AME 308 PROJECT

April 24, 2024

Raven Colbert, Andrew Danser, Raul Torres Jr., Henry Glover

AME 308 Project

April 24, 2024

Group Members:

Raven Colbert
Andrew Danser
Raul Torres Jr.
Henry Glover

Raven Colbert – Designed upper motor and propeller; completed drawings for upper motor, propeller, main body, assembled motor explosion, and assembled drone explosion; completed FEA; Final edit for document and PowerPoint.

Andrew Danser – Designed main body, battery clips, camera, propeller guard and assembled components together.

Raul Torres Jr. – Designed bottom motor and caved in feature, complete drawings for bottom motor, motion analysis with friction, movie links with addition movie of comparison, Final edit for Document and PowerPoint.

Henry Glover – Designed battery assembly, completed drawings for battery assembly, completed motion analysis without friction, Gantt chart, final edit for document and PowerPoint.

Gantt Chart

PROJECT: AME 308 CAD Project

Siemens NX

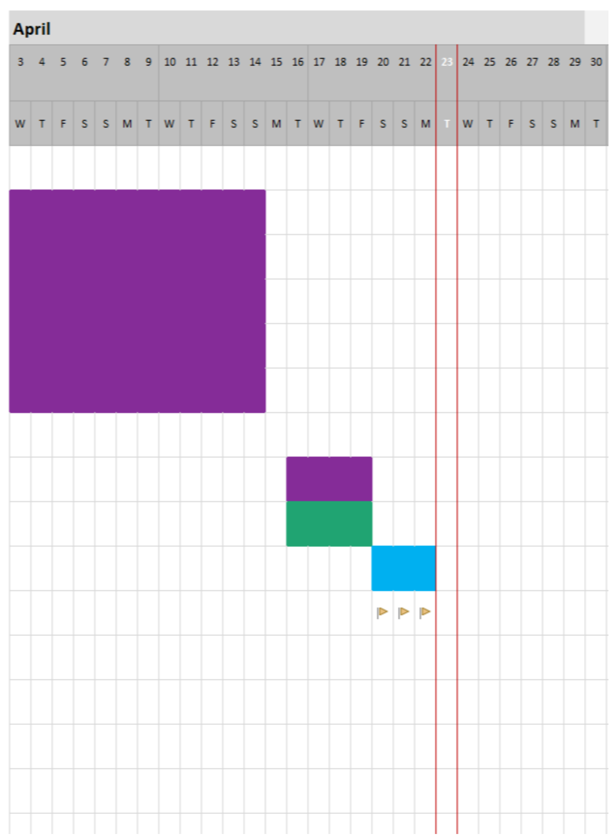
Henry Glover, Raul Torres Jr., Andrew Danser, Raven Colbert

Project start date: 4/3/2024

Scrolling increment: 0.5

Legend: On track | Low risk | Med risk | High risk | Unassigned

Milestone description	Category	Assigned to	Progress	Start	Days
Part Assembly and Drafting					
Bottom_Half_Motor	High Risk	Raul Torres Jr.	100%	4/3/2024	13
Center_Body_Assembly	High Risk	Andrew Danser	100%	4/3/2024	13
Upper_Half_Motor_Propeller	High Risk	Raven Colbert	100%	4/3/2024	13
Upper_Half_Motor	High Risk	Raven Colbert	100%	4/3/2024	13
Battery_Assembly	High Risk	Henry Glover	100%	4/3/2024	13
FEA, Motion Analysis, Report, Presentation					
FEA Analysis	High Risk	Raven Colbert	100%	4/16/2024	5
Motion Analysis	On Track	Henry G. and Raul T.	100%	4/16/2024	5
Report	Low Risk	Everyone	100%	4/20/2024	4
Presentation	Milestone	Everyone	100%	4/20/2024	4



Engineering Drawings:

- Include Center of mass for whole assembly: (0.0182, -0.0181, -8.5224)
- Mass: 0.0203kg

Bill of Materials

NO.	PART NAME	QTY	MATERIAL
1	FINAL_Drone_Assembly1	1	Polyethylene
2	propeller	4	Polyethylene
3	FINAL_Batter_Assembly1	1	Polyethylene

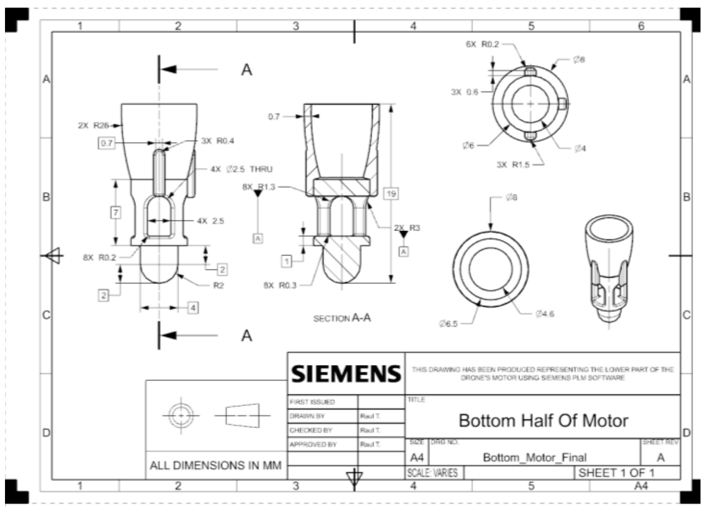


Figure 1: Bottom Motor Drawing

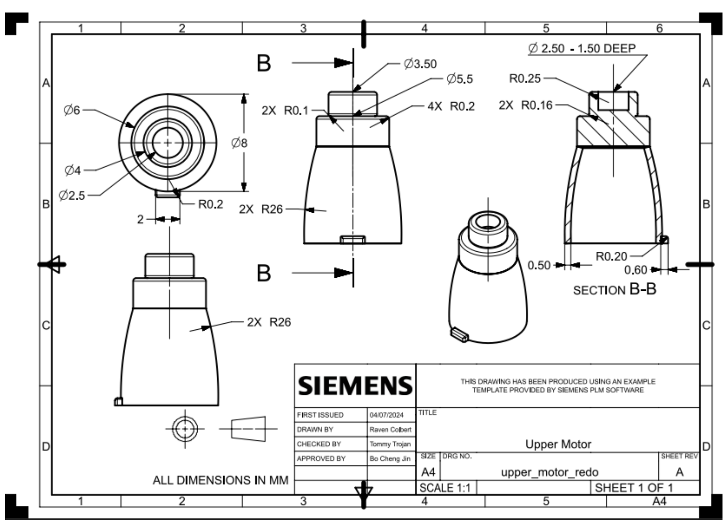


Figure 2: Upper Motor Drawing

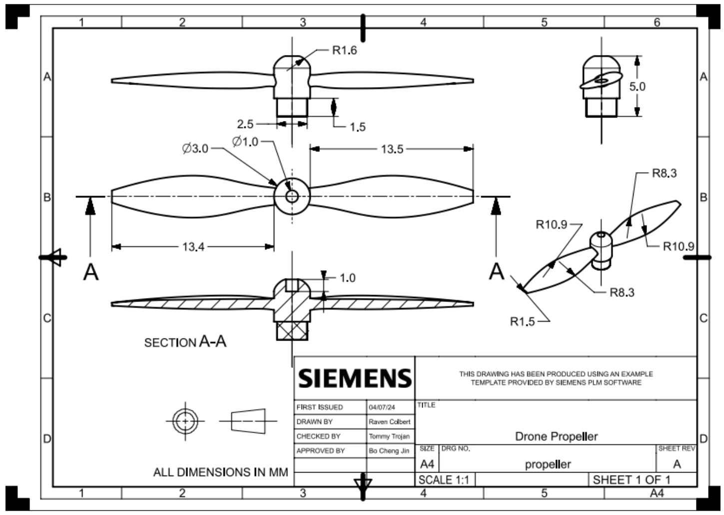


Figure 3: Propeller Drawing

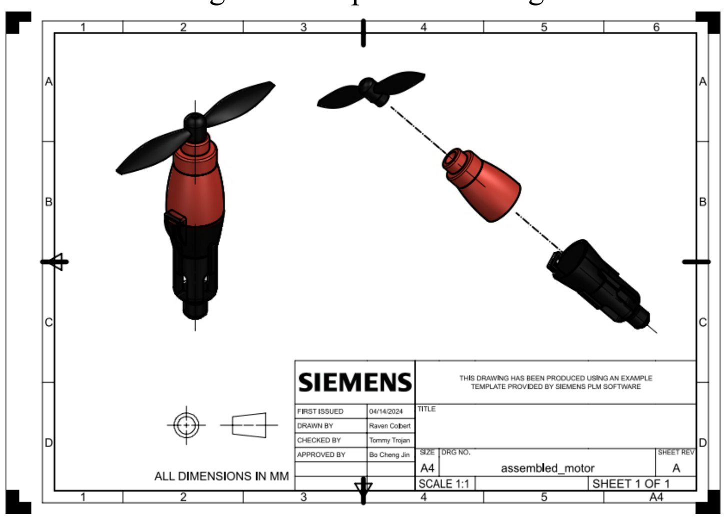


Figure 4: Assembled Motor Drawing

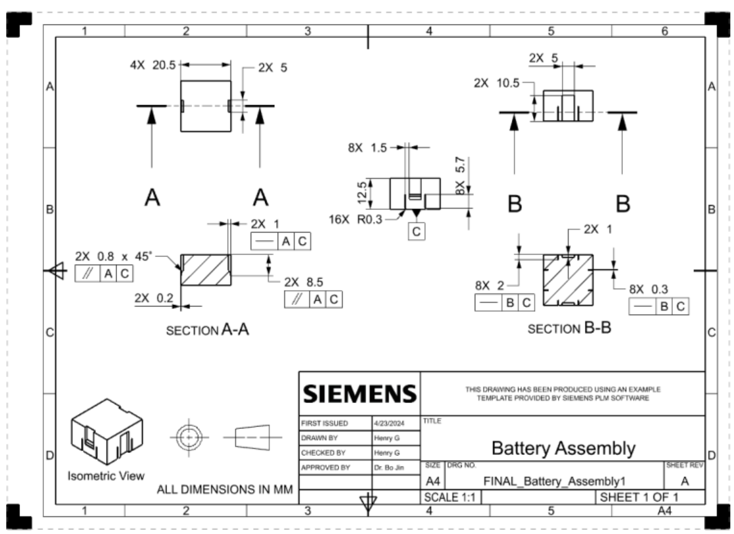


Figure 5: Assembled Motor Drawing

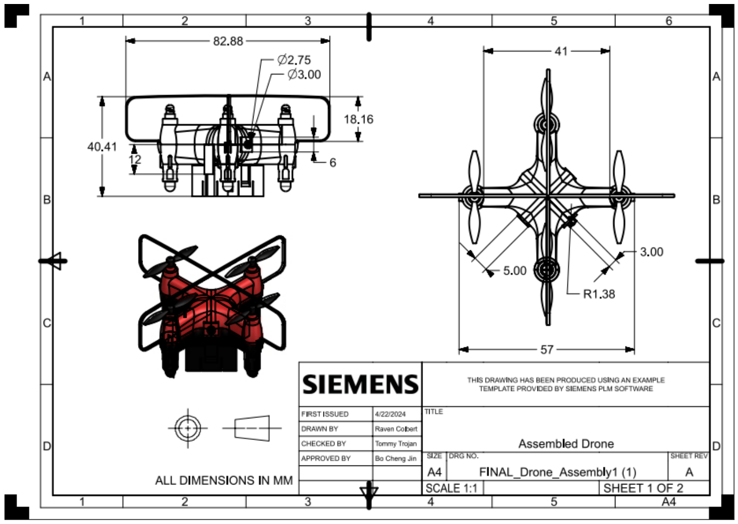


Figure 6: Drone Main Body Drawing

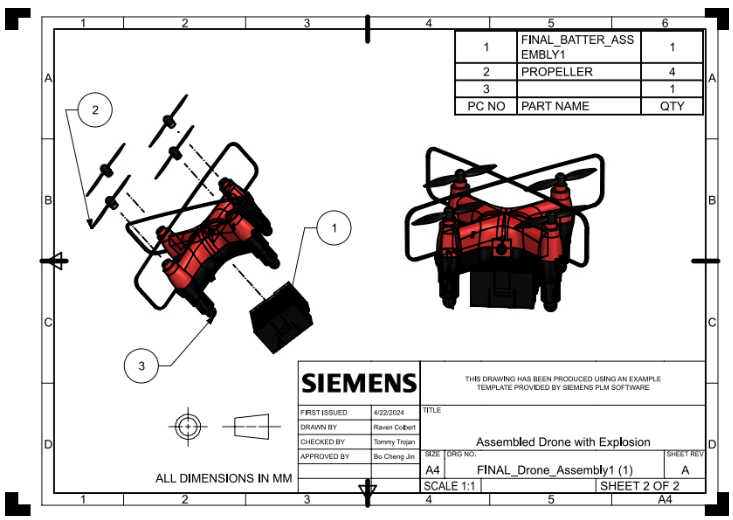


Figure 7: Assembled Drone Drawing

FEA Analysis:

To idealize the final assembly the propeller guards were taken off as they pose no real influence on the structural integrity of the drone. For the Finite Element Analysis (FEA), the propellers were chosen to take the majority of the load. The propellers are the main moving part of the drone, so it is assumed that they will take the majority of the load. The boundary condition applied to the propellers is a cylindrical constraint with fixed radial and axial growth and free axial rotation. The load condition applied to the propellers is a torque of 15 N*mm. The mesh density of the drone varied, with the body having a mesh density of 1mm, the battery being 1.5mm, and the propellers having a final mesh density of 0.5mm. The mesh density for the propellers was originally 0.4mm, but after several iterations, a mesh density of 0.5mm was decided on. This density had the smallest convergence rate (30.74%), with a maximum (unaveraged) stress of 1.991 MPa, or 288.77 psi. The maximum stress occurred at the base of the propeller where it meets the motor. This makes sense, as the friction between the propeller and motor leads to stress. Because the FEA was conducted on the entire drone and not the propeller alone, the convergence rate is much higher than expected. Repeating the FEA without the main body would garner a much smaller convergence rate.

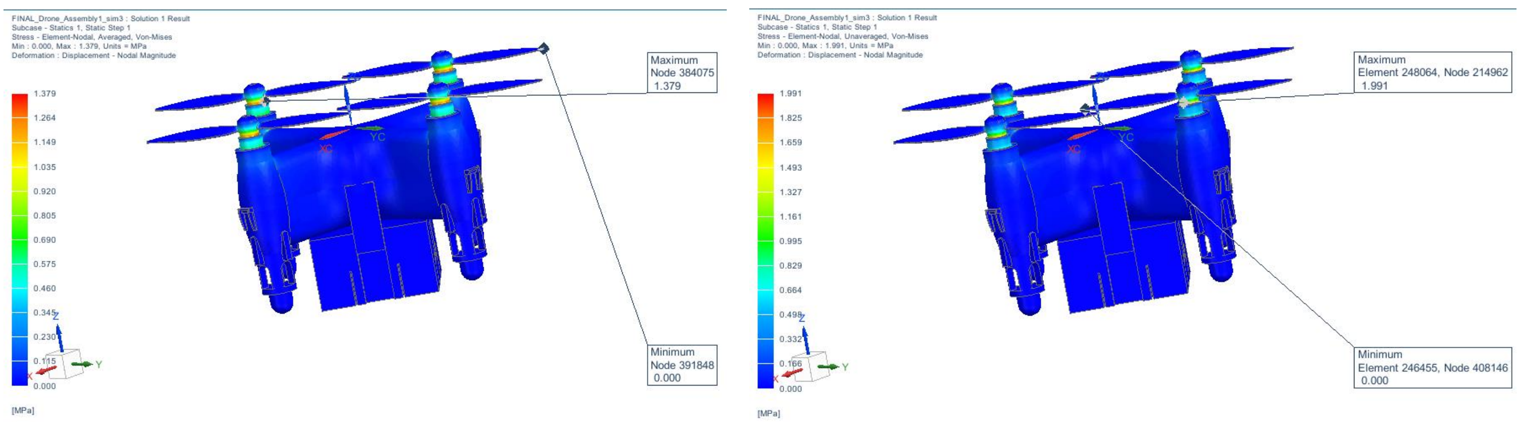


Figure 8: Stress Contour Plot – Von-Mises (Averaged vs. Unaveraged)

Version	Element Size	Element #	Node #	Max Disp. (mm)	Max Stress Unavg. (MPa)	Max Stress Avg. (MPa)	Convergence
1	0.4	150131	252676	0.0451	2.083	1.39	33.26932309
2	0.6	133958	223865	0.0451	1.921	1.312	31.70223842
3	0.55	136252	228053	0.0452	1.913	1.324	30.78933612
4	0.5	139142	233177	0.0451	1.991	1.379	30.73832245

Figure 9: Table of FEA Progress

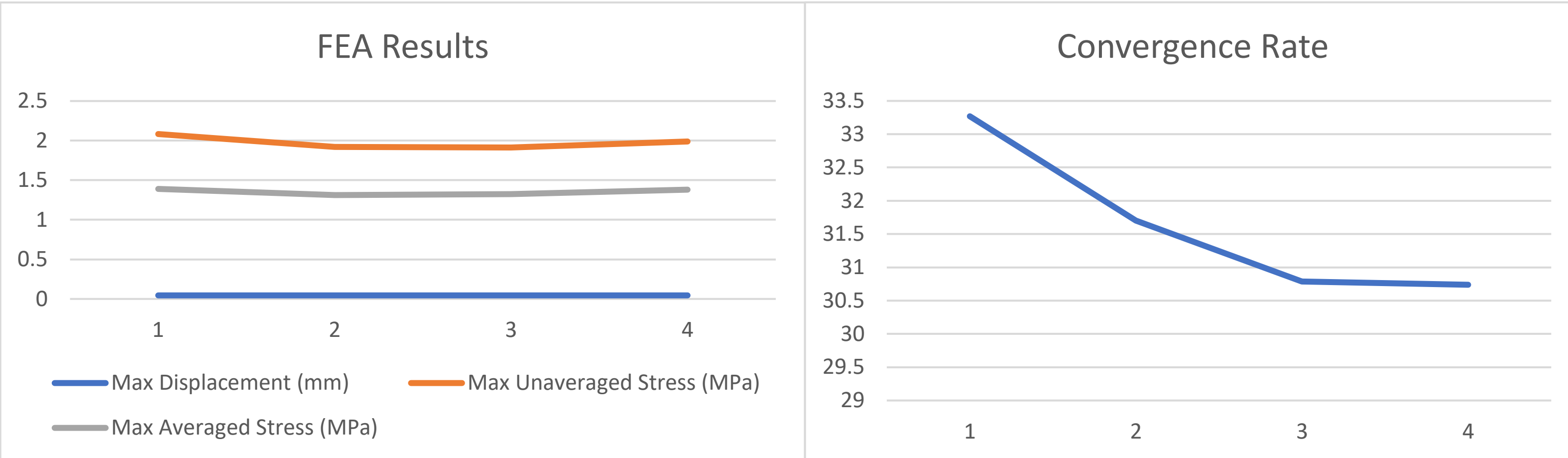


Figure 10: Graph of FEA Results (Left) and Convergence Rate (Right)

The stiffness matrix of the propeller did not change, as the material used (polyethylene) did not degrade. Therefore, the material remained in the linear regime. The displacement for the propeller occurred at the tips of the fins, and the displacement was very small, at only 0.0451mm. The total propeller length is ~30mm, so there was only a 0.15% displacement. The displacement location makes sense, as the tips of the fins are the most flexible part of the propeller, so they will bend the more than the part of the fin that is connected to the base.

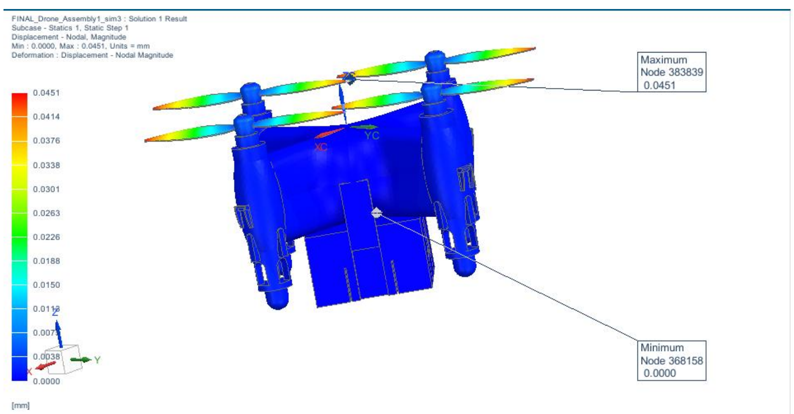


Figure 11: Displacement Contour Plot

Realistic Motion Analysis:

As explained before, to create real world conditions, the assembly part file was idealized and stripped of the drone's propeller guards as in real-life, the drone would operate without them. To do motion analysis, the propellers were chosen because the propellers are the components that generate thrust and allow the drone to fly. There is significant displacement on the propellers in the z-direction. The propellers are subject to dynamic loads due to rotational motion. Understanding their displacement, stresses, and forces acting on the propeller is crucial in the drone's structural integrity and the way the drone flies.

Motion Analysis Settings

- Motion Analysis without Friction
  - Velocity = 20 °/s
  - Acceleration = 5 °/s^2
  - For Solution:
    - 50,000 steps for 10 seconds
- Motion analysis with friction
  - Static friction = 0.355
  - Coefficient of Dynamic friction = 0.19
  - Velocity = 10 °/s
  - Acceleration = 0.5 °/s^2
  - Stiction Transition Velocity = 5 °/s^2
  - For Solution:
    - 20,000 Steps for 10 seconds

Motion Analysis Images (Joints, drivers, bodies)

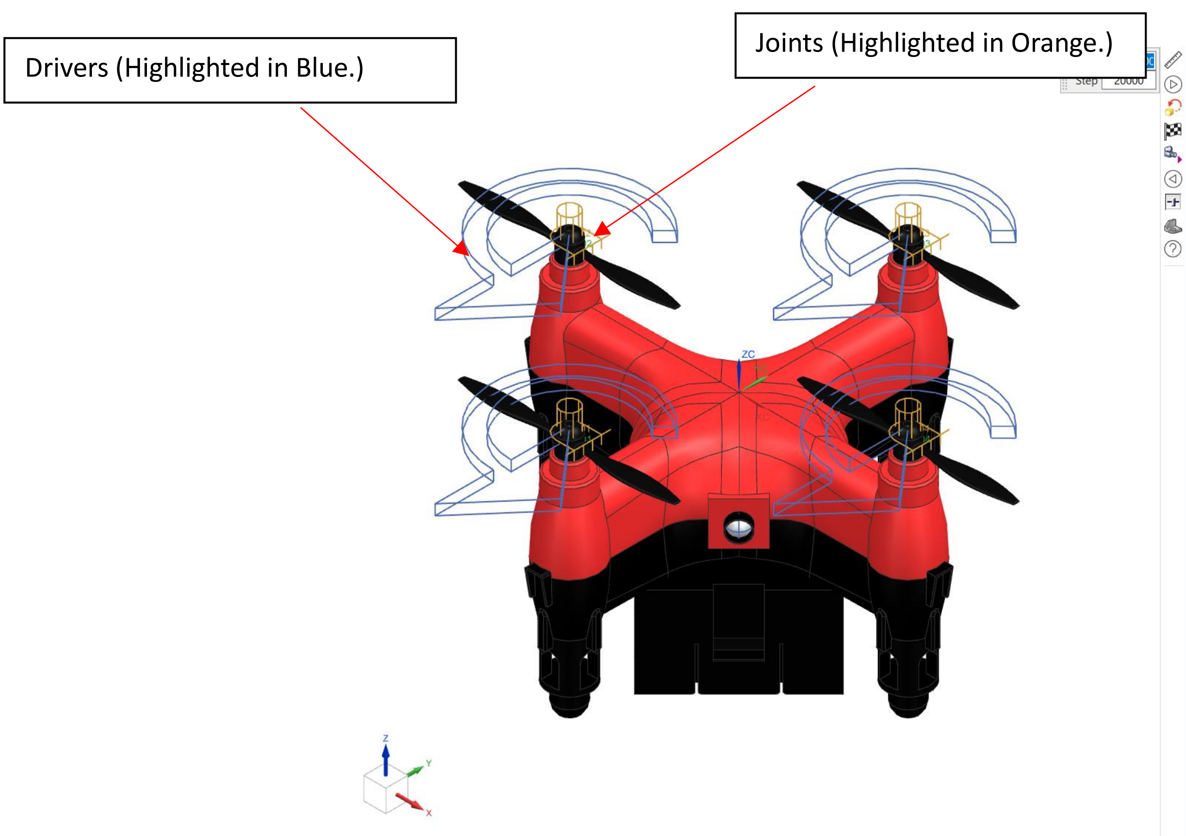


Figure 12: Motional analysis joints and drivers

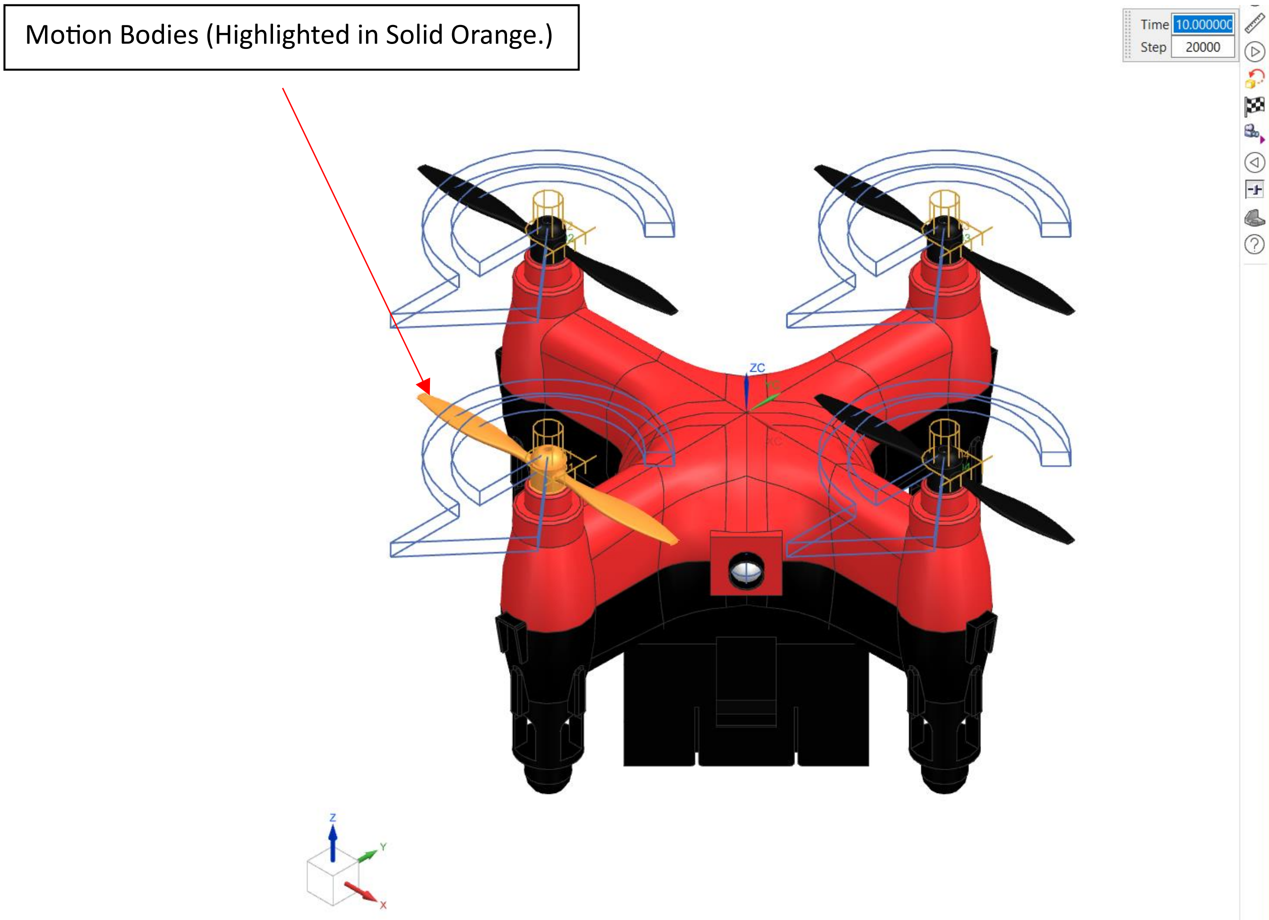


Figure 13: Motional analysis 4 propellers as motion bodies

Links For Motion Analysis

Below are three links to the movies of our Motion Analysis on the drone's propellers.

1. Motion of Propellers with Friction on all Joints
- https://youtu.be/ZhRjcJsHRso
2. Motion of Propellers without Friction
- https://youtu.be/ih-GiVE5_Jo
3. Motion of 2 Propellers Without Friction and 2 Propellers with Friction
- https://youtu.be/wBe1lwKSfHQ

From the motion analysis videos, it is seen that in the motion without friction, the velocity is not constant and is always increasing with time due to the constant acceleration of 5 $°/s^2$. Giving off this smooth and always increasing speed as time increases.

But in the case of friction, it demonstrates that even though there is a velocity with constant acceleration, there is friction that hinders the rate at which the velocity increases. In the third video, it demonstrates the difference between the effects of friction and without friction that hinders this increasing change in velocity.

References

- PolyAlto, Groupe. "5 Plastics with Low Coefficient of Friction." *Blogue*, blogue.polyalto.com/en/5-plastics-with-low-coefficient-of-friction#:~:text=Dynamic%20coefficient%20of%20friction%3A%200.19,to%20high%20loads%20and%20friction. Accessed 23 Apr. 2024.
- MatWeb.com. *Overview of Materials for Polyethylene Terephthalate (PET), Unreinforced*, www.matweb.com/search/DataSheet.aspx?MatGUID=a696bdcdff6f41dd98f8eec3599eaa20. Accessed 23 Apr. 2024.