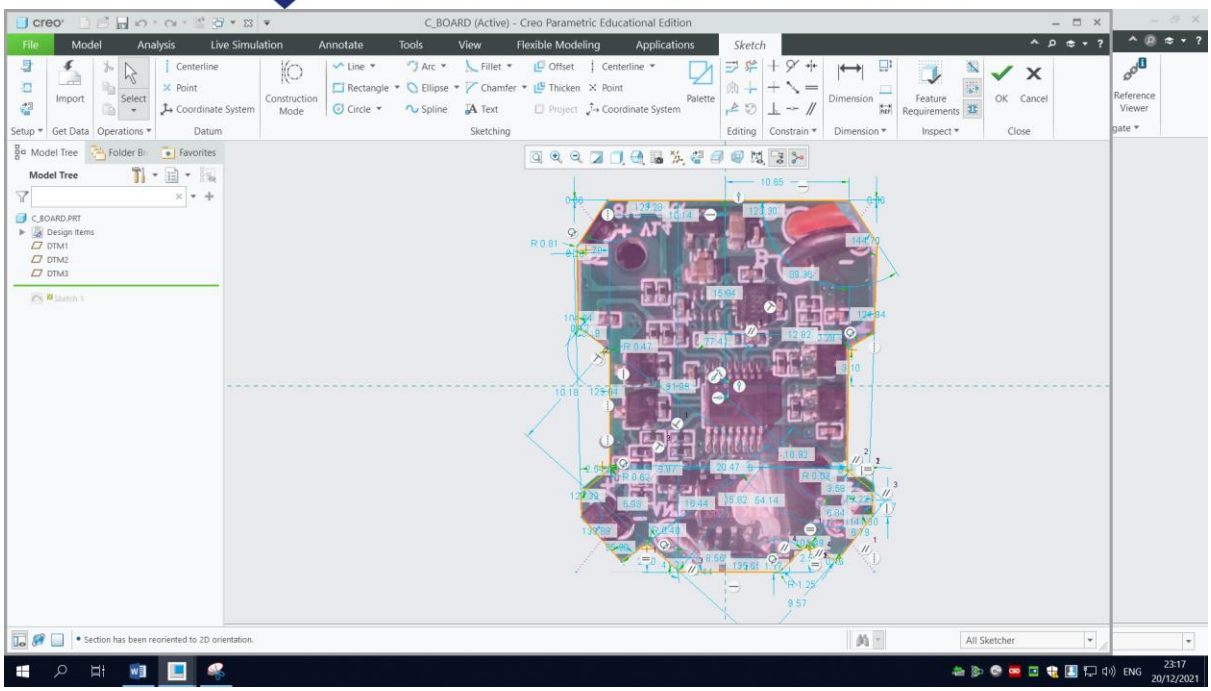


fig5

Upper Body-

- Extrude the sketch shown in fig6.1 to a height of 6.4mm
- Create a angular plane as shown in fig6.2
- Create a revolve section as shown in fig 6.3
- Revolve remove the section using remove material option.
- Use mirror 3 times to make same component on all sides.
- Use the front plane to draw a revolve section as shown in fig6.4
- Use shell tool to make wall thickness of 4mm
- Now use dimensions to make hollow structure at end of the wings and mirror them.

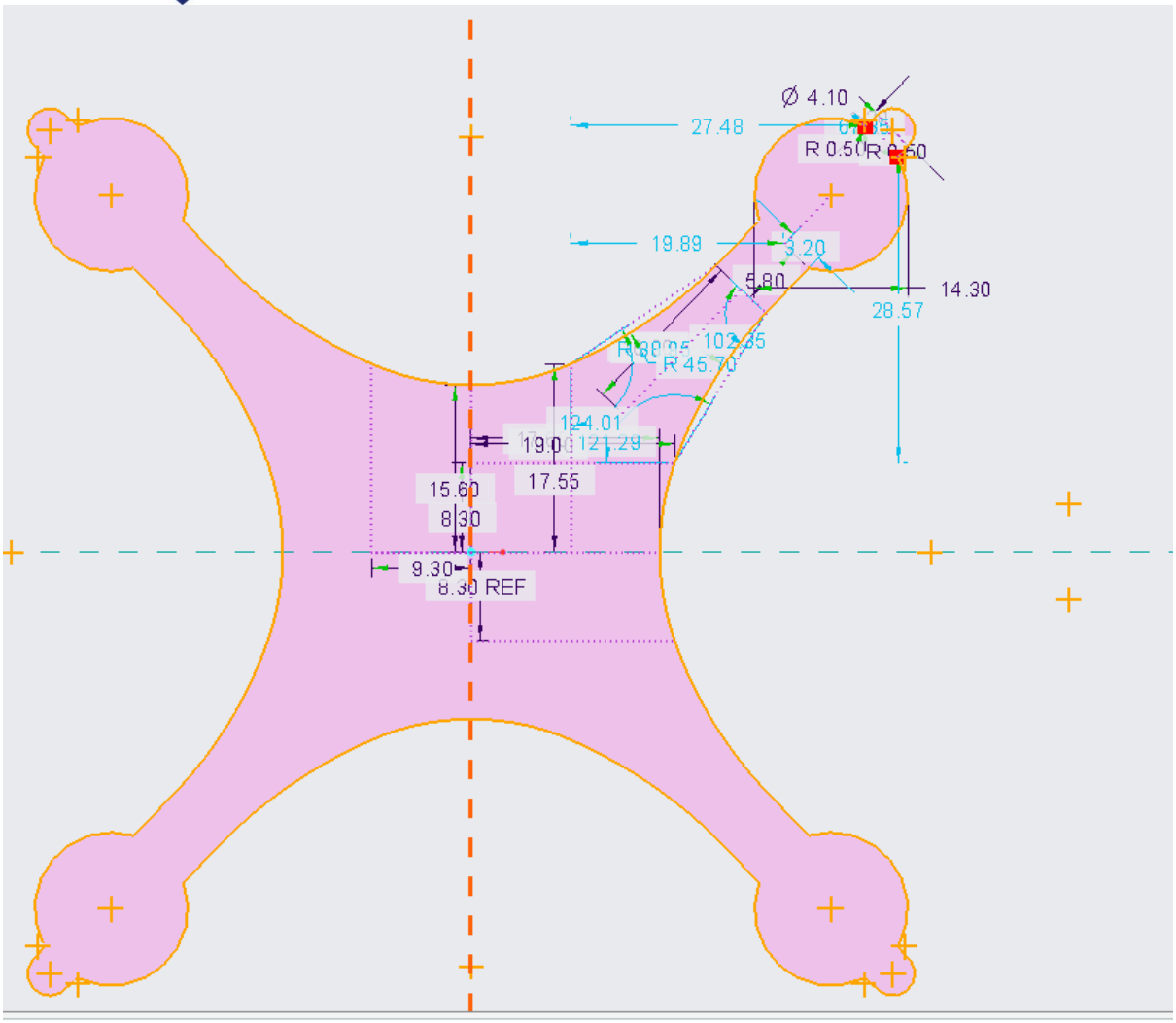

Ø 4.10
27.48
R 0.50
19.89
3.20
5.80
14.30
28.57
R 45.70
19.0
17.55
15.60
8.30
9.30
8.30 REF

fig6.1

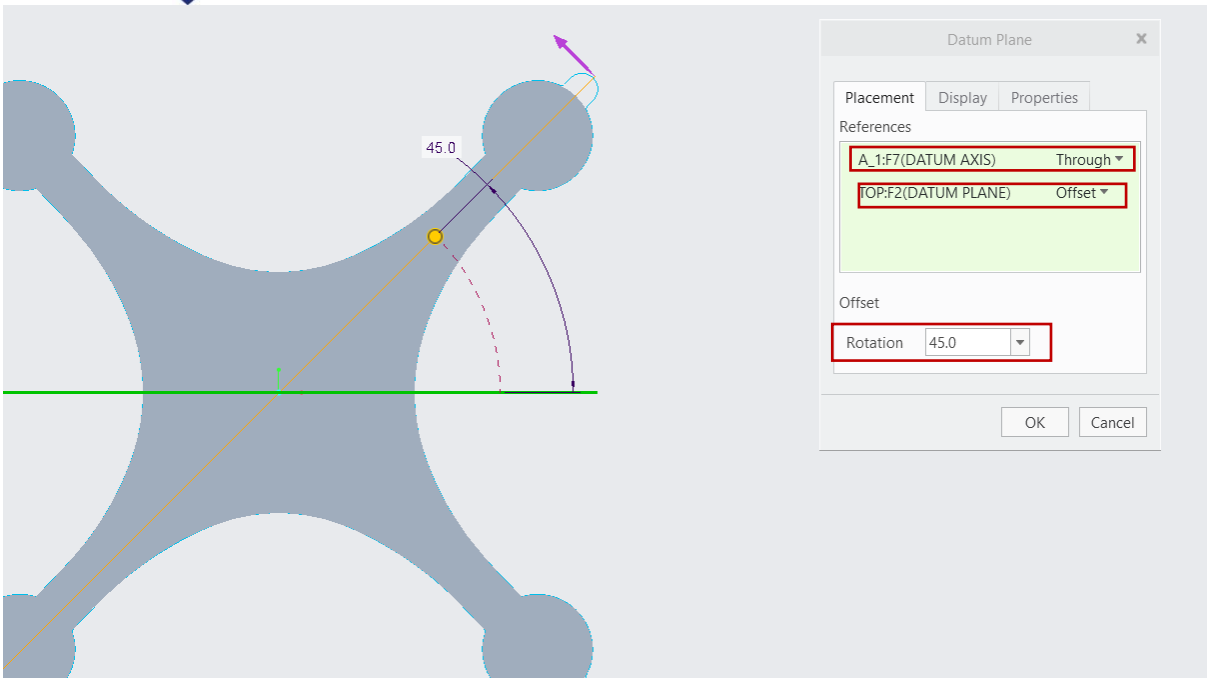
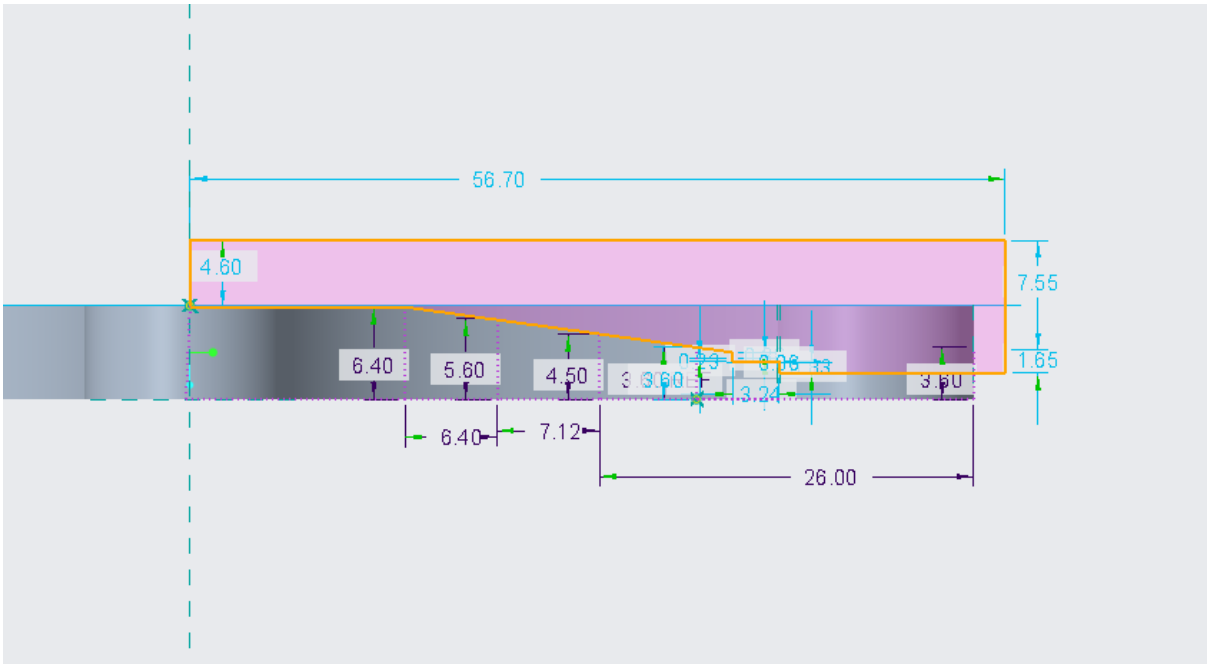

45.0
Datum Plane
Placement
Display
Properties
References
A_1:F7(DATUM AXIS)
Through
TOP:F2(DATUM PLANE)
Offset
Offset
Rotation
45.0
OK
Cancel

fig6.2


56.70
4.60
7.55
1.65
6.40
5.60
4.50
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3.24
6.40
7.12
26.00

fig6.3

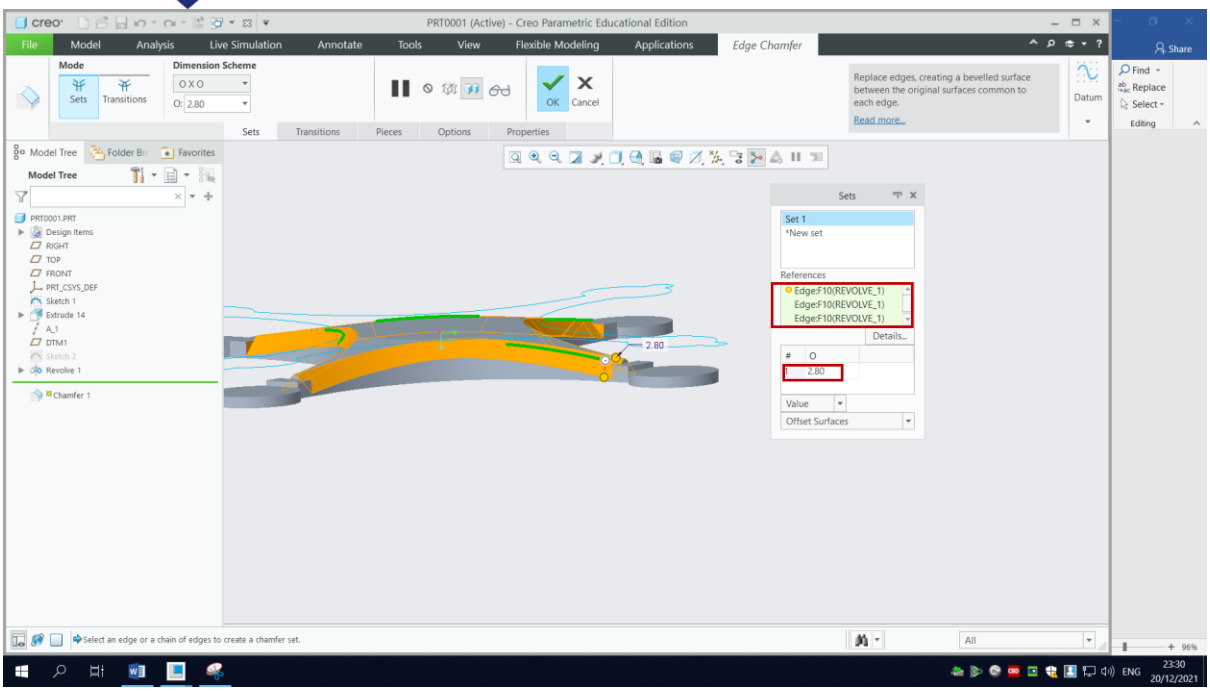

fig6.3

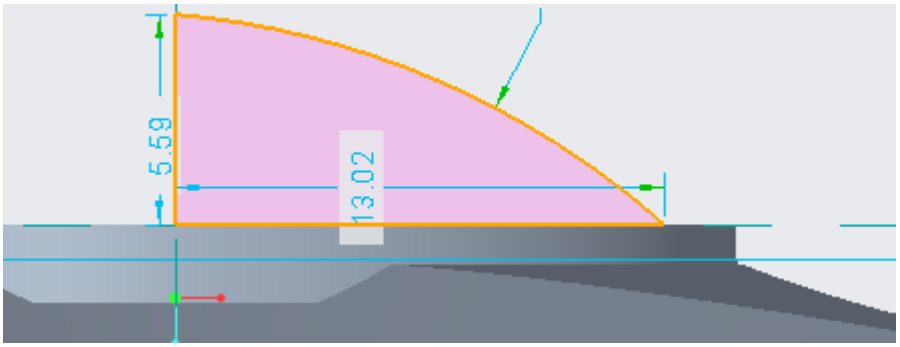

fig6.4

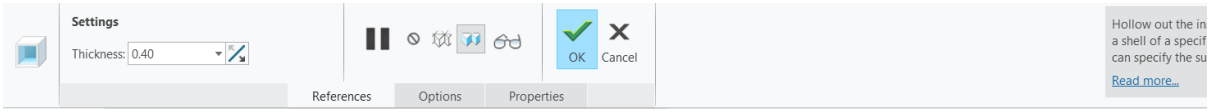

fig6.5

Lower Body-

*Repeat all the step till making a shell as in Upper body making with few changes like keep the extrude height **7.5**mm and skip the part where the dome id made using revolve.*

- *Remove material as shown in fig7.1*
- *Extrude the pattern in top plane as in fig 7.2*
- *Draw a section in middle plane and extrude symmetrically to **23mm** as shown in 7.3*
- *Now shell this to a thickness of **0.4mm***

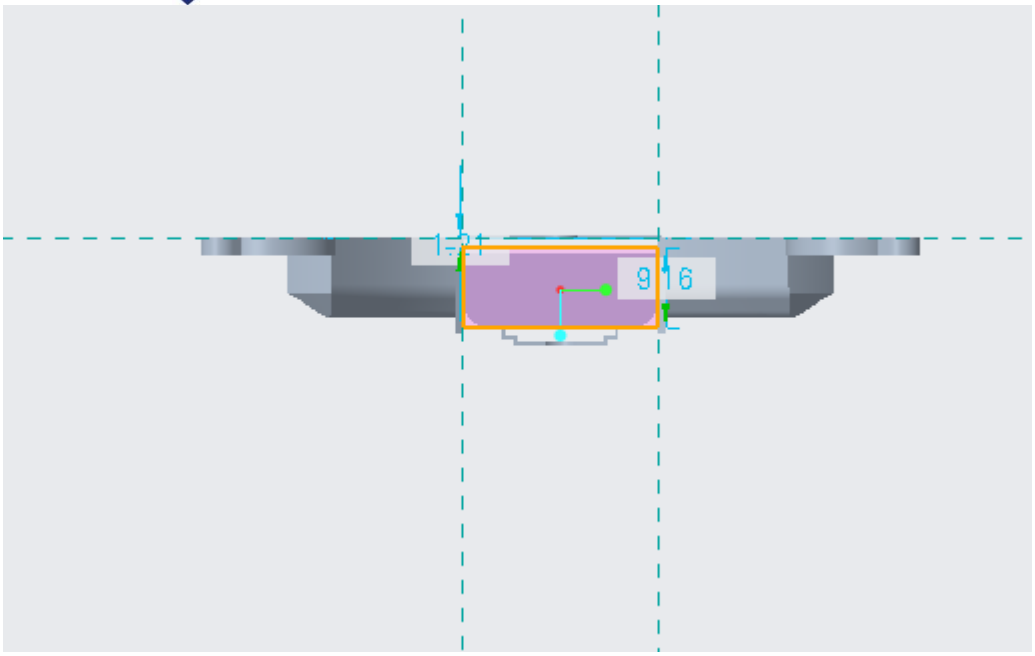

fig7.1

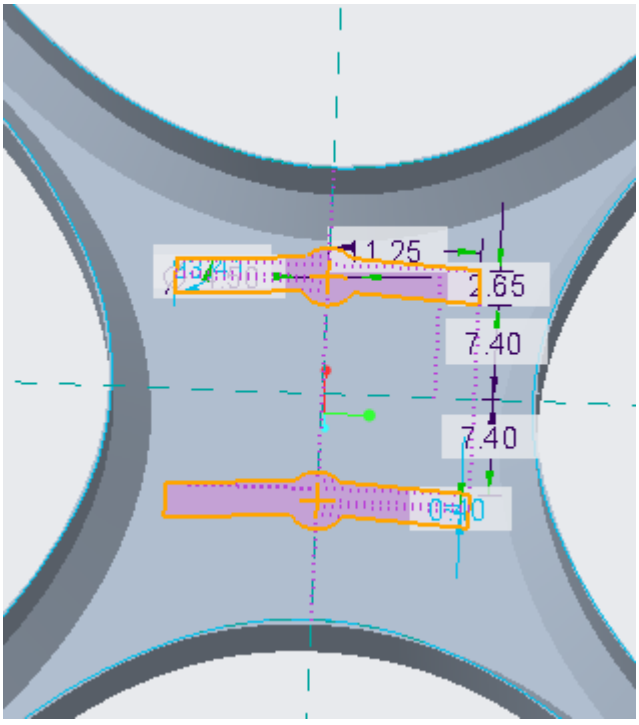

fig7.2

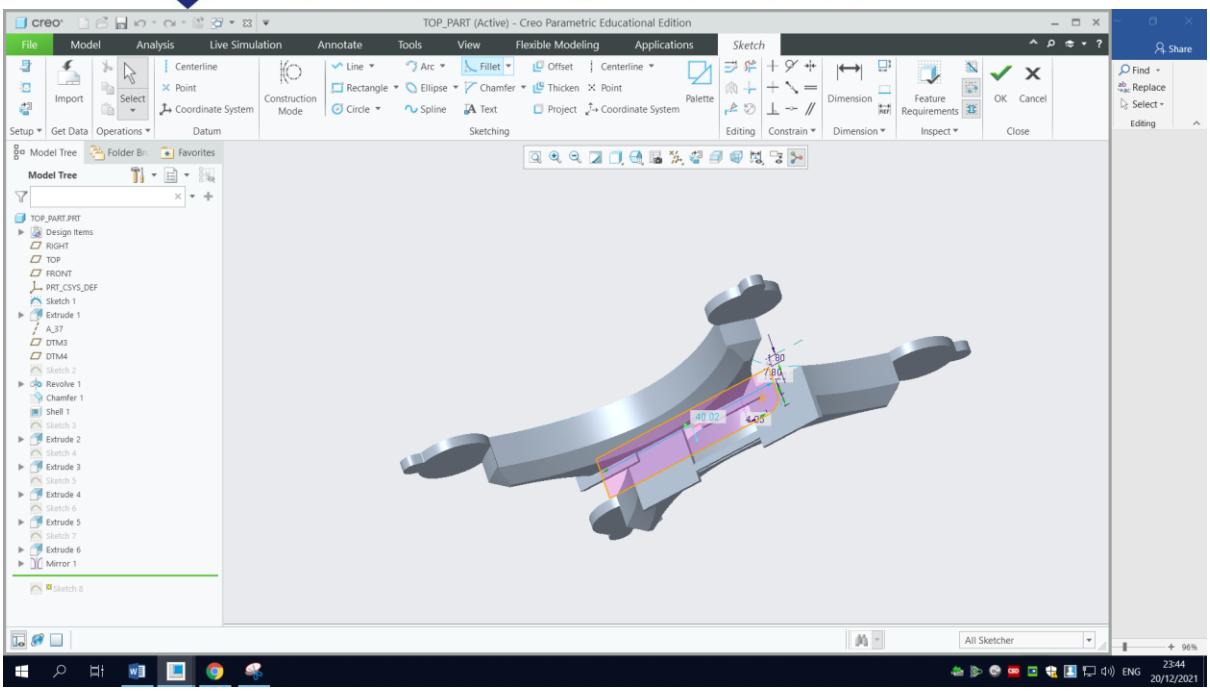
TOP_PART (Active) - Creo Parametric Educational Edition
File
Model
Analysis
Live Simulation
Annotate
Tools
View
Flexible Modeling
Applications
Sketch
Model Tree
TOP_PART.PRT
Design Items
RIGHT
TOP
FRONT
PRT_CSYS_DEF
Sketch 1
Extrude 1
A_37
DTM3
DTM4
Revolve 1
Chamfer 1
Shell 1
Extrude 2
Extrude 3
Extrude 4
Extrude 5
Extrude 6
Mirror 1
Sketch 8
All Sketcher

fig7.3

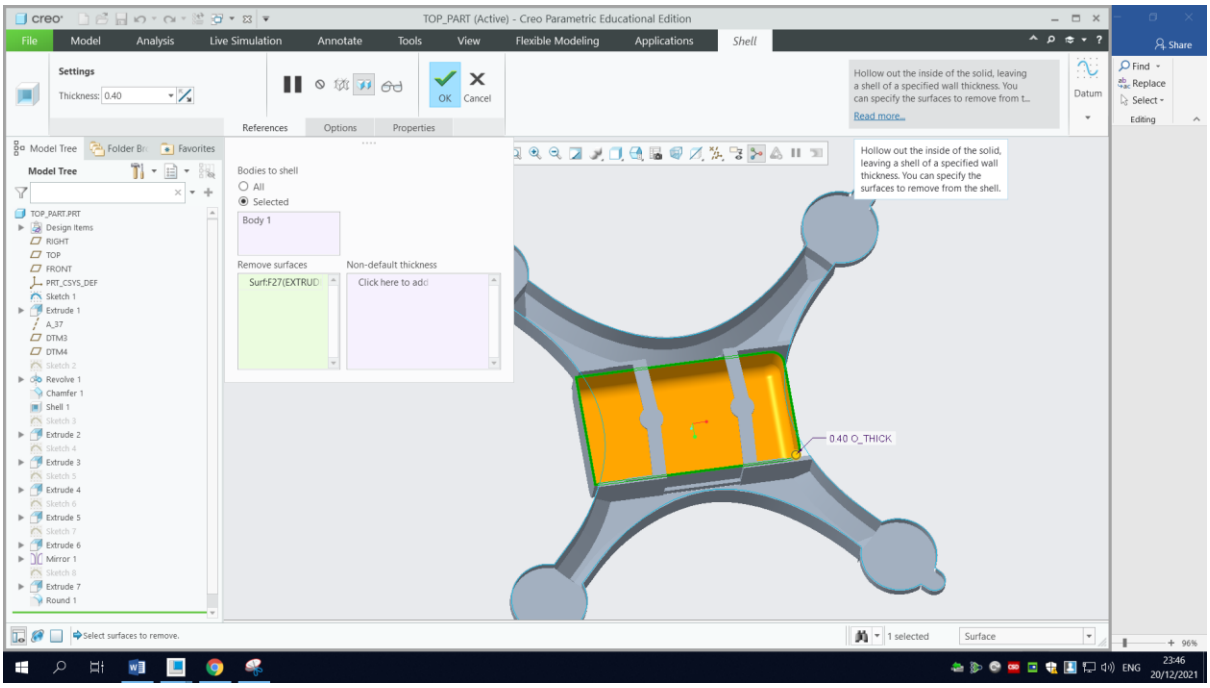
TOP_PART (Active) - Creo Parametric Educational Edition
File
Model
Analysis
Live Simulation
Annotate
Tools
View
Flexible Modeling
Applications
Shell
Settings
Thickness: 0.40
OK
Cancel
References
Options
Properties
Hollow out the inside of the solid, leaving a shell of a specified wall thickness. You can specify the surfaces to remove from t...
Read more...
Datum
Bodies to shell
All
Selected
Body 1
Remove surfaces
Surf:F27(EXTRUD
Non-default thickness
Click here to add
Hollow out the inside of the solid, leaving a shell of a specified wall thickness. You can specify the surfaces to remove from the shell.
0.40 O_THICK
Model Tree
TOP_PART.PRT
Design Items
RIGHT
TOP
FRONT
PRT_CSYS_DEF
Sketch 1
Extrude 1
A_37
DTM3
DTM4
Revolve 1
Chamfer 1
Shell 1
Extrude 2
Extrude 3
Extrude 4
Extrude 5
Extrude 6
Mirror 1
Extrude 7
Round 1
Select surfaces to remove.
1 selected
Surface

fig7.4

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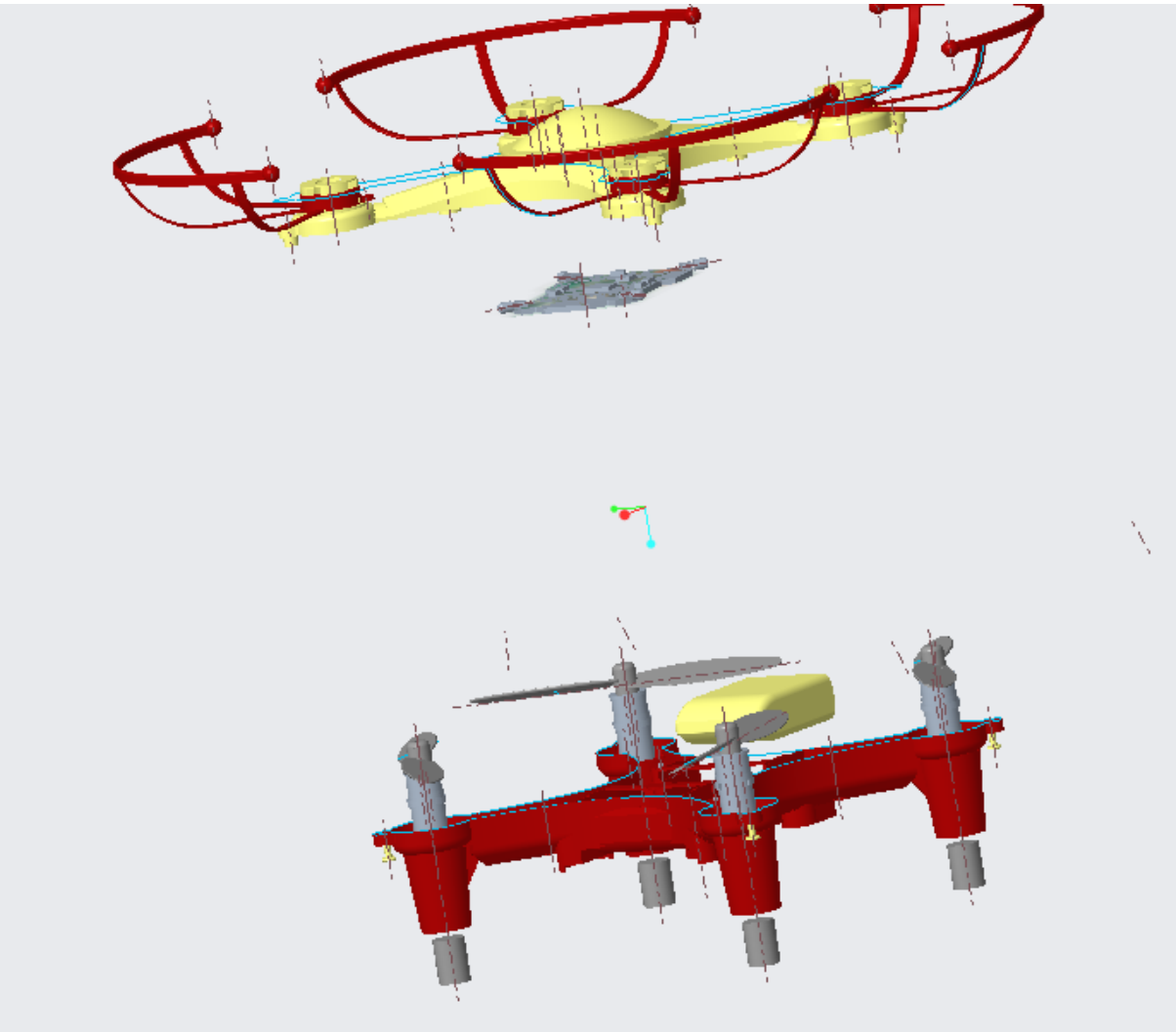
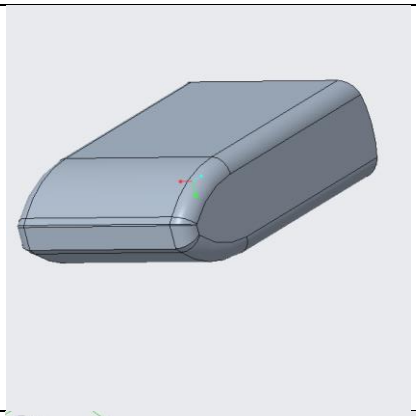
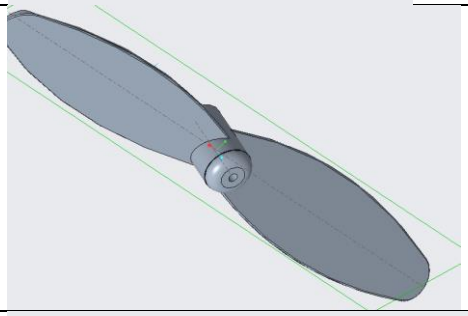
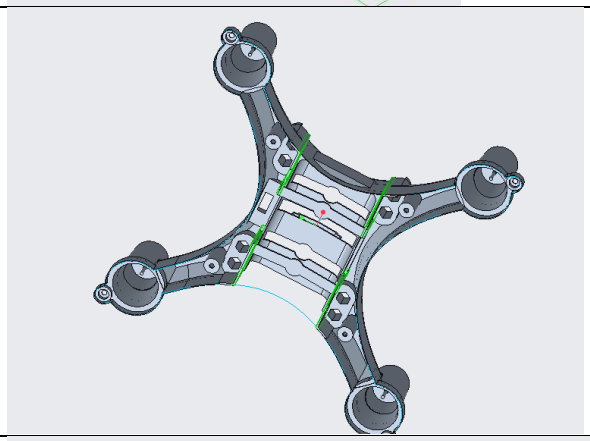
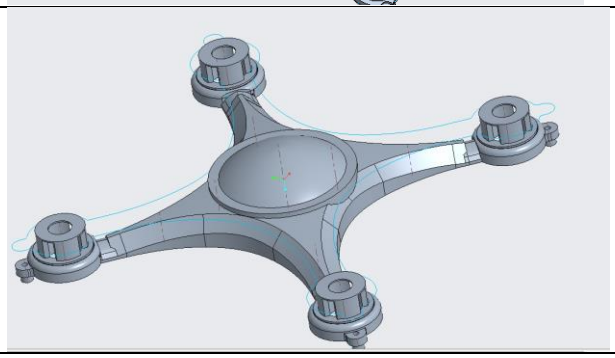
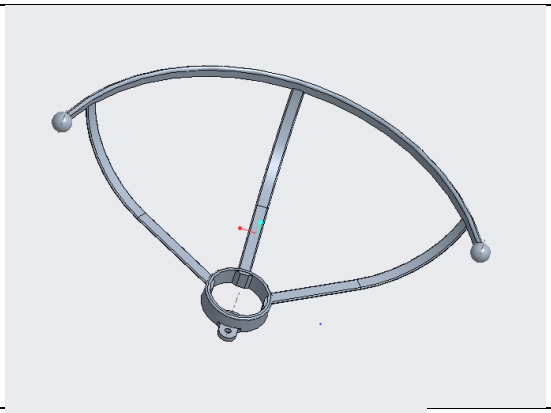
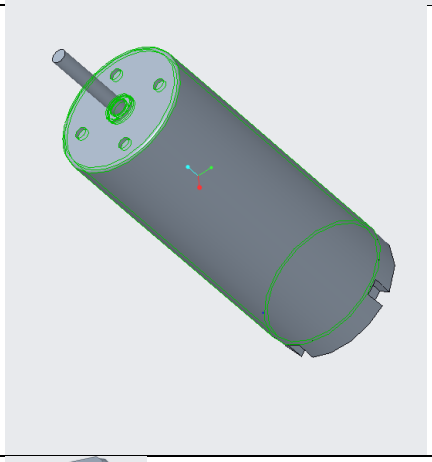
Bill of Materials (BOM)

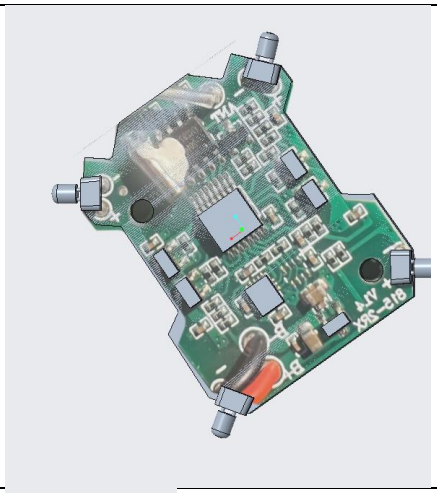
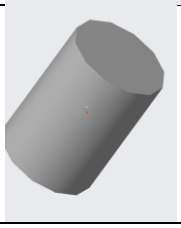
Bill of Materials state all the important components in the product and specified information about their material constitution and manufacturing process needed to make them. It also lists the quantity of each part used.



	Material used	*Manufacturing technique*	*Quantity*	*Images*

M Name of component				
Battery	Li-ion polymer	*Chemical processing*	*1*	
Propellers	*HDPE*	*Injection moulding*	*4*	
Lower Body	*HDPE*	*Injection moulding*	*1*	
Upper body	*HDPE*	*Injection moulding*	*1*	

Propeller Guard	*HDPE*	*Injection moulding*	*4*	
Electric Motors	*Steel casing*	*Machining*	*4*	
Screws	*Cast Iron*	*casting*	*10*	 *X 4,*  *X 4,*  *X 2*

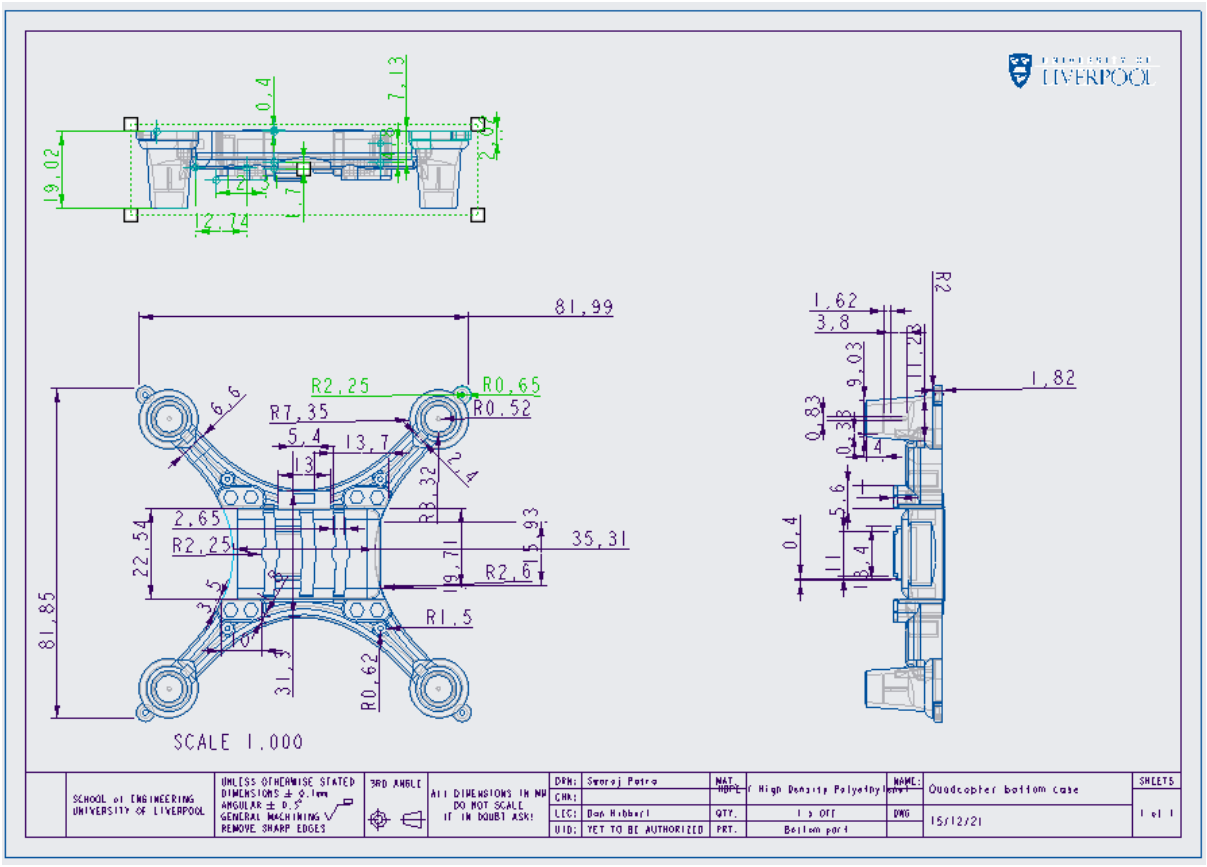
Circuit Board	*Resin, silicon and copper*	*Multilayer Casting*	*1*	
Base Guard	*Moulding*	*Rubber*	*4*	

Bill of materials table

2D Technical Drawings

The following drawings are present in a4_SOE_template. They can be used by a designer or manufacturer to remake or improve it just using the drawings. The mainly consist of dimensions of the object. The following objects are parts with specifically designed dimensions.

Lower Body:



Upper Body:

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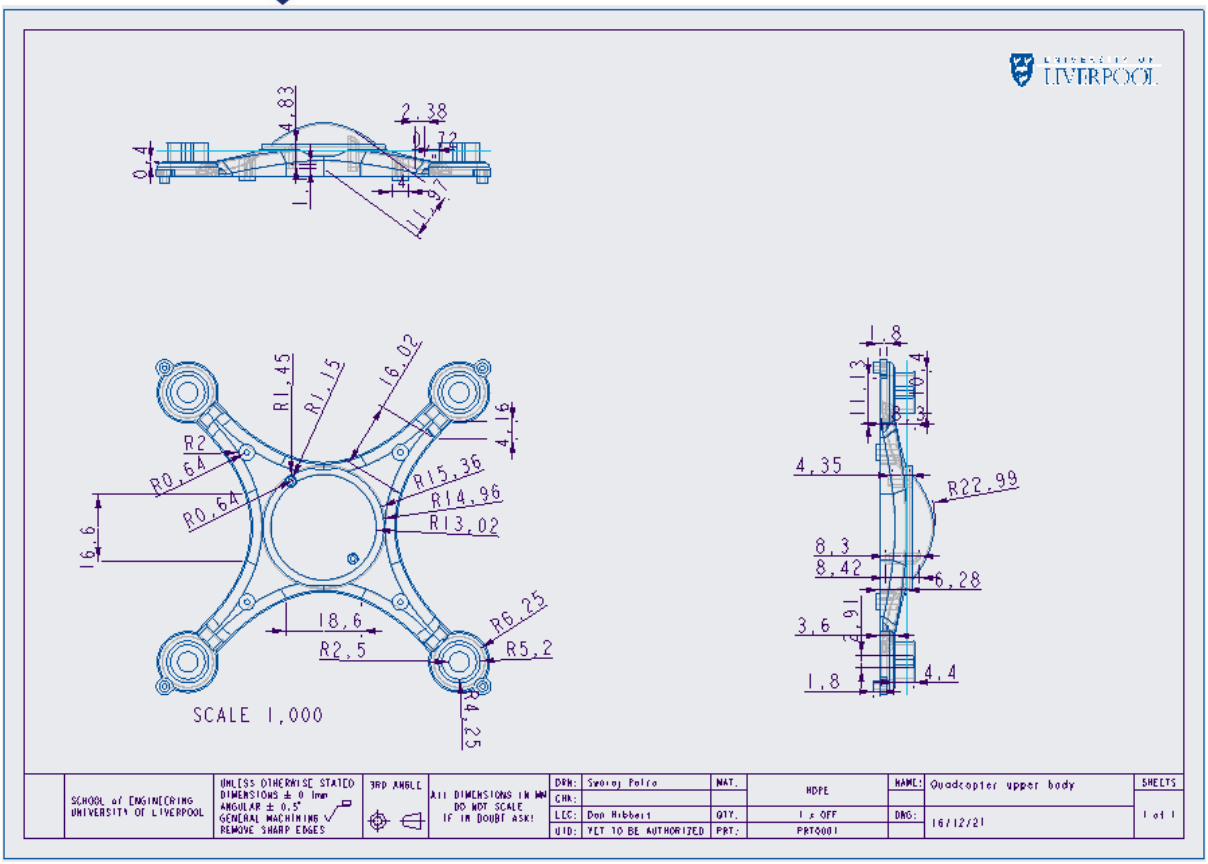
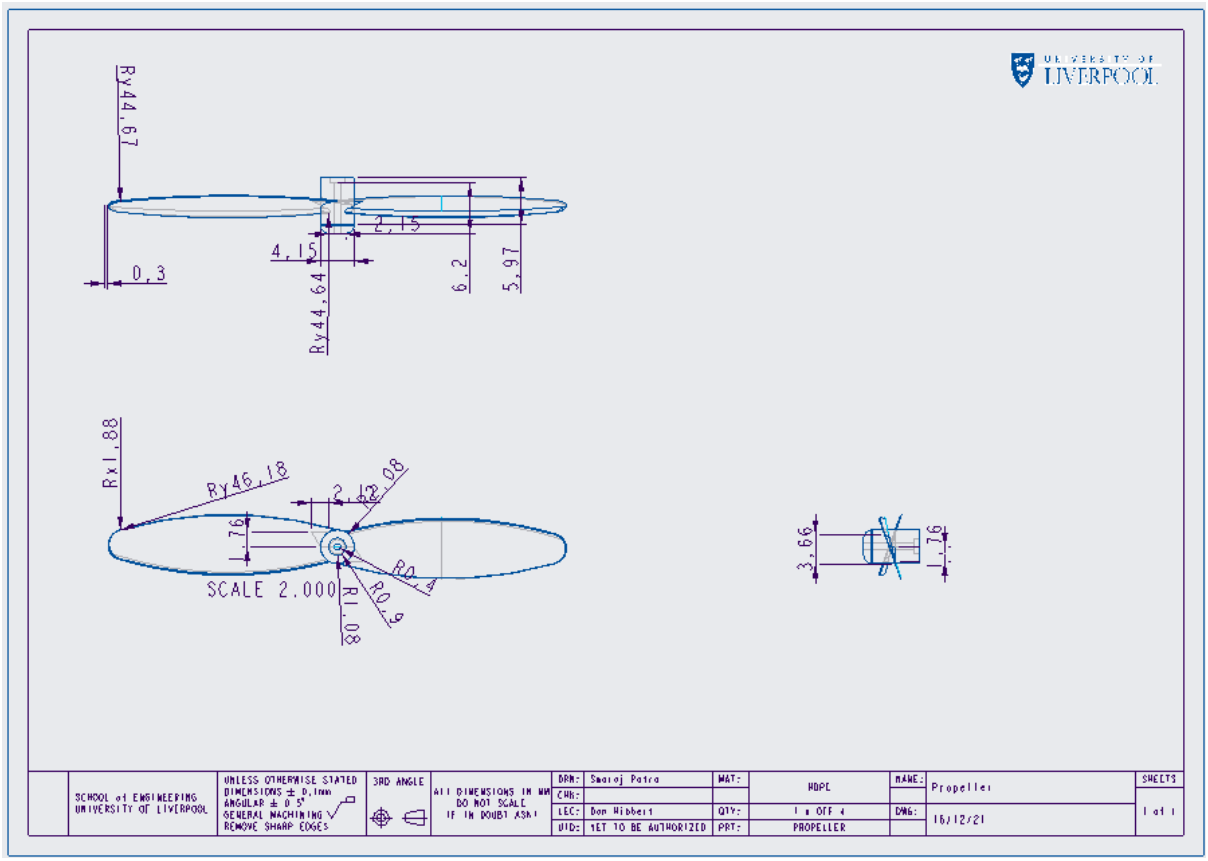
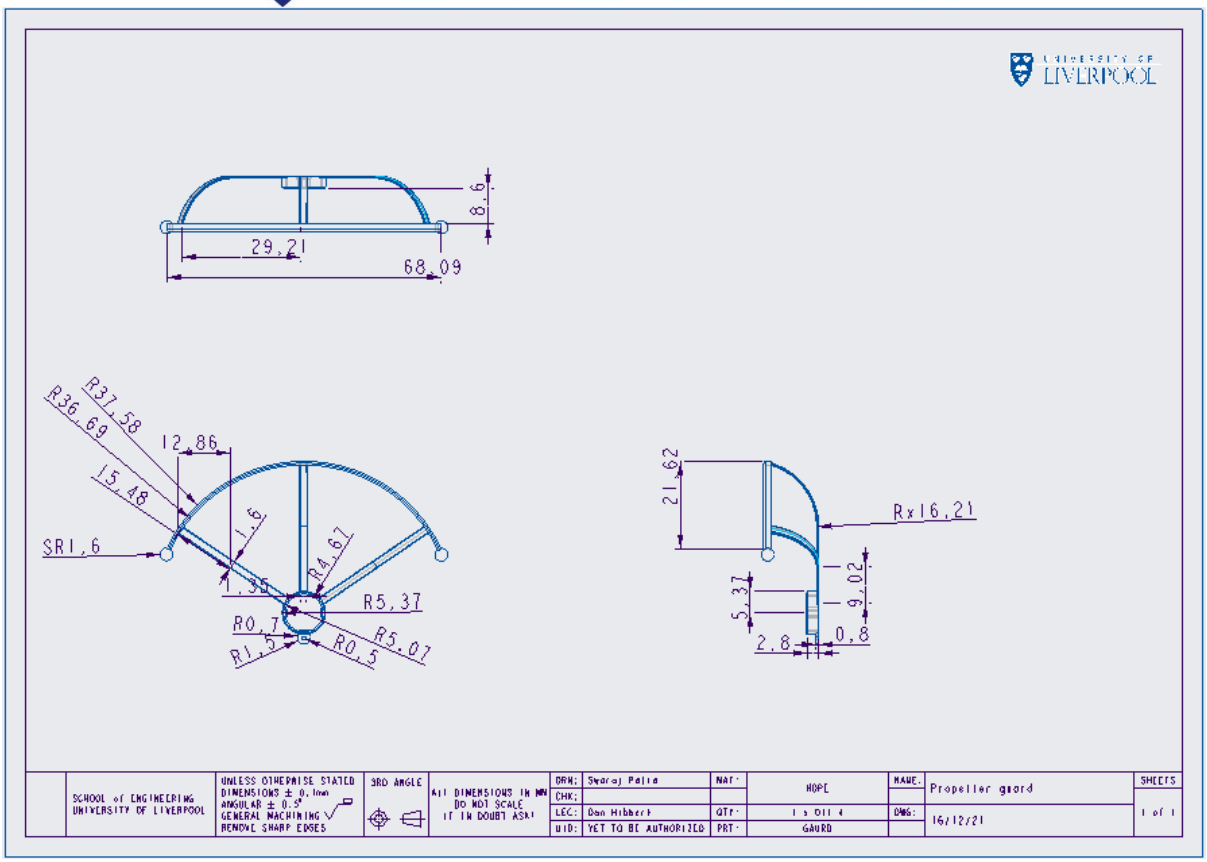


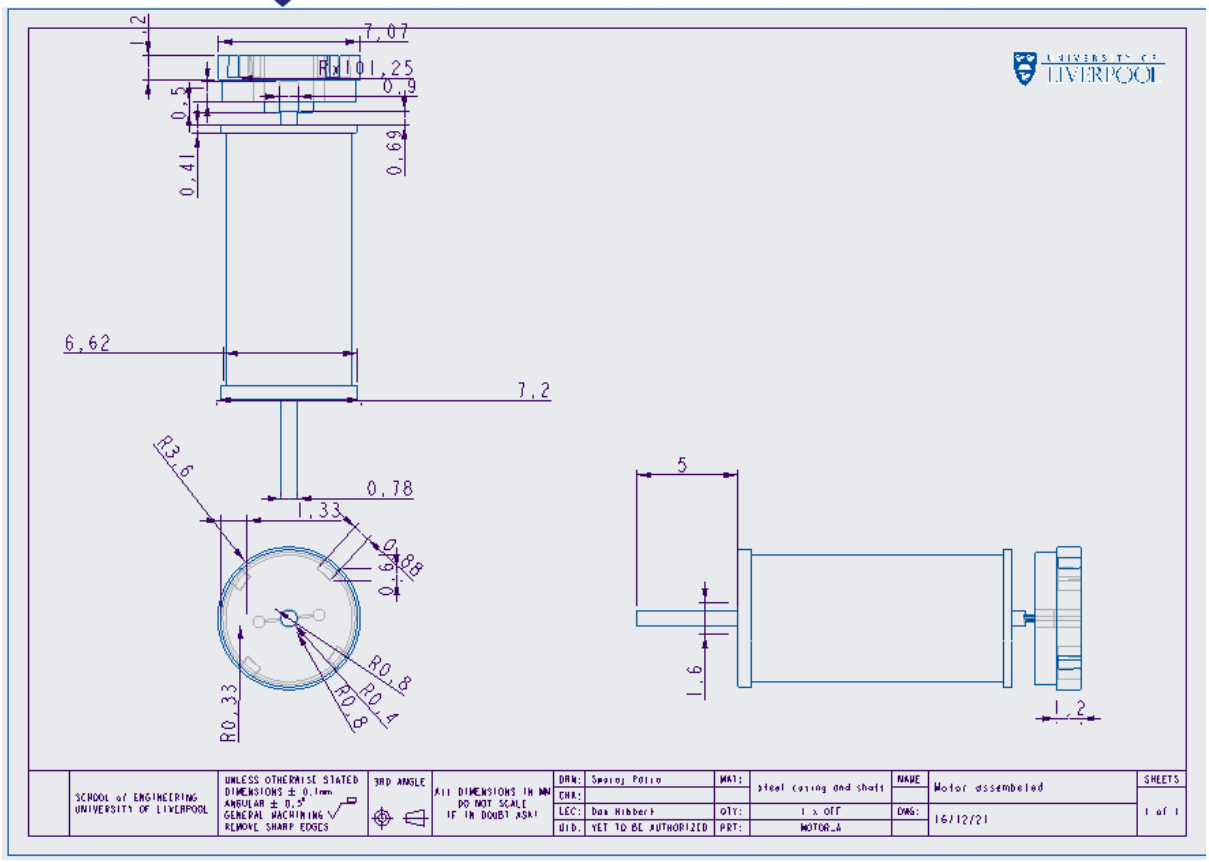
Propellers:



Propeller Guard:


8,6
29,21
68,09
R37,58
R36,69
12,86
15,48
SR1,6
1,6
1,35
R4,67
R5,37
R0,7
R1,5
R0,5
R5,01
21,62
Rx16,21
5,37
9,02
2,8
0,8
SCHOOL of ENGINEERING
UNIVERSITY OF LIVERPOOL
UNLESS OTHERWISE STATED
DIMENSIONS ± 0,1mm
ANGULAR ± 0,5°
GENERAL MACHINING
REMOVE SHARP EDGES
3RD ANGLE
ALL DIMENSIONS IN MM
DO NOT SCALE
IF IN DOUBT ASK!
DRN: Swaraj Palia
CHK:
LEC: Dan Hibbert
UID: YET TO BE AUTHORIZED
MAT: HDPE
QTY: 1 x QTY 4
PRT: GAURD
NAME:
DWG:
Propeller guard
16/12/21
SHEETS
1 of 1

Motor:



References.

- MNFG604 Manuals and tutorial videos