CAD in Mechanical Engineering

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Section 01

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Final Project Report

May 2019 / Group 8 Present

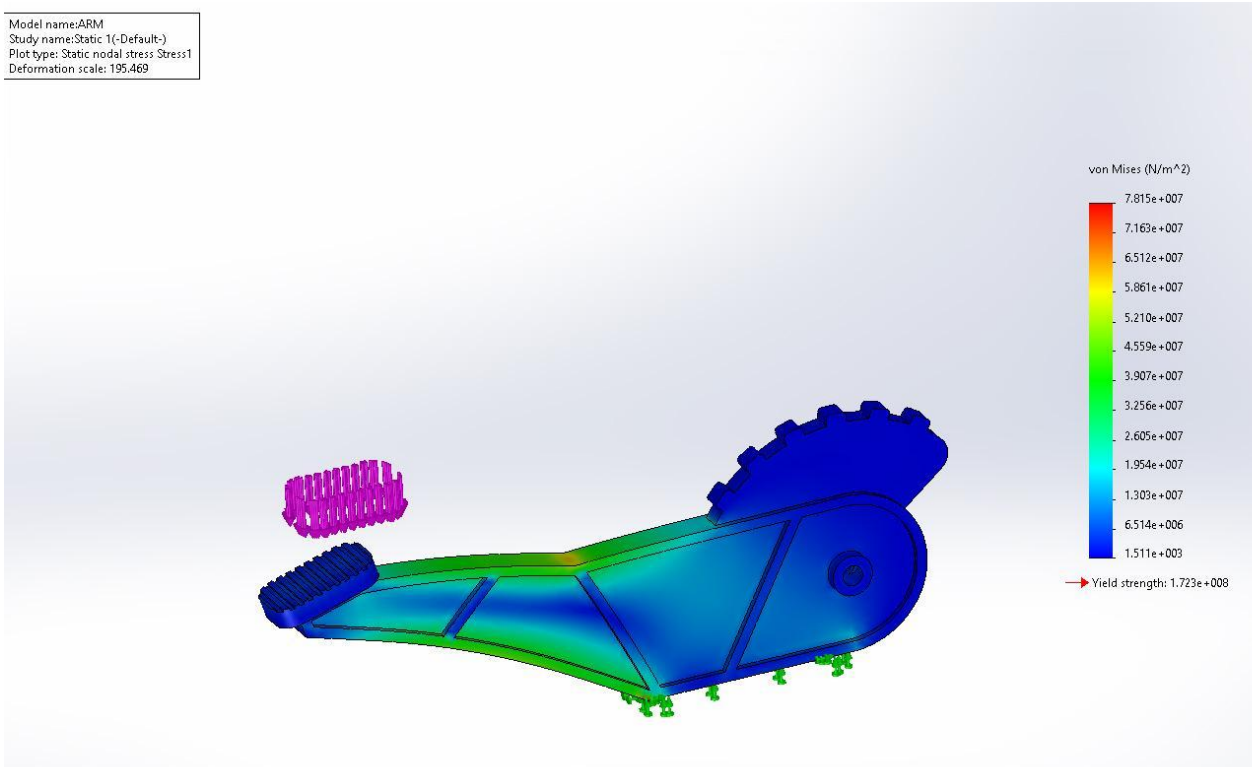
➢ Motivation & Components

The project we designed and created is, briefly, a drone with a robot arm and a piston. The drone we used nowadays in real life, is just used for aerial camera shooting, we want it to be different. The main idea of the whole project is, to make a special drone that can work in more different fields. As the proposal wrote, the drone is the basic component, we still need more additional parts to add on to realize a special, durable and multifunctional drone. Adding a movable robot arm that can rotate freely, and a piston part, which is attached to the bottom of the main box, we make the drone become a multifunctional tool and be suitable to work under different environment conditions rather than only flying and shooting pictures. Plus, we can

attach a proper size camera or other specific function of the light bulb to the piston, depending on the outside environment.

The main parts of the assemblies are: main body of the drone, 6 independent operation wings, 1 landing frame, 6 inside DC motors, 1 piston and 1 robot arm. Between the motors and wings, we applied gear mates, and, as for the arm, the rack mate is used on it to realize the hand being movable to grab object. Color of grey, black and white are mainly used for the whole appearance of the drone. The shield tube of the piston can used as a protection or waterproof box. Additionally, to get more scientific and realistic design, the material we plan to apply to the Main Body of the drone is Titanium, a lightweight, strong and corrosion resistant metal. For Robot Arm Pincher, is Stainless Steel, having both the strength of steel and corrosion resistance.

The Movable Pincher FEA will be attached below, while it is grabbing a 10-kg object:



➢ Distribution

(Repeat Parts count as ONE Same Part)

- ***Ava Zawacki***: (Total 8 parts)

Main Drone Body: Hex top, Hex bottom, Main box, Middle connection, Side connection, Bottom connection plate

Inside DC Motor: Magnet in motor, Motor gear

- ***Zhijing Hu***: (Total 26 parts, 2 Type of Mechanical Mate)

(Assemble all parts and assemblies & 3 Animations)

Wings: Fan Rod, Fan gear, Wing Frame, Wing Bridge, Drone Fans

Landing: Landing frame, Landing Rod, Landing Feet, Back frame, Landing-Body rod

Screws: 4 Different screws (Ø15.0 mm Wing Bridge, Ø8.0 mm Side body, Motor Shield & Hex), General nut (Ø8.0 mm)

Outside Motor: 4 Different Outside Motor Shield (Top1 & 2, Shield, Motor container), Motor Rod, Motor gear

Connection: Body-Piston connection rod, Body-Piston connection box, Body-Arm connection box, Body-Arm connection rod

Robot Arm: Fixed Pincher

***Mechanical Mate:** Gear Mate in wings (between Inside Motor and Drone Fan), Rack Mate in rack rod (with *Huan)

- ***Huan Min***: (Total 12 parts, 1 Types of Mechanical Mates)

  Robot Arm: Rack rod, Movable pincher piece, Pincher base, 5 Different Arm body, 4 Different Arm connections

  ***Mechanical Mate:** Rack Mate in rack rod (with *Zhijing)

- ***Sara Atzbi***: (Total 9 parts)

  Piston: Piston Shield, Piston main body, 4 Different connections in piston, 2 Different arm of the piston, Connection rod (attached to the main bottom of drone)

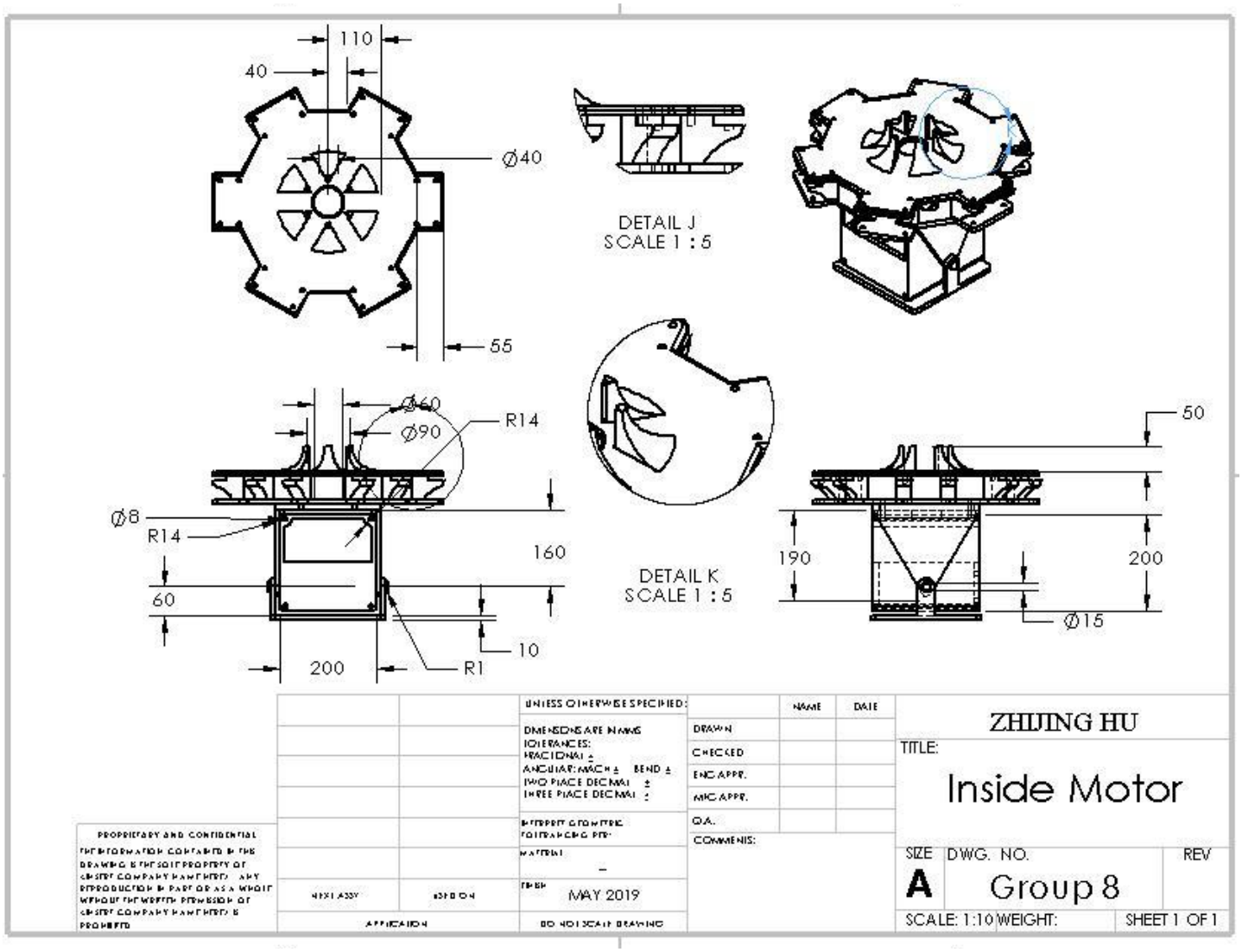
- ***Joshua Salmon***: (Total 7 parts)

  Inside DC Motor: 2 Different inside motor shields (Inside motor top & bottom), Coils, Motor brush, Middle brush pool, Top bearing, Side slice piece

➢ Description

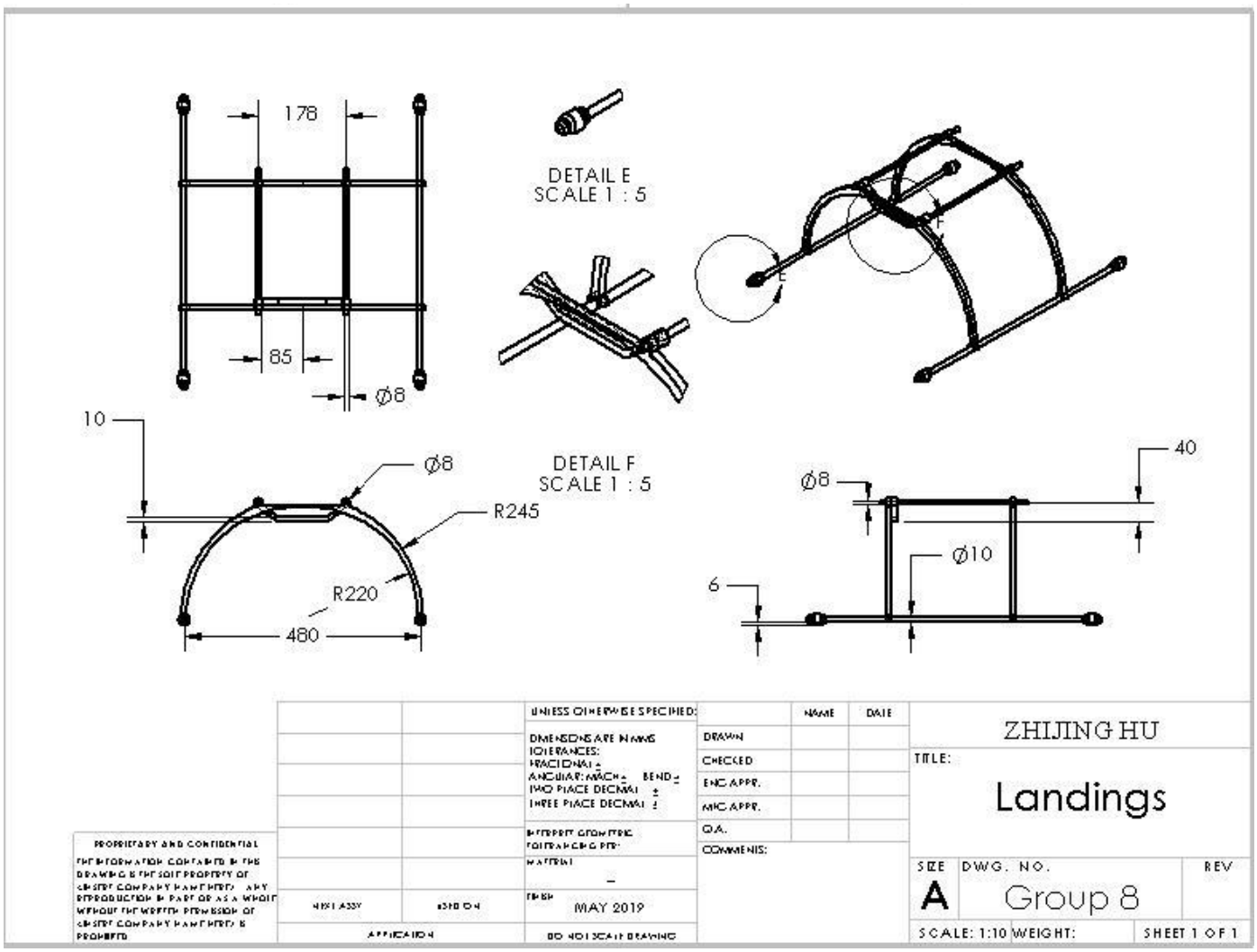
(A) Parts & Drawings

➢ **Main Body**



The main body consists of 6 parts, which can be built easily through Extruded Boss/Base. Next, use Extruded Cut to create the holes and space for screws insert and main hollow box room. The only tough thing is the Hex bottom. 4 construction lines have to be made, separated by 30 degrees and totally form a 90 degrees sketch. To create main hexagon, based on one piece sketched on construction lines, we used the Mirror Entities to get the whole hex and rest of screws holes. The limited distance is fixed to leave enough space for the Connection Bridge, which is mainly created by Extruded Boss/Base and Circular Pattern to fix.

➢ **Landing Foot**

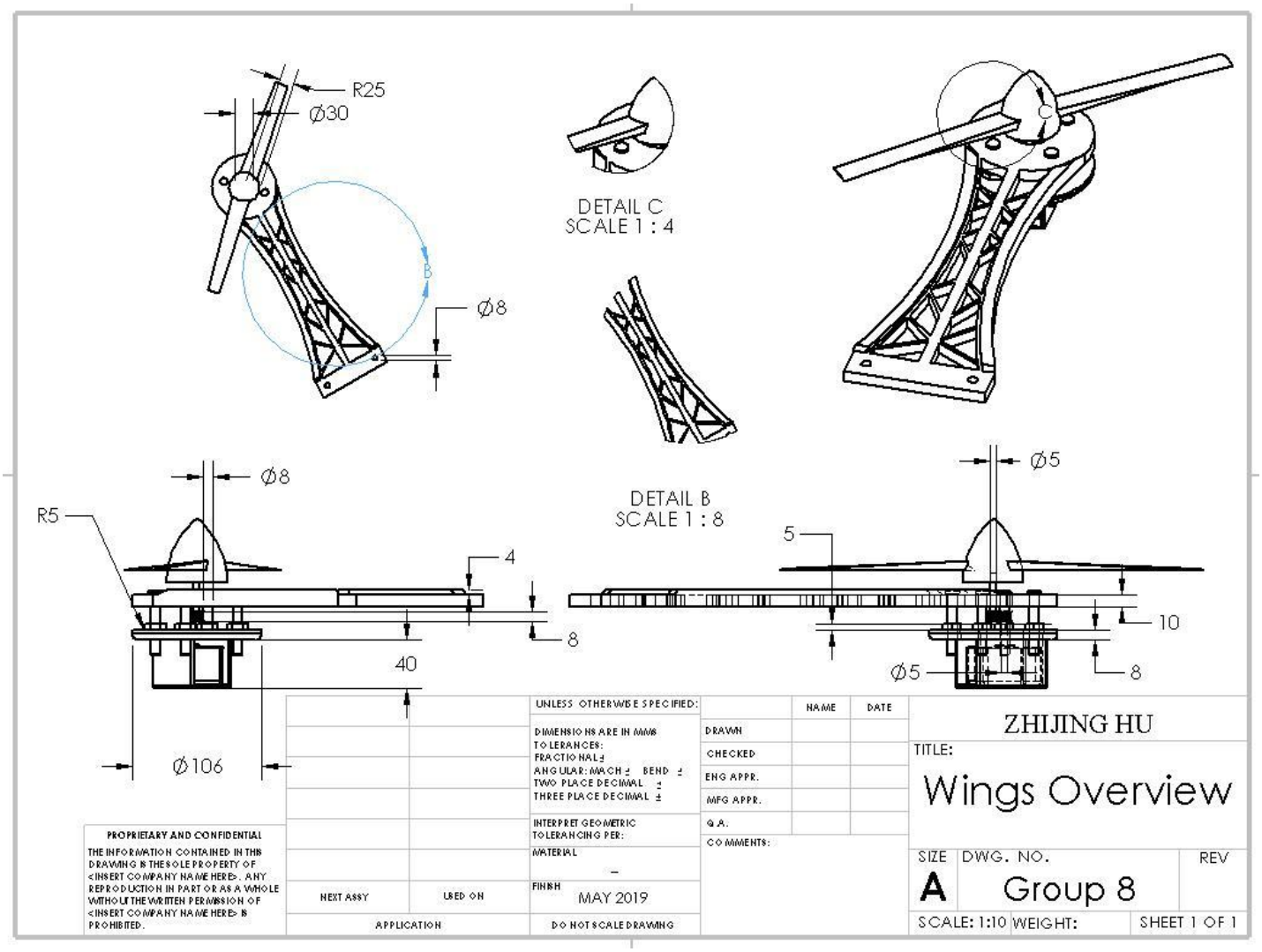


2 Landing Rods, 4 Landing Feet and 2 Connection Rods can be quickly and easily done by Extruded Boss/Base or Revolved Boss/Base depending on the cross-section sketch. Plus, the Back Frame can be built, based on the distance of two connection rods, by following Mirror Entities and Extruded Boss/Base.

For the left 2 huge Landing Frame, the difficulty is mainly about the height. It is greatly and scientifically depended on the attached piston. In order to realize the goal: a freely movable piston, we tried several times to change the size and dimensions for the

piston to make it fit into both the connection part and the landing frame height. The frame in built through Extruded Boss/Base and Copy Mate to fix.

➤ **Wings & Fans**



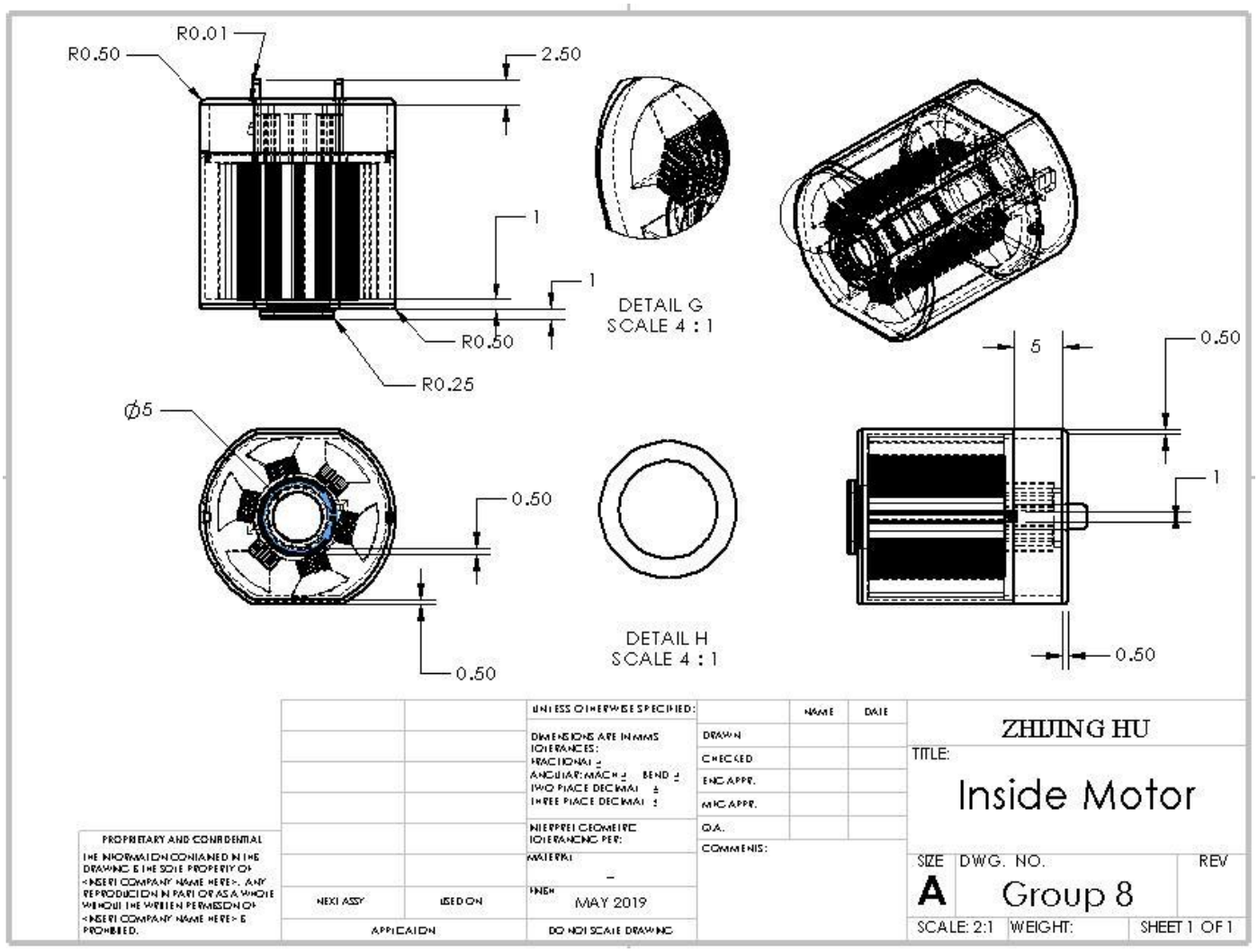
For Wings & Fans part, firstly, a specific sketch is required to design a wing frame. Wing Frame has a plenty of figure patterns on that, as shown in the Engineering Drawing Detail B, which basically can be done by Extruded Cut after drawing a scientific and attractive shapes. The small edges can be formed through Extruded Boss/Base. The

difficulty to build the frame is mostly focusing on designing and drawing. Thus, 30 and 45 degrees are mainly used to draw the triangles and trapezoids in order to simplify designing.

Drone Fan is created by Loft tool by setting two geometric reference planes with two fan's cross sections, one specific guideline as well. To connect the outside motor and the drone fan, the gears with rods are required to build. Gear Mate is applied to drive the fan, and the ratio is 1:1000, which will be explained in detail in Mechanism part.

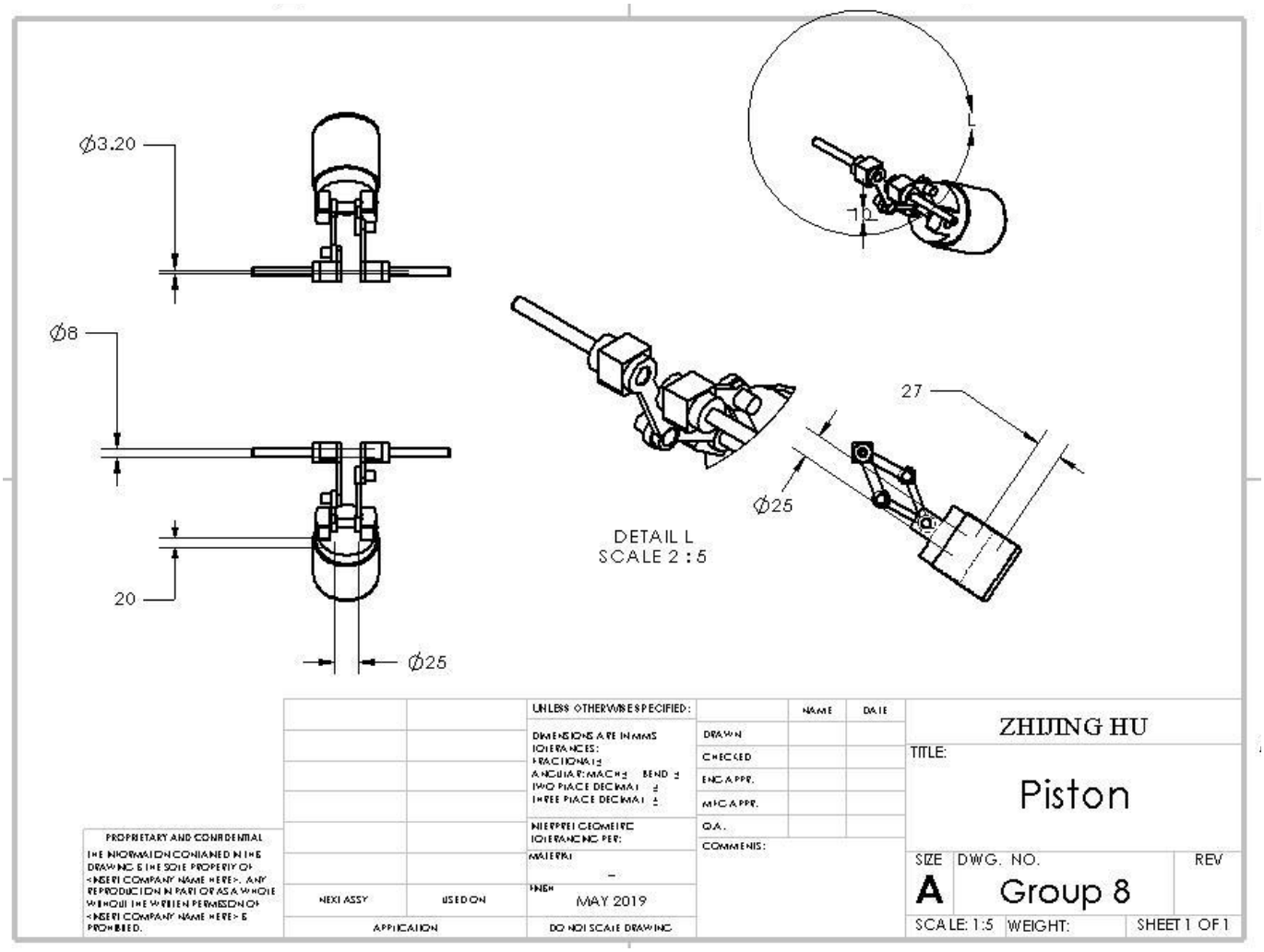
To connect and fix the Outside Motor Shield, 4 Screws with, 4 or 8 Nuts, need to be built. Use the Extruded Boss/Base to build the main body of the screws. Fillet tool is followed to make the touch top. Nuts and Outside Motor Shield can be easily designed and built with the proper dimensions through Extruded Boss/Base and Extruded Cut.

➢ **Inside Motor**



Extruded Boss/Base and Circular Pattern are used to build up the entire inside motor. Shell Tool is used for creating the shield. It's complex to build up a real coil, therefore, the solution is created one small coil section and copy several of itself to form up a large coil. Fillet tool is applied to make the shield edges.

➤ **Piston**

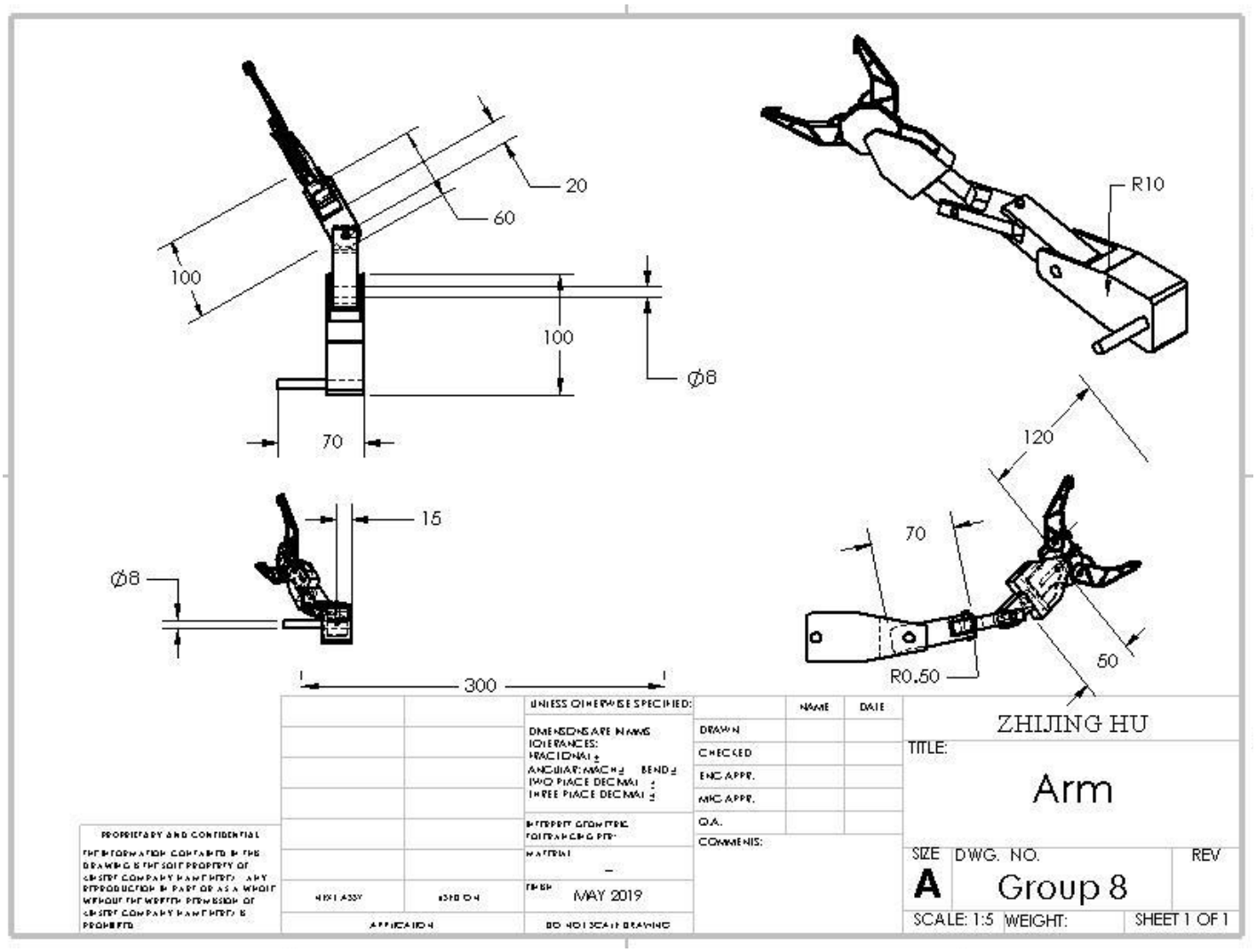


A movable and free rotate piston is made of 4 pieces of connection bars and 3 pins. The connections with main body are required 2 cuboid box and 2 connection rods, which can be made by using Extruded Boss/Base and Extruded Cut. Fillet tool is used for the Top Shield edge and also the cuboid edges.

The Connection Bars can be formed through Extruded Boss/Base after drawing proper sketches. Use the specific dimensions for Extruded Cut to get holes for Connection Pins, which are also can be easily made of Extruded Boss/Base or Revolved Boss/Base.

The main difficulty we met in this part is the motion of Connection Bars. We set the proper limited angles between each plane of the Connection Bars, which can be a good approach to prevent them open with too large angles.

➤ **Arm**

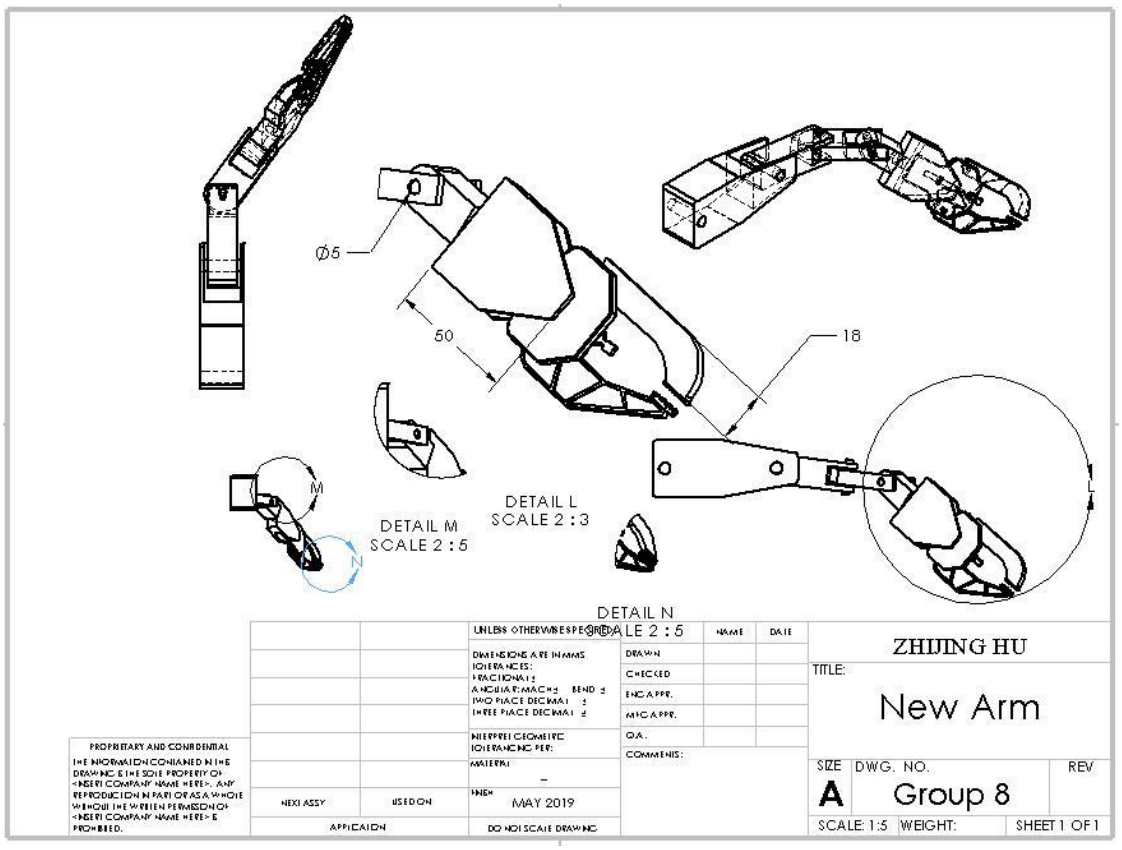


The Engineering Drawing above shows the original design of the arm; however, we did have a serious trouble on assembling it. The difficulties we encountered this part are: one is a plenty of mate relations we have to set. And when we are trying to assemble it to the whole project, there were huge amounts of conflicted mates, showing over

defining the components, and that is the main reason that we give up assembling two movable pincher hands. Instead, one movable pincher and one fixed pincher are built, the NEW engineering drawing attached in the following text; the other one is the Rack Mate.

The robot arm is a brilliant idea to add new Mechanism Relations, Rack Mate on the entire project. The Rack Mate will be introduced and explained in the following mechanism part. The Connection Pin can be easily built via Extruded Boss/Base or Revolved Boss/Base based on the sketches and dimensions that required to connect 4 pieces of arm body. Extruded Cut is applied to cut enough space for the arm connections.

The solution for the problems we encountered are: we directly assemble the arm pieces part to the whole project and redo the mate relations, and then we assemble a fixed pincher hand instead of one original movable one. It takes a long time to make this decision and we are going to insert another new Engineering Drawing of the NEW ARM below after the adjustment. For the other one, the mechanism part will go through it.



(B) Mechanism

The main mechanism relations we applied in the whole project are: Gear Mate and Rack Mate. First of all, in order to make the drone fans work well while the DC motors are driving, we apply the gear mate between two gears in original wing assembly, one is at the end of the motor rod and the other is at the end of fan rod. Scientifically, the motor has to transfer the kinetic energy through the gear to the drone fan. To modify the driving rate, since we cannot easily and directly show the real rotation rate through the SolidWorks, we approximately set the teeth ratio as 1:1000 (Motor Gear : Fan Gear) to illustrate the fast fan rotation speed. Repeat the assembly procedure, connect the rest of the wings. All 6 drone fans are connected with own independent DC motor, which can be

remote controlled to get different rate of rotation, then achieving changing both flying heights and directions.

Secondly, in robot arm, we also apply the gear mate to restrict the motion of two pincher pieces. When one piece moves, the other one moves symmetrically. By restricting the angle of the pincher piece plane, also, we can make the pincher open and close within a proper and specific angle ranges. Then, move on to the rack rod. The rack mate is required for completing the mechanism here. Applying the rack mate both on rack rod and one pincher piece, we can make the pincher pieces move while the rack plate or rod moves. The robot arm is operated manually, grabbing tolerable masses or objects.

Overall, the only difficulty we have encountered, is mainly on the rack mate. This special mechanical mate hasn't been introduced in the class; thus, we don't have any practice on that. We made some searches on the website and finally discover some tutorial videos about the rack mate, which help us to get some practical knowledge about this mate relation. Due to the shape of the rack rod, although we successfully set the rack mate in the end, it may still not perfectly match the edge of the rack rod when the pincher pieces are doing the motion (Plus, the videos didn't achieve their work either).

(C) Animation

There are two different animation works we have done for the project: Trial animations and Final Animations. For the trial animations which we showed in the presentation slide, we selected and created two trial animations to display our project:

Overview and Arm Part. The overview animation takes about 1 min, and the other is around 15 sec.

The script of the overview animation is, firstly, going through different normal perspective by rotation animation (Isometric, top, back view etc.). Our next step is, zooming in one specific wing and apply explore view on it, showing the outside motor then follows the inside motor. Then, change of the view, move to the piston attached below the main box. We show the 4 connection of the piston can move freely, rotating and zooming out the whole drone view back to trimetric view. The second animation follows the script: going through an overall view and show how the pincher work. We did roughly on the second animation, in order to leave as much time as possible to go on the presentation.

Before the Final submission, we created another NEW one. The NEW version of animation will take 1 min to go over through every detail of our final project.

The NEW animation is basically combining previous two trial animations into a more detailed and completed one. First 10 seconds, the overview of our drone from different Display Perspectives: isometric, front, bottom and top views, mainly display the important components of the whole drone. Then we zoom in to one specific and clear wing part. A motor is required to drive the motor and drone fan, then follow the Explode View of the entire Fan and Motor to show the inside motor's construction. After fully collapsing the exploded parts, we move on to the piston part. Do some motion of the piston arms to show the movable piston is designed and then we turn our focus to the robot arm. Apply some motions or motor to move the arm components, then drive the

arm and pincher to move. After every session of display, we zoom out and turn on every six drone fans to display the final session of the overview animation.

Summary

The chance for a teamwork final project provides us with a precious experience to work with classmates. It's also another opportunity to make new friends and take practices on build-up CAD ability. We shared the ideas for the proposal, thought what we need to do for the checkpoint together, as well as helped groupmates to solve the difficulties we had faced with while doing our own parts. We learned the significance of being responsible for own part work and get prepared for have a better time arrangement awareness in the near future.

Going through every feedback the professor gave us, we made several group discussions to assign the work with the purpose to realize a satisfying group project. The future improvement can be made, if we have more time, for our project, are:

1. Apply more specific, physical and proper materials to the total design through the simulations and tests;
2. Improve the drone's appearance;
3. Add a container for the robot arm after grabbing small objects;
4. Make the proper dimensions for the inside motors to make them fit the outside shields;
5. Create another mechanism relation on piston (Gear mate or Slot mate) so that it can be remoted through a more direct and scientific way.