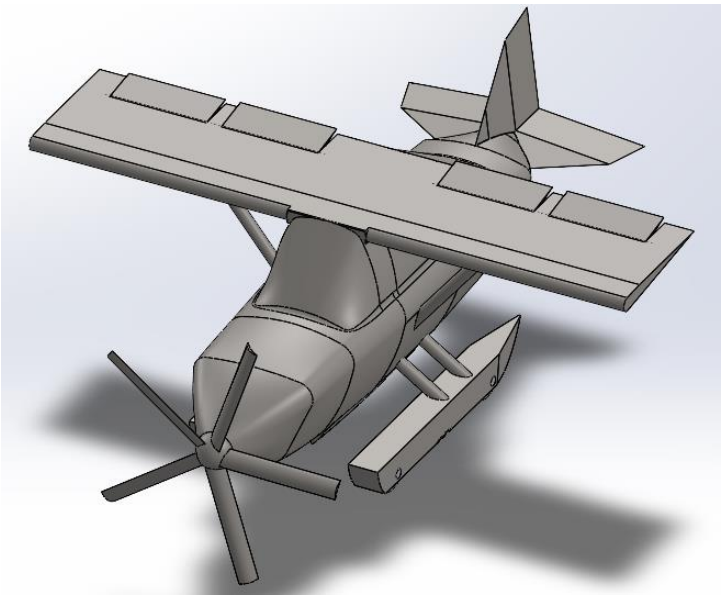
EML 3022: CAD PROJECT

FALL 2024

Crop Duster Airplane

Christian Arriaga-Franco

UID: 4852-6475



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Introduction

After using SolidWorks for the whole semester and passing the certification exams, all that was left was to create a design that of my own which could showcase my abilities to use such a program. Being in the mechanical engineering program, I have love and interest for components that move and work together to create assemblies which can do greater tasks when combined. With that said, my initial thought was creating some sort of engine, either an engine with a V-displacement or an engine with an I-displacement. I find these motors fascinating and how not only mechanical systems are involved but also electrical systems. From the Rotation of the crankshaft to the firing of the spark plug, every component is interconnected and unique. However, this idea soon went down the drain as the professor highly recommended, we do not follow an engine tutorial as there are so many and it wouldn't show what you can make as an engineer. So, apart from my love of moving components, I am very into the design aspect of how vehicles or other moving items look. I always take time to think about how the body of the car is designed and if it truly fits the rest of the car. In that way I guess you could say that I'm judgmental of how cars look but, in my opinion, most cars look great. With my decision to create something that's aesthetically pleasing to look at and involves engineering, the first thing that came to mind was an airplane. I have always been interested in the engineering that it takes to get these huge tons of metal off the ground and fly which just sounds abnormal. Of course, when it comes to airplanes, there are many types, from ones that carry soldiers, animals, civilians, cars, and even other planes. Mine will carry none of those. Instead, it's designed after airplanes called crop-dusters which carry chemicals that are then released onto the crops as the airplanes fly over them.

Design

To create the design for my airplane, I was not able to find any cad files to base the airplane off of and everything that I created is one of one of off my own imagination. I did reference some photos of crop-duster style airplanes and small airplanes to find the key design features that I would have to include in my design. So, for the main features of my airplane, it includes one big wing that sits on top of the aircraft which is supported by two supports to help the wing from bending so much to the point where it would break. The wing has directional wings embedded into that would allow the pilot to steer the airplane and there is also an additional cross wing in the back for stability in the air. To power and fly the aircraft, there is only one engine, as it is a relatively smaller airplane, that will drive a big, 5-winged, propeller which should keep it in the sky with no problem. To land the airplane, it has 4 legs which are connected to the hub for the wheels and there are 4 of them. Now to transport the chemicals, are chambers within the wheel hubs and airplane that have latches on them which will open on the pilot's command.

Material

The material that I chose to use for the whole airplane's body is cast alloy steel. With a strong base for the metal, this airplane should have no problem in experiencing weak points while flying through harsh air friction. However, one part, separate from the rest of the airplane, the wheels, are to be created to aluminum alloy. The reason for this is because it did seem it to be as efficient for the airplane to have to move wheels that are heavier than they need to be. These Aluminum wheel should be fine in carrying the weight of the plane if paired with strong tires.

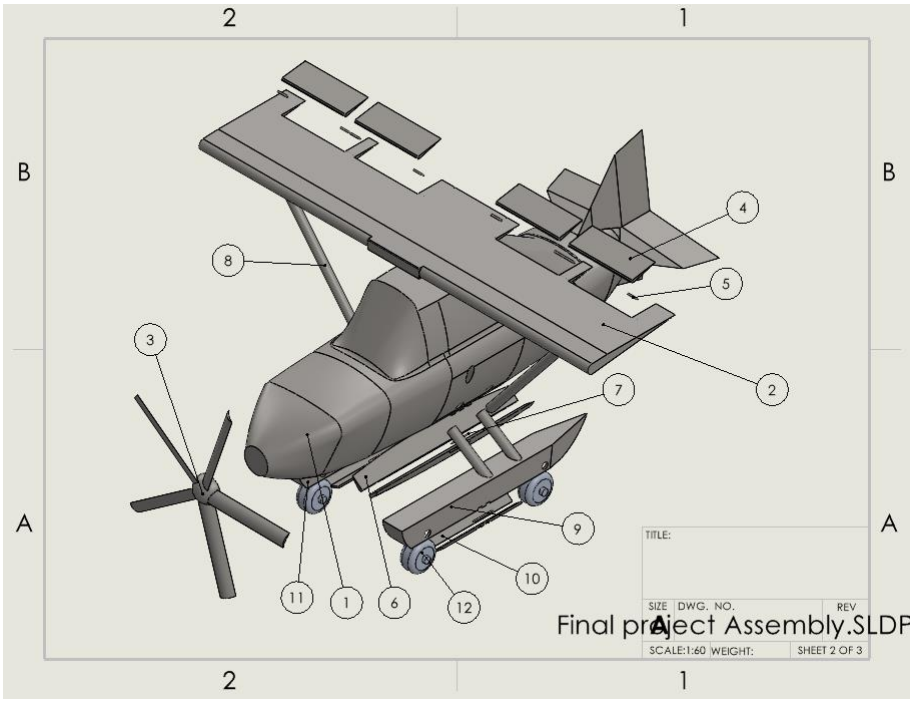
Difficulties Faced

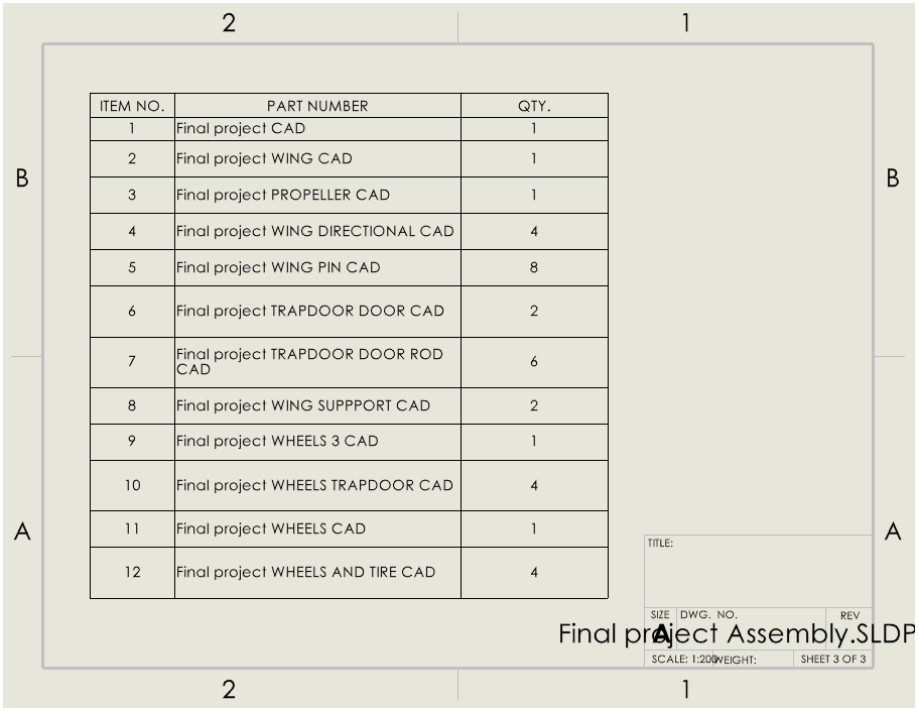
The main difficulties that I faced throughout the creation of the airplane were mainly from the body of the airplane with no wings, propeller, and landing gear. The main reason for this was because the body of the airplane follows an egg shape and normally that wouldn't be a problem because of the ellipse feature that SolidWorks has but this shape is irregular. It was something that can only be created through lofts. For this reason, every time I had to extend the airplane, I would have to create a new plane that was referenced from another part of the airplane. The distance of the plane that I made with the reference had to be a certain distance, otherwise the feature would look off. On top of creating the loft, I also had to create guidelines for the loft to be brought out. This would improve the geometry of the airplane and give the round change that the egg does. Apart from that I would say that the next most difficult wasn't creating the design but making the drawing files for it. Over the span of what I would say came out to be a week, the drawings for some of the parts took long and might not be the best with the way we were taught how to create drawings, but I tried my best to dimension what was needed to be dimensioned for the creation of the aircraft. Like before, the lofts caused difficulty in that part of the design because of all the different references that it took to create one loft.

Assembly

Below are the different drawings for the airplane and the components that make up the assembly of the airplane.

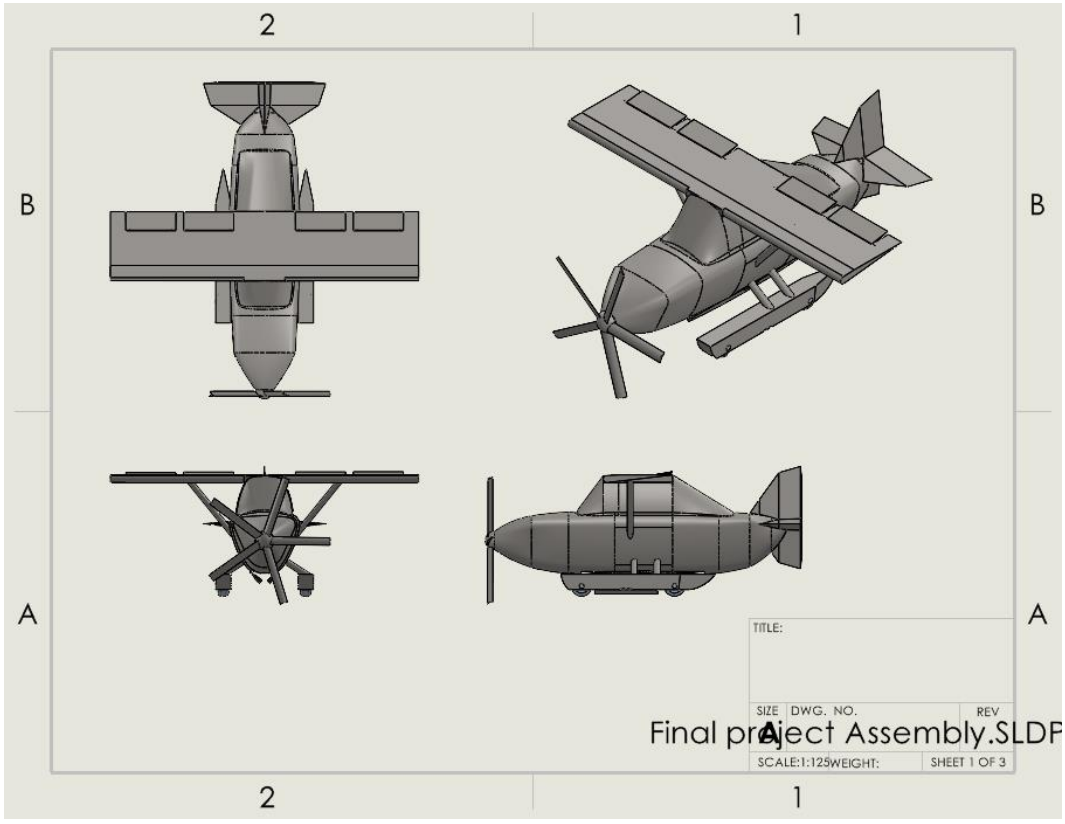
Assembly drawing in exploded view with balloons and BOM:

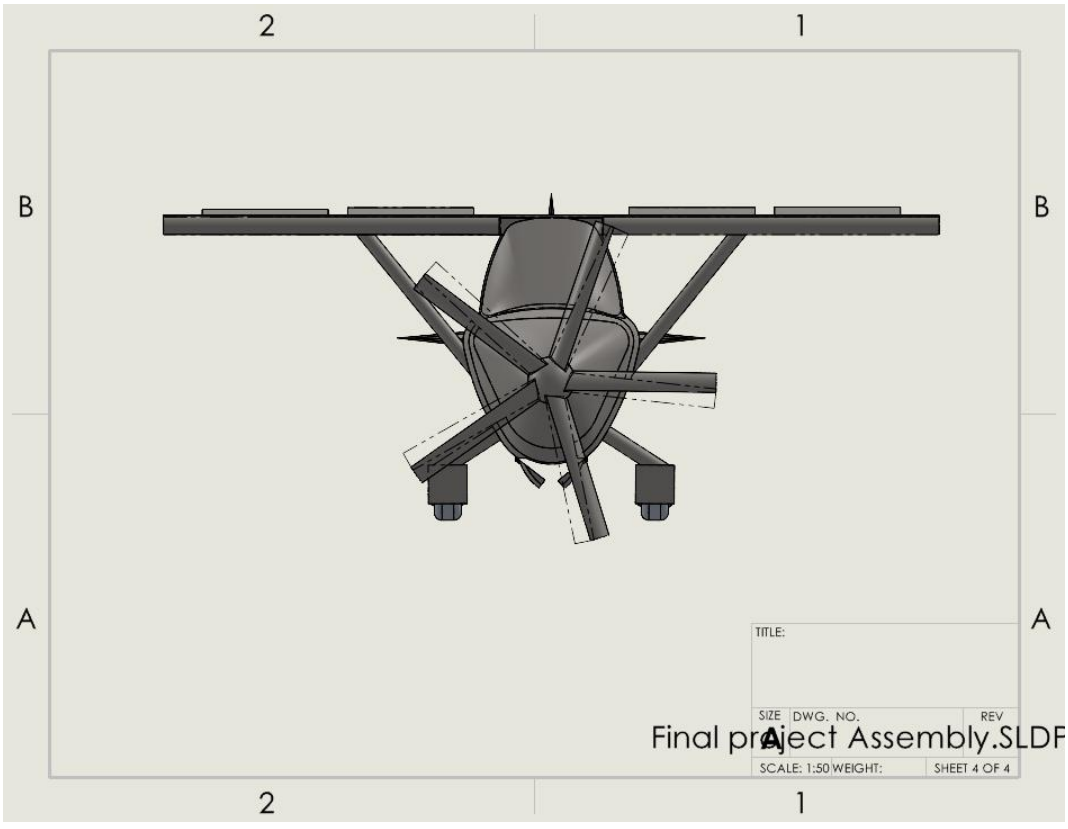




ITEM NO.	PART NUMBER	QTY.
1	Final project CAD	1
2	Final project WING CAD	1
3	Final project PROPELLER CAD	1
4	Final project WING DIRECTIONAL CAD	4
5	Final project WING PIN CAD	8
6	Final project TRAPDOOR DOOR CAD	2
7	Final project TRAPDOOR DOOR ROD CAD	6
8	Final project WING SUPPPORT CAD	2
9	Final project WHEELS 3 CAD	1
10	Final project WHEELS TRAPDOOR CAD	4
11	Final project WHEELS CAD	1
12	Final project WHEELS AND TIRE CAD	4

Assembly alternate position drawings:

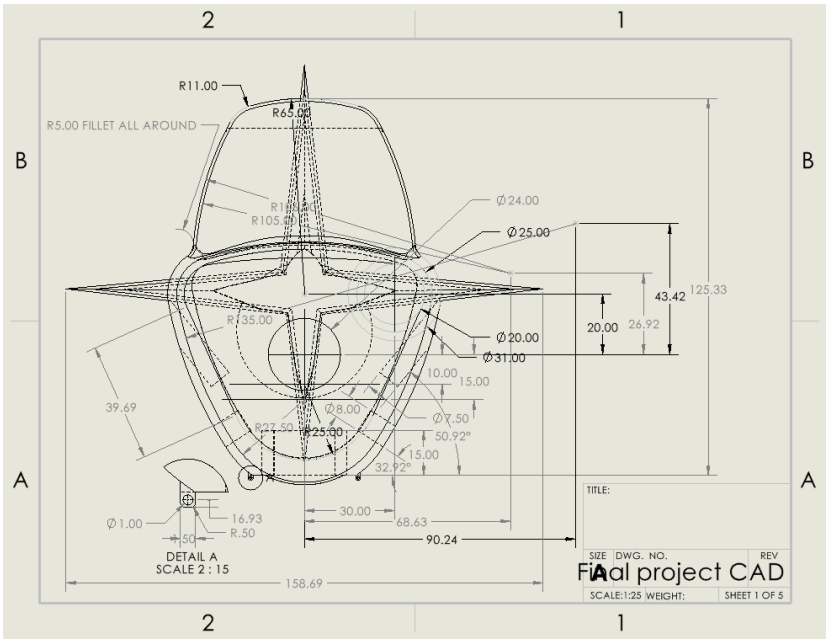


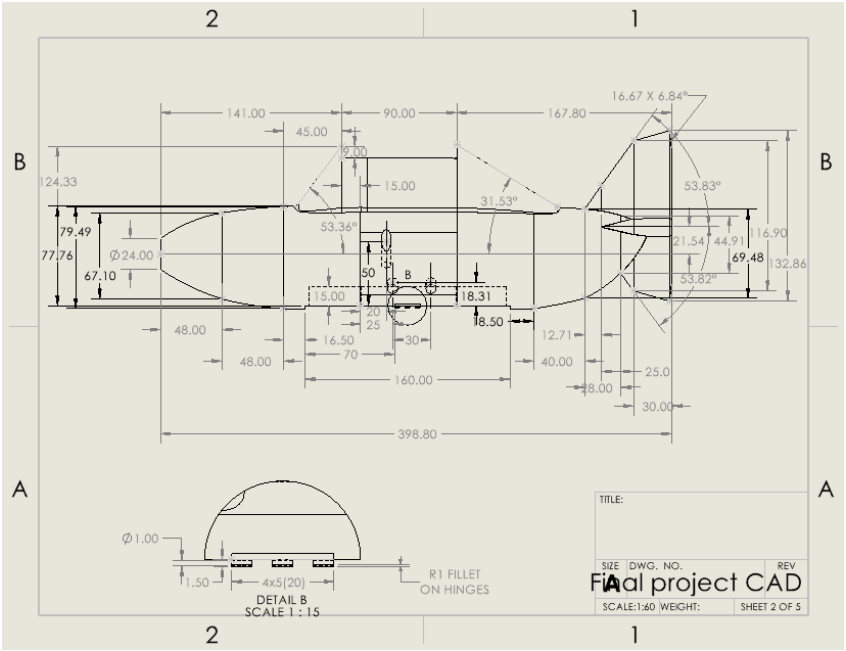


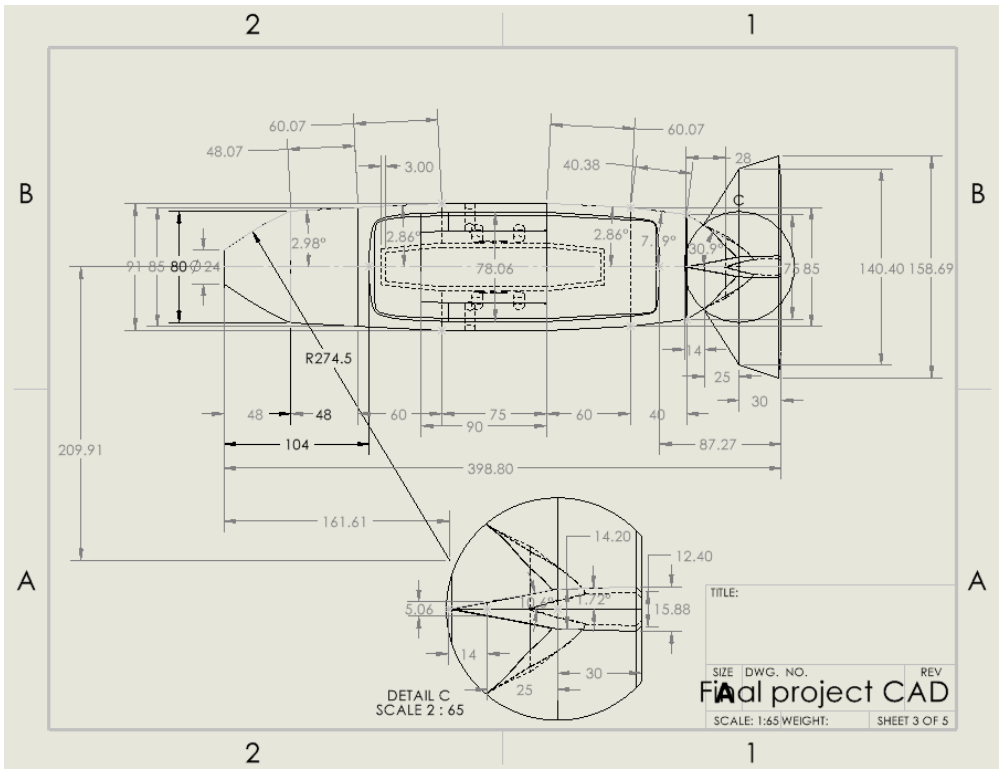
Every Part Drawing:

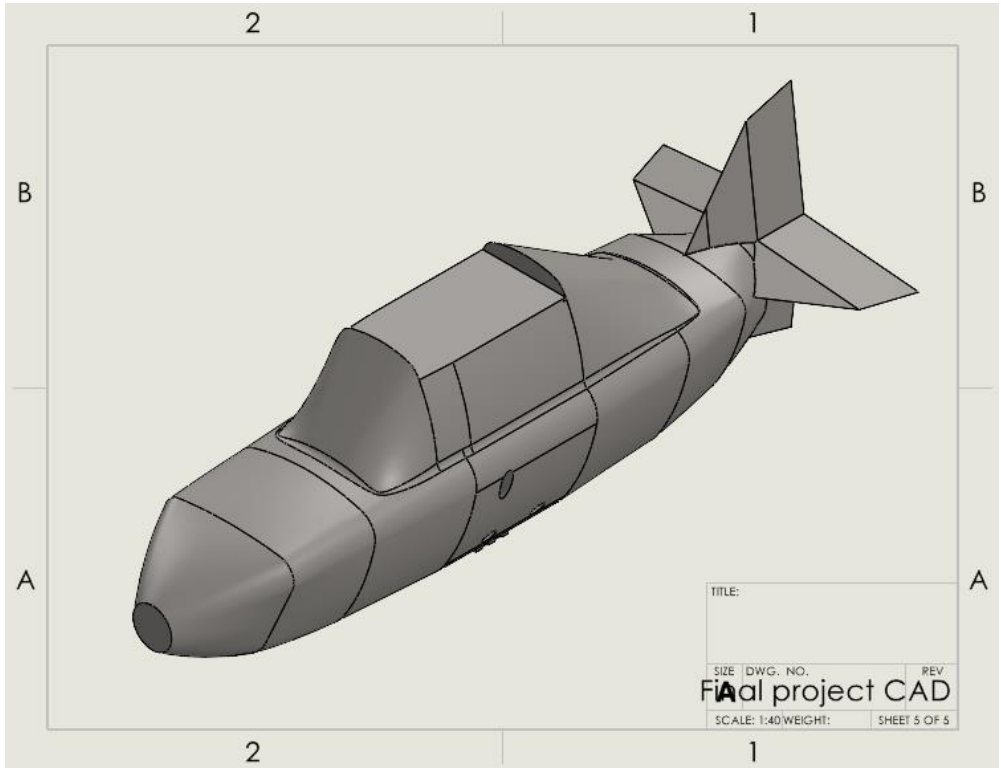
Plane Body:

All dimensions are in inches, pounds, and seconds but I had to split up the drawing into three different pages because of how many dimensions were needed to create this part. And dimensioning might be messy because of the lofts.



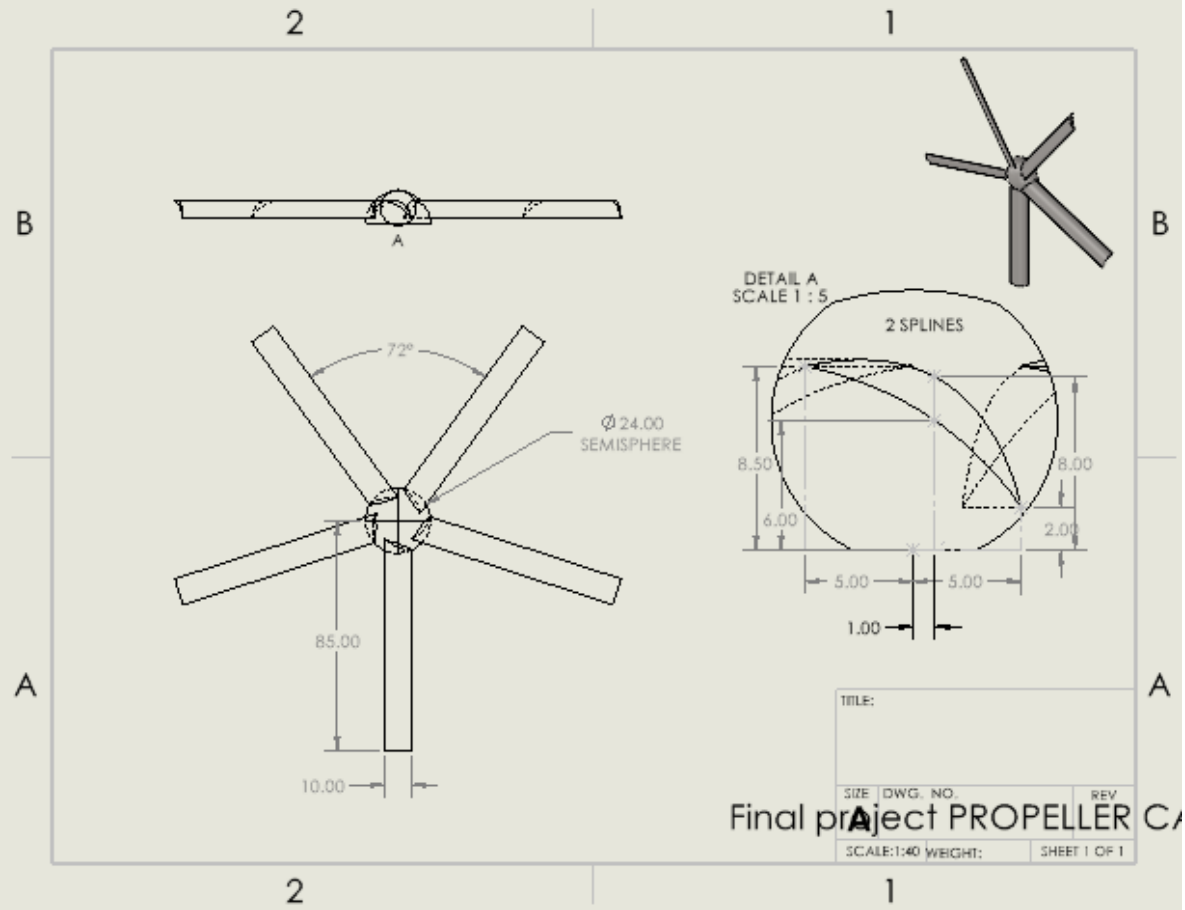



2
1
B
A
60.07
48.07
3.00
60.07
40.38
28
2.98°
2.86
2.86
7.9°
30.9°
91.85
80 Ø24
78.06
76.85
140.40
158.69
R274.5
48
48
60
75
90
60
40
14
25
30
87.27
209.91
104
398.80
161.61
14.20
12.40
5.06
1.72°
15.88
14
30
25
DETAIL C
SCALE 2 : 65
TITLE:
SIZE
DWG. NO.
REV
A
Final project CAD
SCALE: 1:65 WEIGHT:
SHEET 3 OF 5


2
1
B
A
TITLE:
SIZE
DWG. NO.
REV
A
Final project CAD
SCALE: 1:40 WEIGHT:
SHEET 5 OF 5

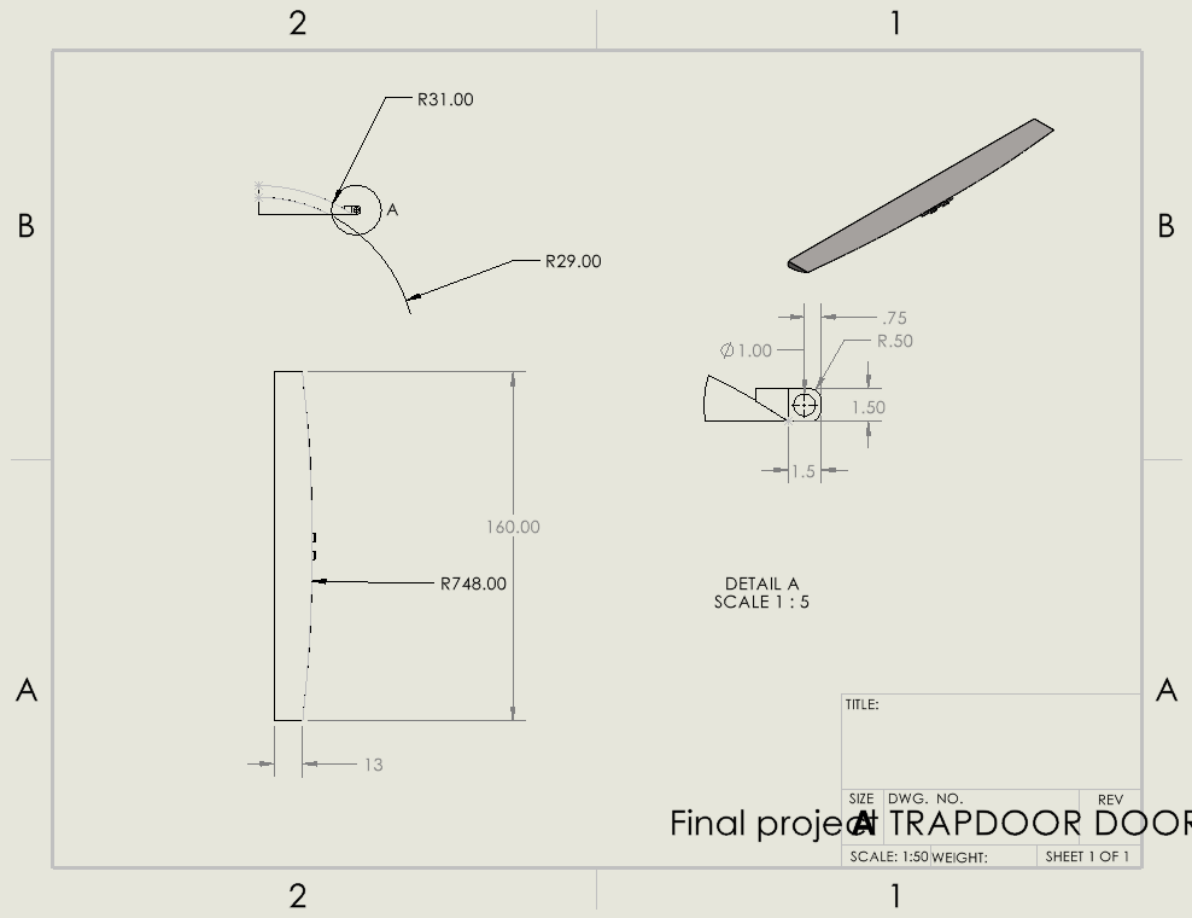
Propeller:

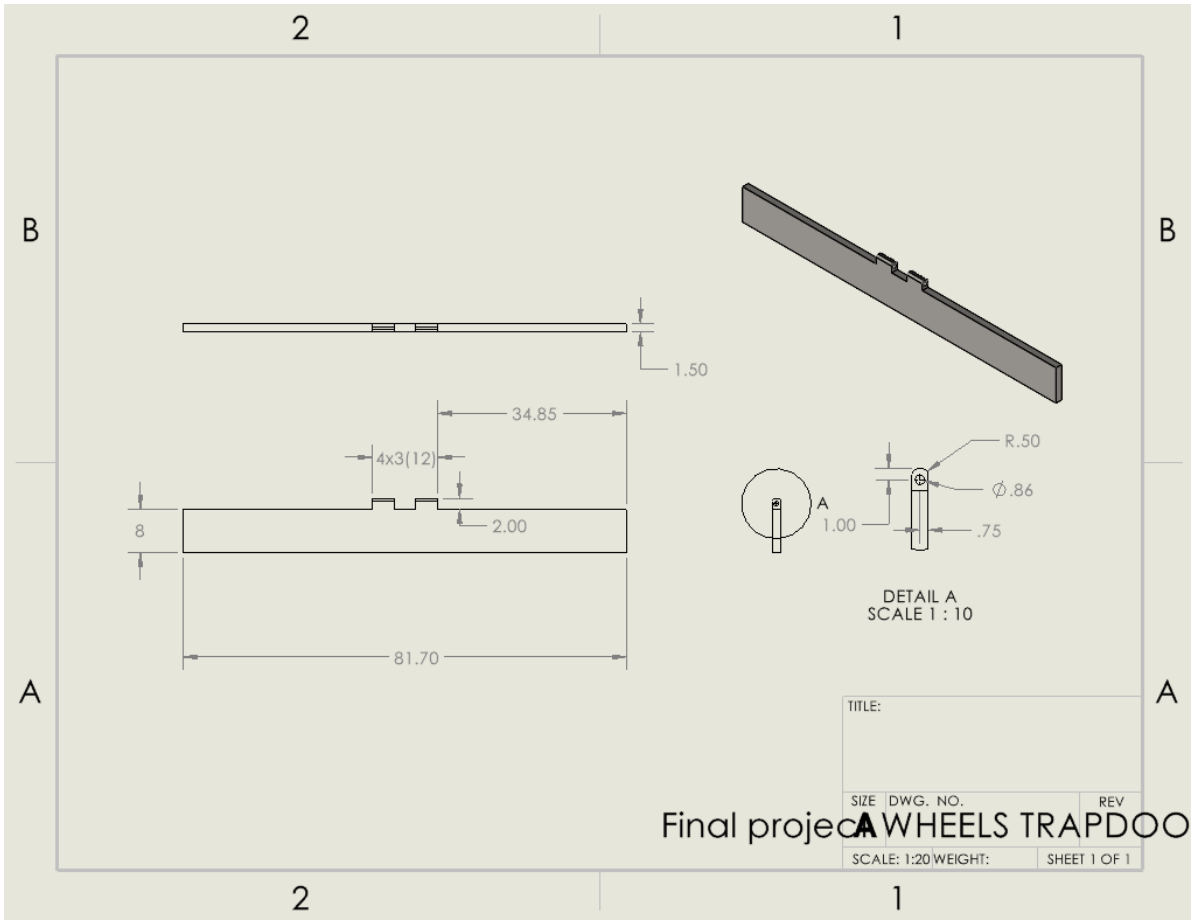
All dimensions are in IPS. The key feature for this part is using a spline for the shape of the propeller's blades. There are 5 blades, each 72 degrees apart, and a small semi-circle in the middle of the part.



Trapdoors:

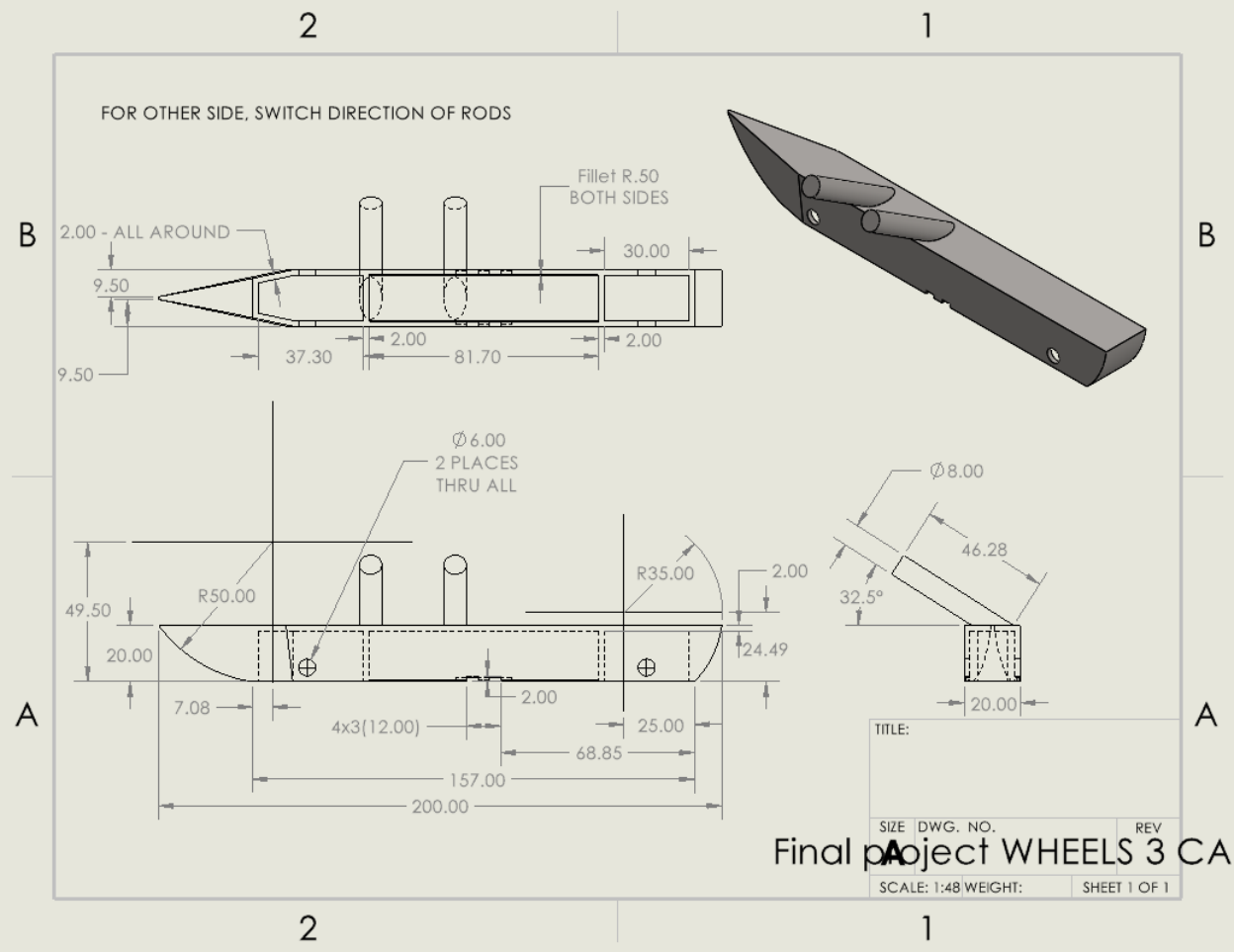
All dimensions are in IPS. The trapdoor for the body follows the body line for the main body so it might be better to cut them out from the body, but I tried my best to replicate the body lines with a couple of lofts. However, in drawings, lofts are difficult to dimensions and just used my best judgment to dimension these trapdoors.

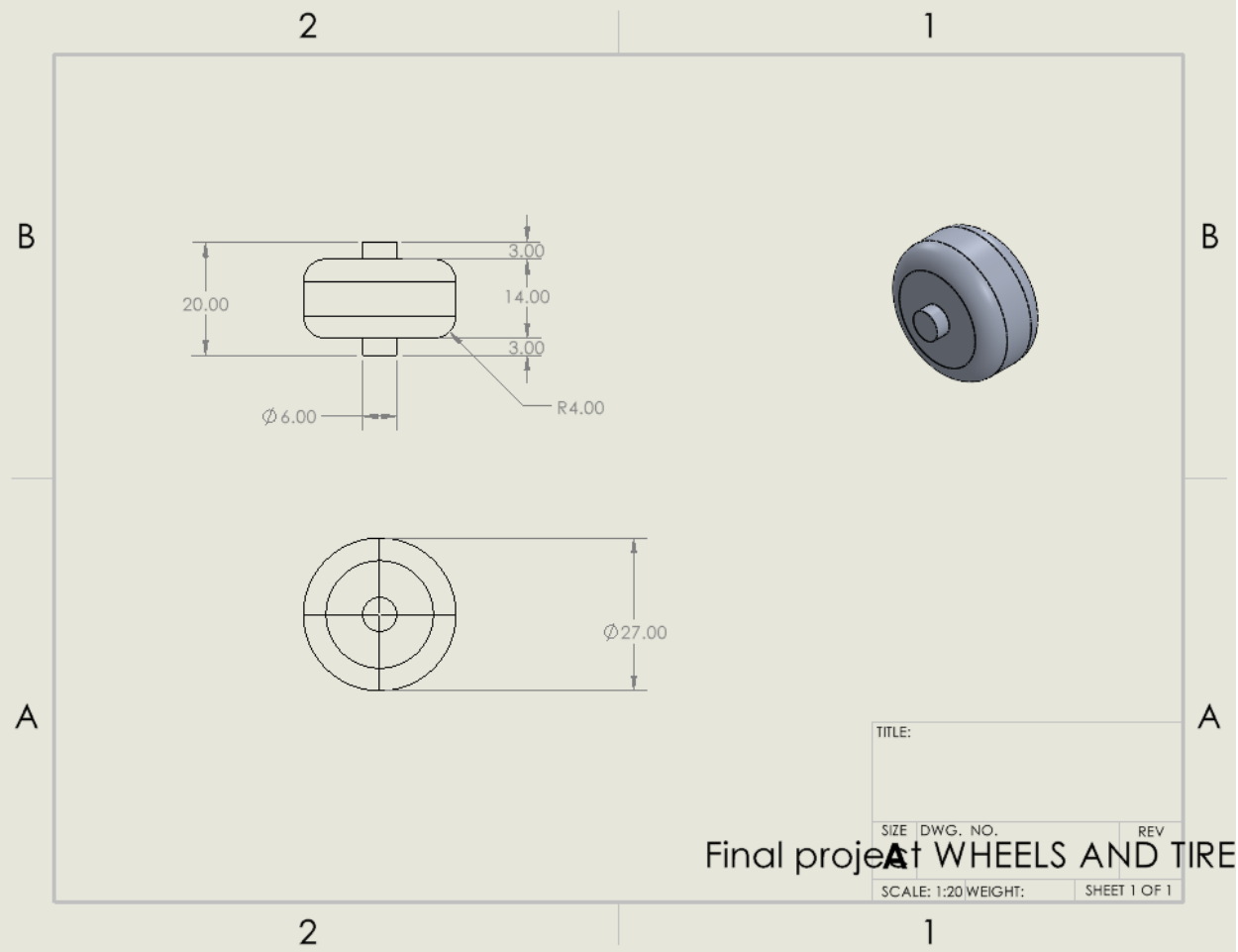



2
1
B
B
A
A
1.50
34.85
4x3(12)
8
2.00
81.70
R.50
Ø.86
A
1.00
.75
DETAIL A
SCALE 1 : 10
TITLE:
SIZE
DWG. NO.
REV
Final project WHEELS TRAPDOO
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1

Wheel Hub and Wheels:

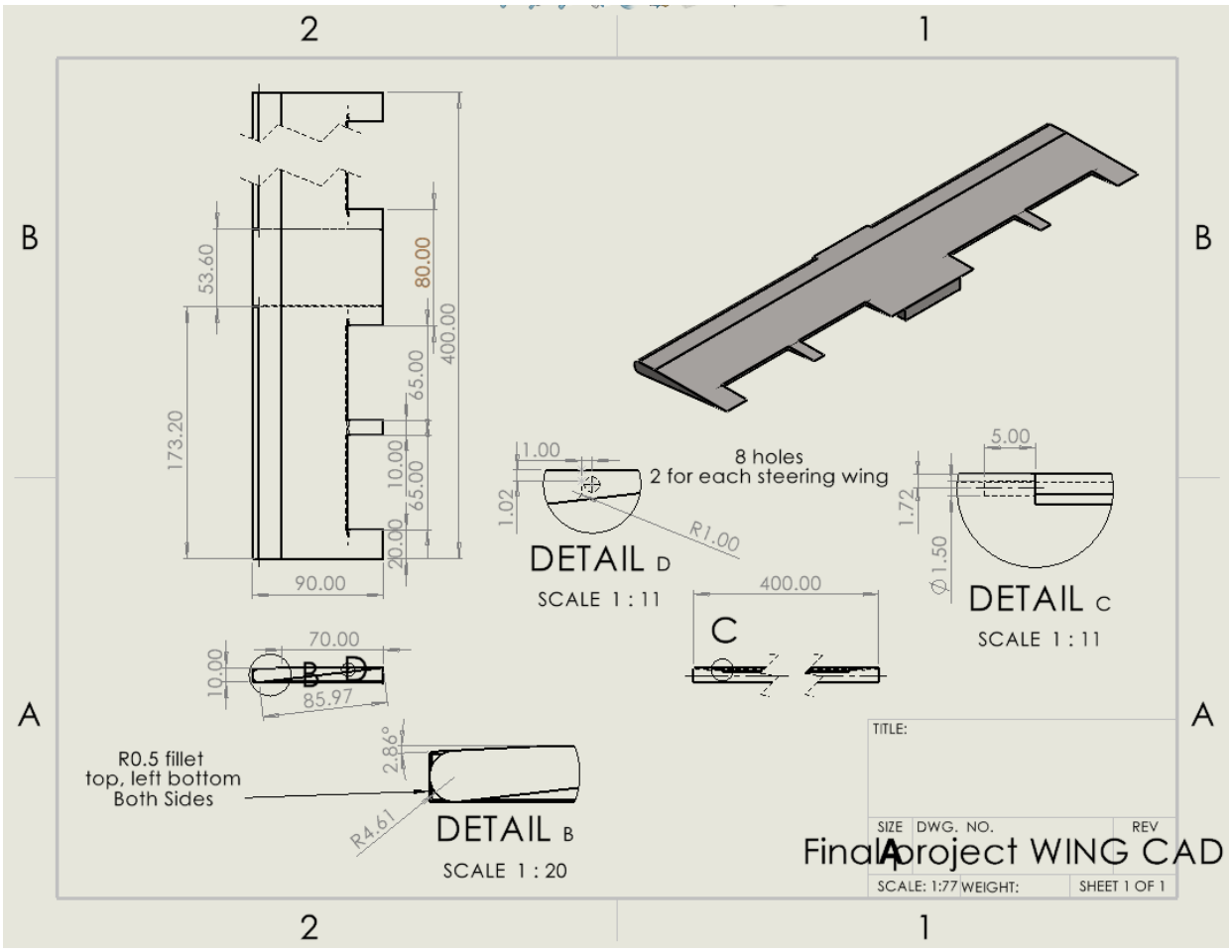
All dimensions are in IPS. Created to hold chemicals and the wheels, the wheel hub has strong supports that connect it to the body for maximum support and to use the additional space in the hub, a place to store chemicals was made. The wheels are made to fit inside the two other holes on each side of the storage compartments.




2
1
B
B
20.00
3.00
14.00
3.00
R4.00
Ø6.00
Ø27.00
A
A
TITLE:
SIZE
DWG. NO.
REV
A
Final project WHEELS AND TIRE
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
2
1

Wing and steering wings:

All dimensions are in IPS. The wing is designed as one piece for maximum support across the wing and is big to help fly the big body that it's attached to. The steering wings that are made to fit in the holes of the big wind are to help the plane turn in the sky and go whatever direction is needed.


2
1
B
A
53.60
80.00
400.00
65.00
173.20
10.00
65.00
20.00
90.00
70.00
10.00
85.97
1.00
8 holes
2 for each steering wing
1.02
R1.00
DETAIL D
SCALE 1 : 11
400.00
C
5.00
1.72
Ø1.50
DETAIL C
SCALE 1 : 11
R0.5 fillet
top, left bottom
Both Sides
2.86°
R4.61
DETAIL B
SCALE 1 : 20
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SIZE
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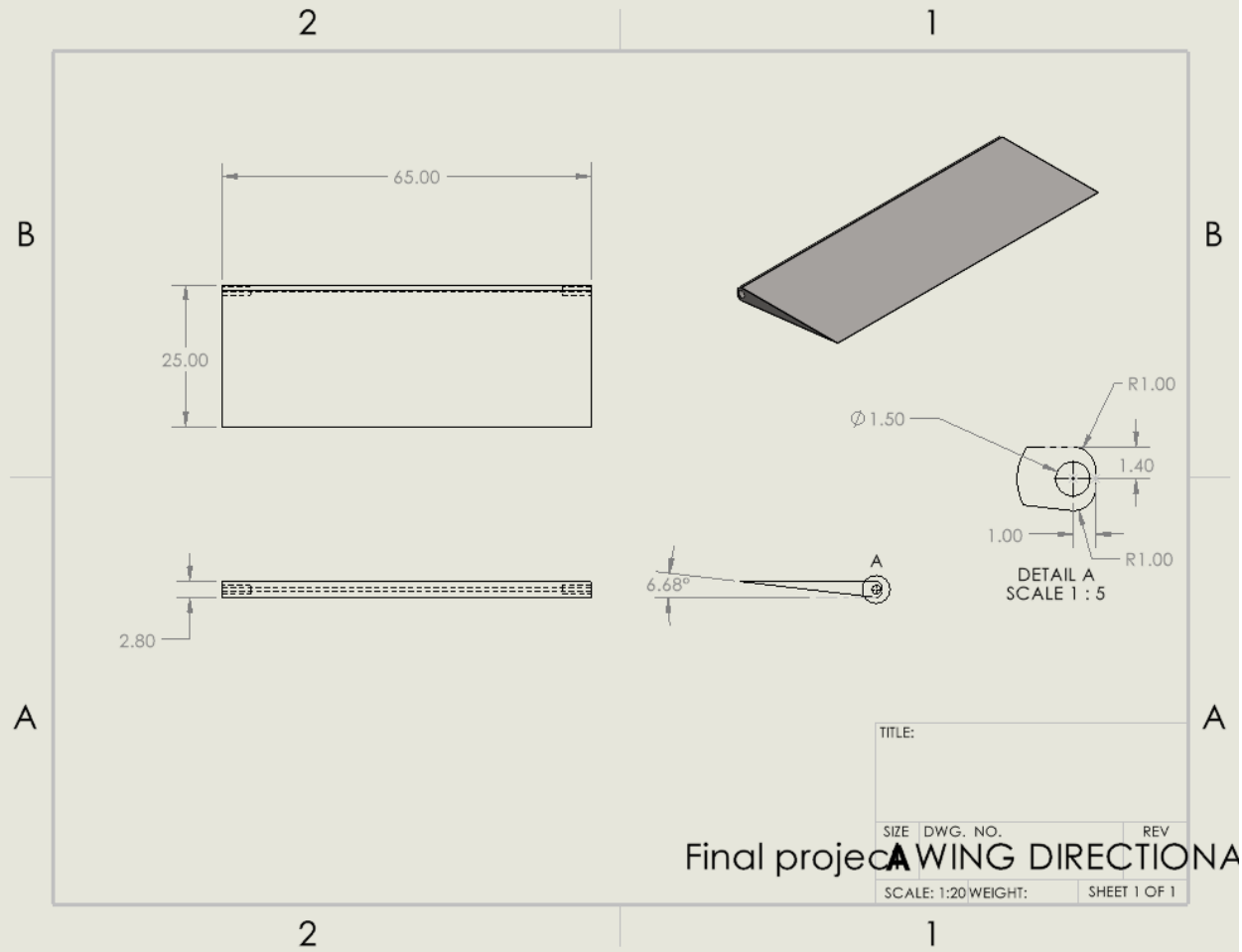
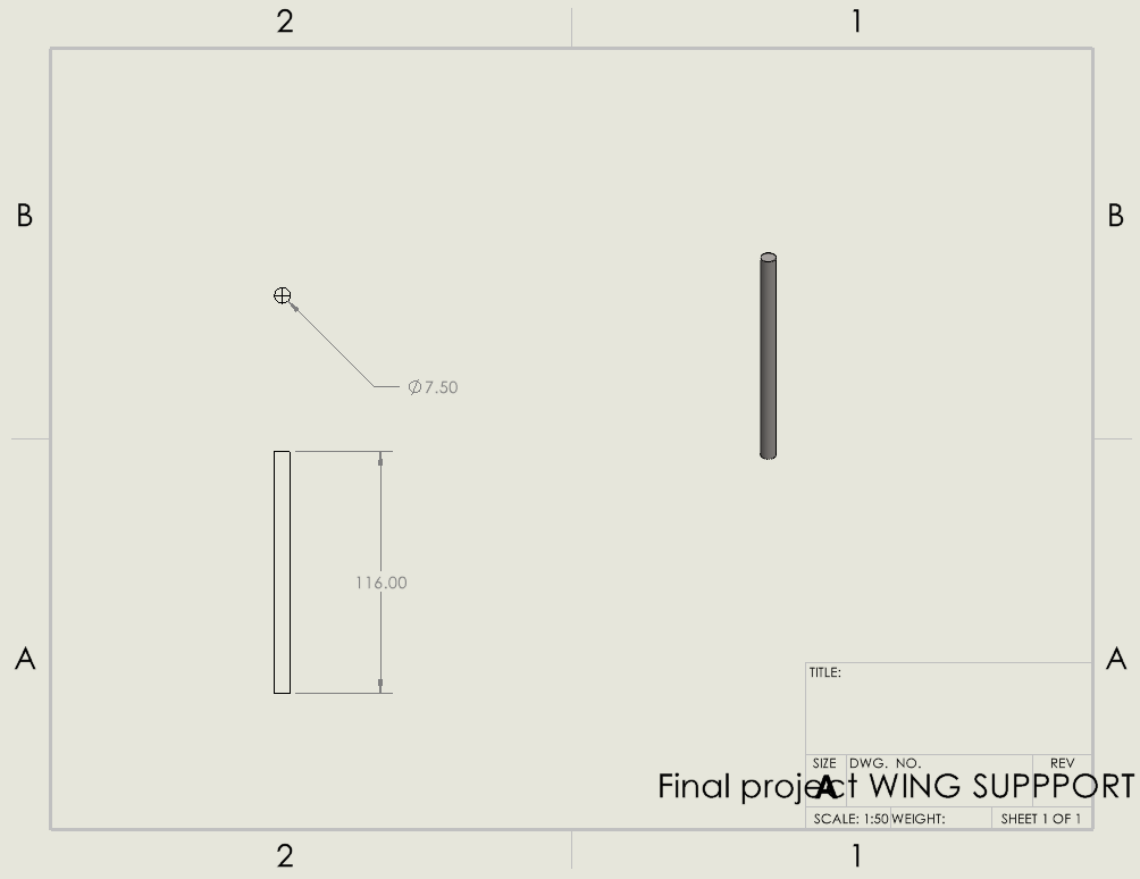
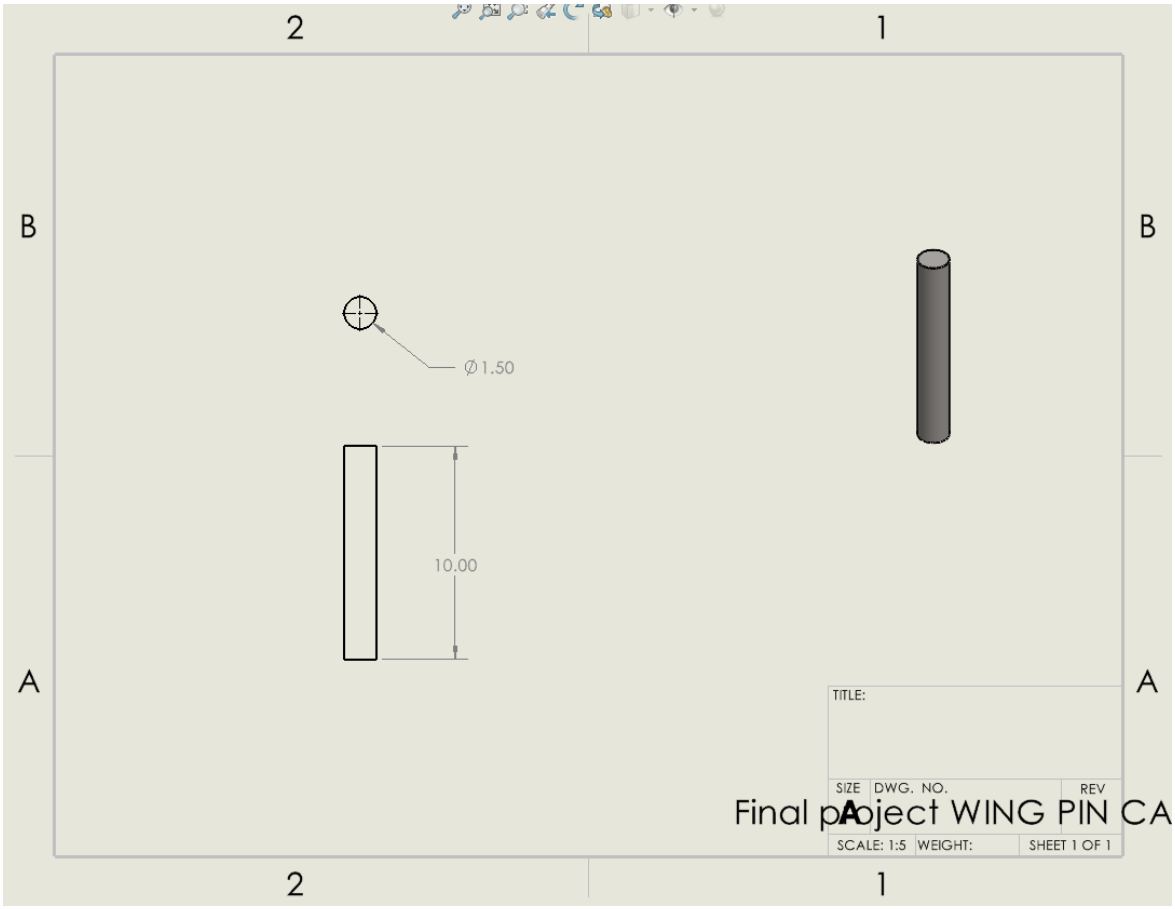
REV
A
Final project WING CAD
SCALE: 1:77
WEIGHT:
SHEET 1 OF 1

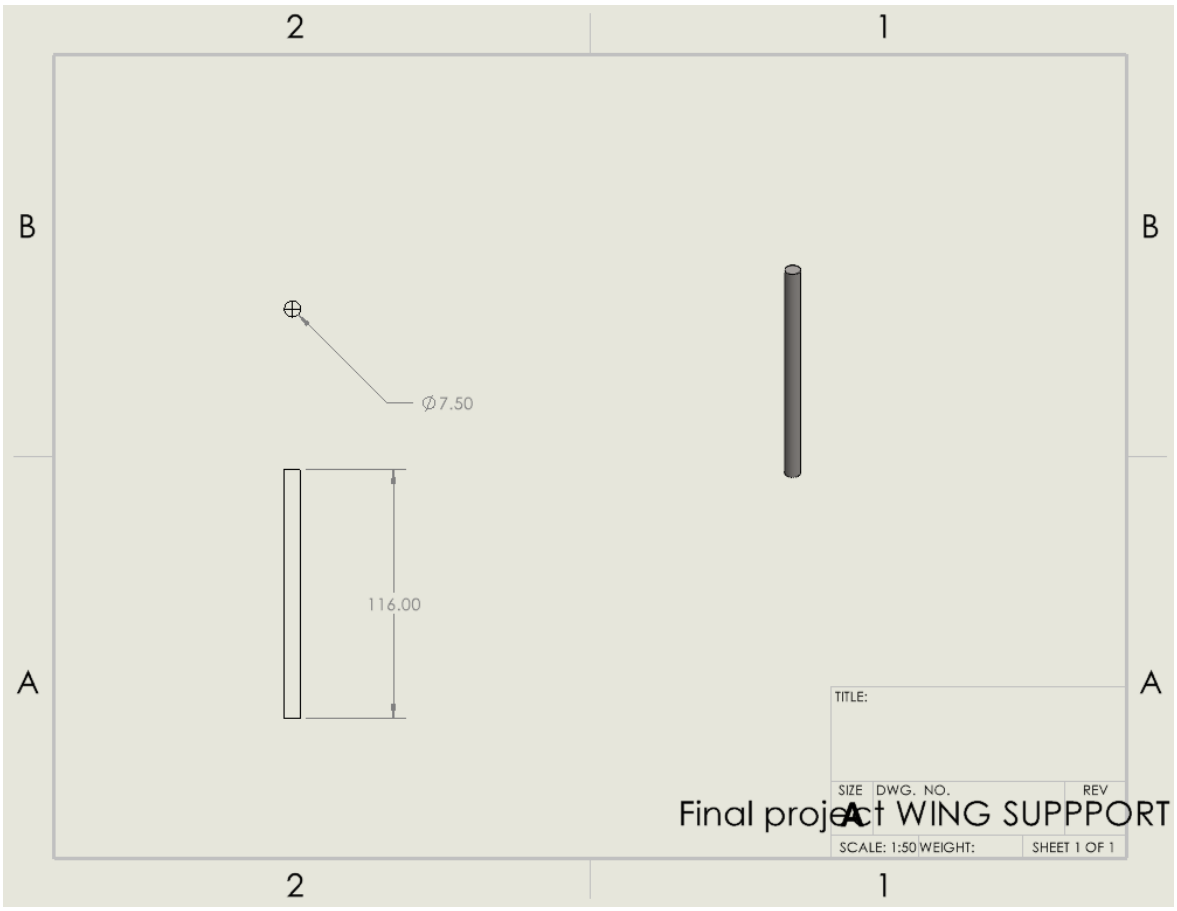

2
1
B
B
A
A
65.00
25.00
2.80
6.68°
A
Ø1.50
R1.00
1.40
1.00
R1.00
DETAIL A
SCALE 1 : 5
TITLE:
SIZE
DWG. NO.
REV
A
SCALE: 1:20
WEIGHT:
SHEET 1 OF 1
Final project WING DIRECTIONA

Supports:

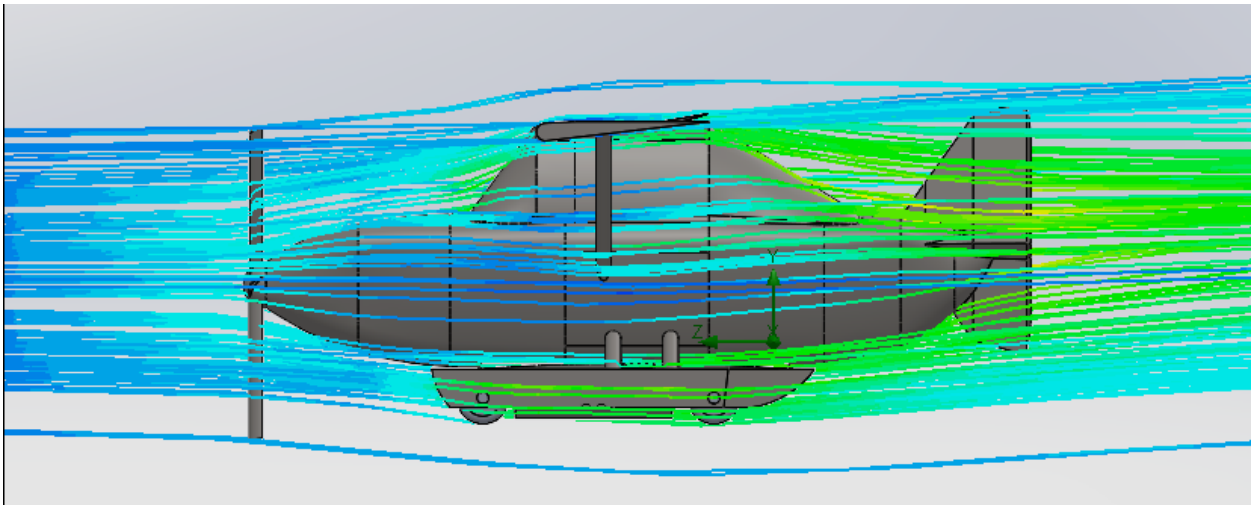
The supports are dimensioned in IPS. All supports were created to help the rigidity of the airplane in some places. Specifically, the wings, however, the rest of the supports are made to hold parts together. Mostly used in the trapdoors and steering wings, this will help the parts function together in harmony in order for the airplane to perform the tasks it needs to do.

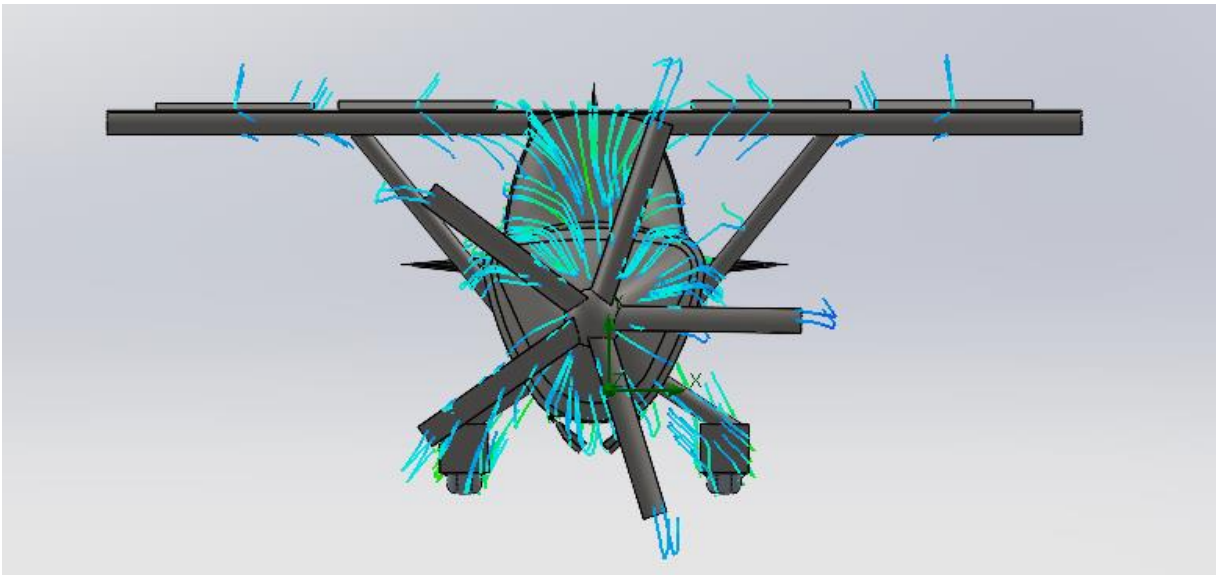


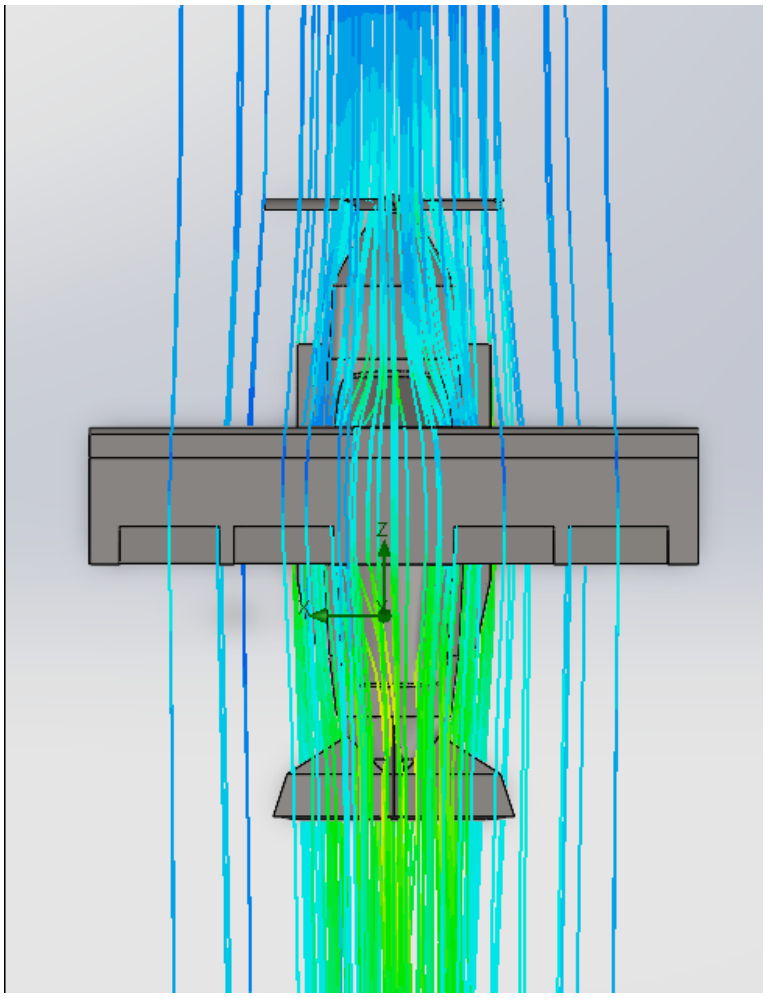

2
1
B
B
Ø1.50
10.00
A
A
TITLE:
SIZE
DWG. NO.
REV
Final project WING PIN CA
SCALE: 1:5
WEIGHT:
SHEET 1 OF 1
2
1


2
1
B
B
Ø7.50
116.00
A
A
TITLE:
SIZE
DWG. NO.
REV
Final project WING SUPPPORT
A
SCALE: 1:50 WEIGHT:
SHEET 1 OF 1
2
1

Analysis







The analysis that I ended up running on my CAD design was a flow simulation. I wasn't sure on how to test if the air could actually fly with no real engine or way to control the aircrafts lift and slope downwards so I analyzed if the design itself would cause any trouble flying if, theoretically it did fly, and what other force to test it against than air. From the flow simulation shown in the images above we are going to focus on how the air is diverted. I understand that the velocity of the air when it's leaving towards the back of the aircraft is slower but that's simply because of the things in the way like the body. However, like I said before, we are going to focus on how the air is diverted, which is what I'm sure most engineers look at to see if the object is aerodynamic. As you can see from the images, the air follows a perfect path alongside the body, and it even comes together at a point towards the rear. This is great because when flying most of that air that

is diverted around the plane will sort of be used as a boost to keep the plane flying smoothly. Next is the steering wings. From the images, you can see a slight disturbance in the air as it comes into contact with the steering wings of the airplane but that's exactly what we want. The wings will go up or down and cause some sort of wall for the air and the friction from the air will build up to make it turn. Lastly are the trapdoors where, as you can see, there also is a slight disturbance caused by them and with the way that air acts, it will try to fill up any space that is empty. So, when flying, all the pilot needs to do is open the trapdoors and the absence of moving air will be filled up by the surrounding air and the chemicals will be taken out by nature. No extra force is required which is great for efficiency.

Concluding Remarks/Future Recommendations

Overall, the design proved itself to be time consuming, but I would say that most features that were used in SolidWorks weren't hard ones to use. However, replicating this will most likely be a challenge with all the lofts. With that said, I would recommend to not stray away from using lofts as a command even though it can help create very unique geometrical shapes. It would just make it difficult for you to create the drawings and the person trying to replicate an even harder time trying to make all the right guidelines and sketches for the lofts. In that sense, it would be to better create an ellipse or even limit yourself to circles that are tangential to lines so that you can do a 360 or 180 rotation from there. Another big mistake which I did not take into account for was the number of splines that are used in this project. This made it extremely difficult to dimension in the drawings and for some it was best to dimension them as arcs. In conclusion, the next steps would be to refine the design in order to make it simpler yet with the same capabilities

just to make it easier replication-wise and timewise. After that is done, next would be to focus on all other components that make up the inside of the body such as the engine, interior, electrical components, and all the engines' accessories. This would essentially complete the airplane and who knows. Maybe this design could be a more efficient one than the airplanes flying over the crop fields now.

Appendix

I would just like to mention one of the inspirations for choosing this design and that would be Dusty Crop hopper from the movie Planes. Growing up, my family wasn't the richest and we were mostly a blue-collar family that worked every day to live here in the United States. I take pride as being a 1st generation student with immigrant parents and I understand how important the secondary education level is and what the engineers do for our country, but I will never forget the blue-collar roots that I have from my parents and how important those laborers are to this country. Making this airplane is meant to help these workers that are the backbone of this country.

SolidWorks Commands Used

Features Checklist

A minimum of 10 different commands should be used from the following table

Put a checkmark next to the features that you used

Boss/Base	
Extrude..	✓
Revolve..	✓
Sweep..	
Loft..	✓
Boundary..	
Thicken..	
Cut	
Extrude..	✓
Revolve..	
Sweep..	
Loft..	
Boundary..	
Thicken..	
With Surface..	
Features	
Fillet/Round..	✓
Chamfer..	✓
Hole	
Simple..	✓
Wizard..	
Draft..	
Shell..	
Rib..	
Scale..	
Dome..	
Freeform..	
Deform..	
Indent..	
Flex..	

Pattern/Mirror	
Linear Pattern..	
Circular Pattern..	✓
Mirror..	✓
Curve	
Split Line..	
Projected..	
Composite..	
Curve Through XYZ Points..	
Curve Through Reference Points..	
Helix/Spiral..	
Reference Geometry	
Plane..	✓
Live Section Plane..	
Axis..	
Coordinate System..	
Point..	
Center of Mass..	
Mate Reference..	
Grid System..	
Tables	
Bill of Materials..	✓

Any other features used for your work

Estimate number of features used in the project: 11