

Investigating Fatigue and Mechanical Failure of Electric Servo Motors

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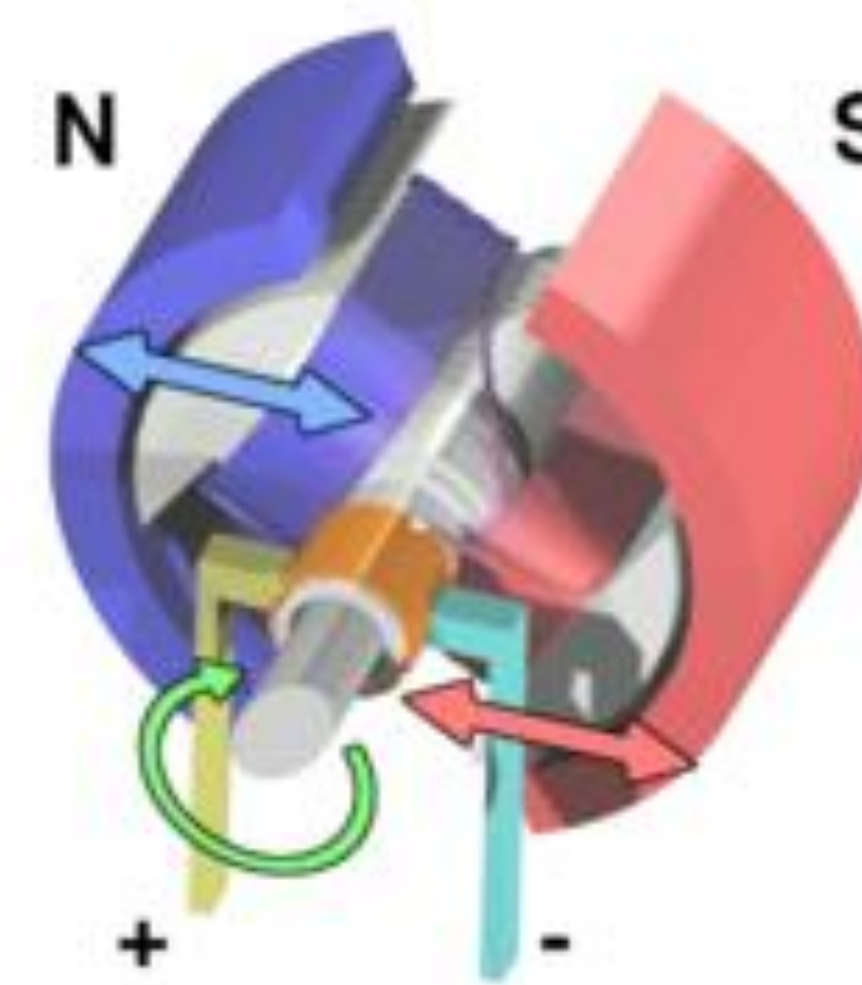
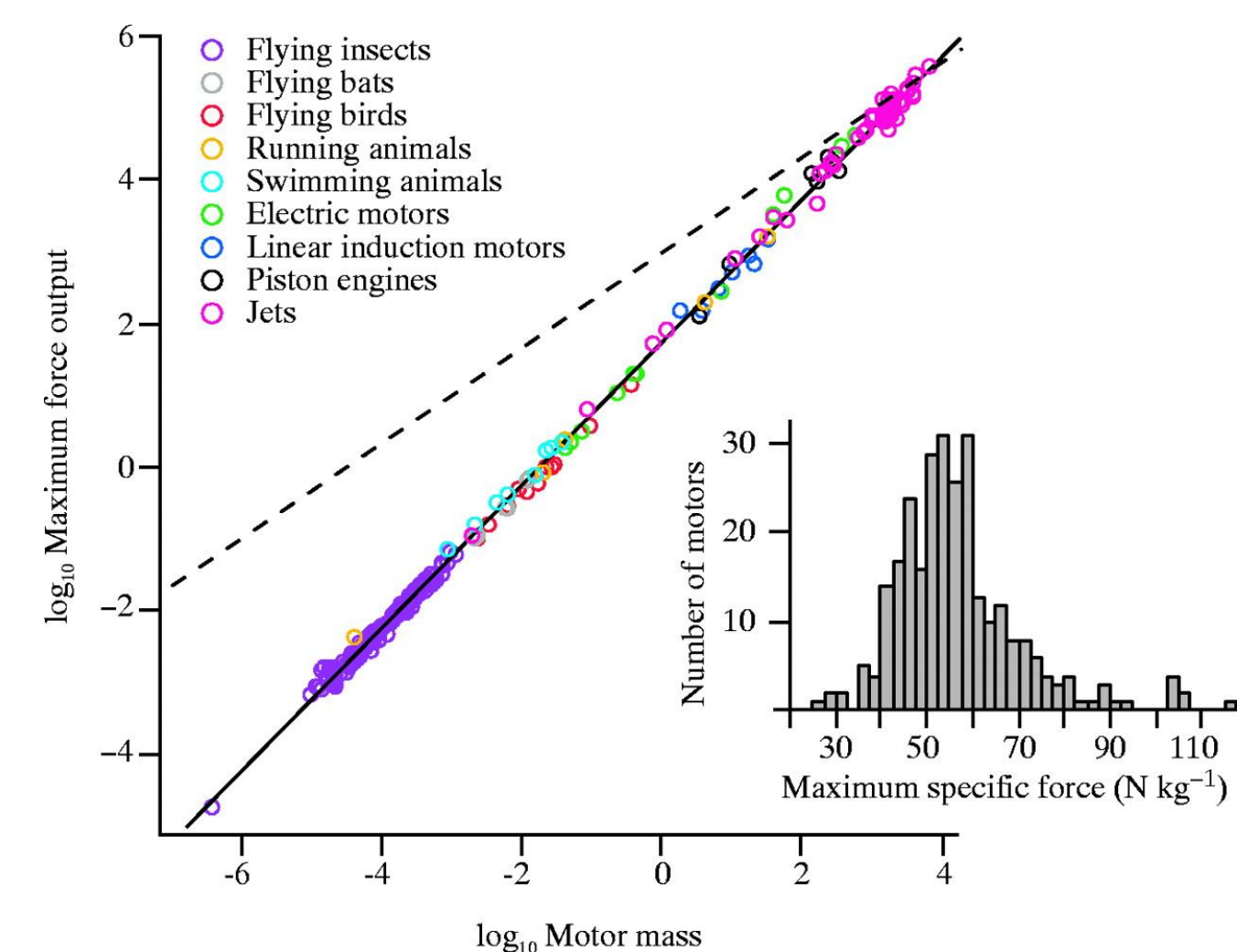
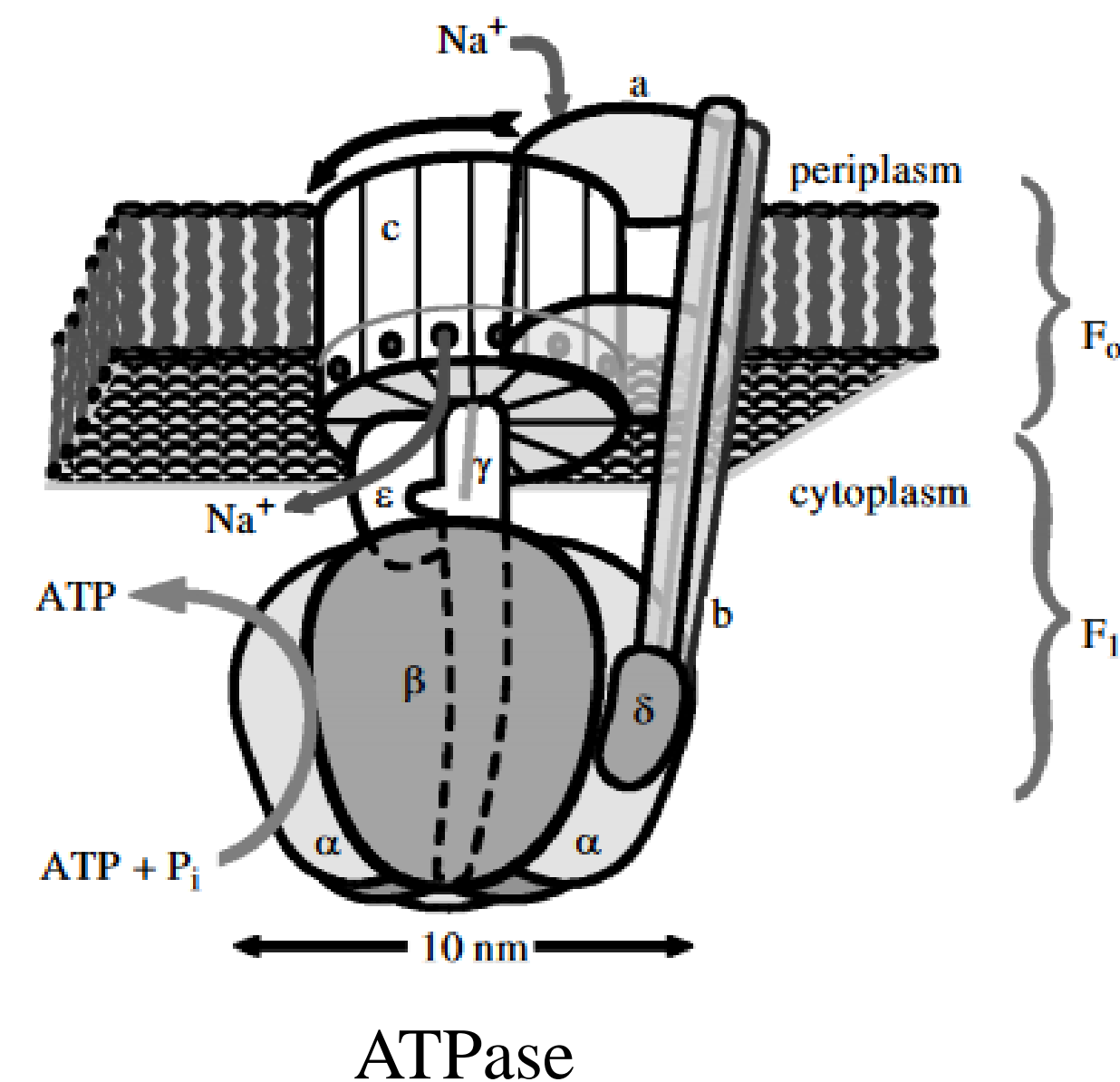
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Introduction

- It has been found that motors of all size scales, from molecular motors up to jet engines, scale in torque production proportional to their mass with a maximum torque density of 57 N/kg.^{1,2}
- Despite the fact that they produce force using completely different mechanisms, all motors seem to share the same fundamental limitation, in which the current proposed theory is that fatigue is the main factor that limits force production.³
- Our project is focused on testing the theory that fatigue is what limits motors, and we plan on achieving this by observing the fatigue of electric servo motors over a range of stress as well as identifying the components that are limited by fatigue.
- Through understanding the limitations of these motors, we hope to improve the force production to create lighter and stronger motors useful in the design of lightweight robots and exoskeletons that amplify human capability.



Force Vs. Mass Scaling

Electric Motor

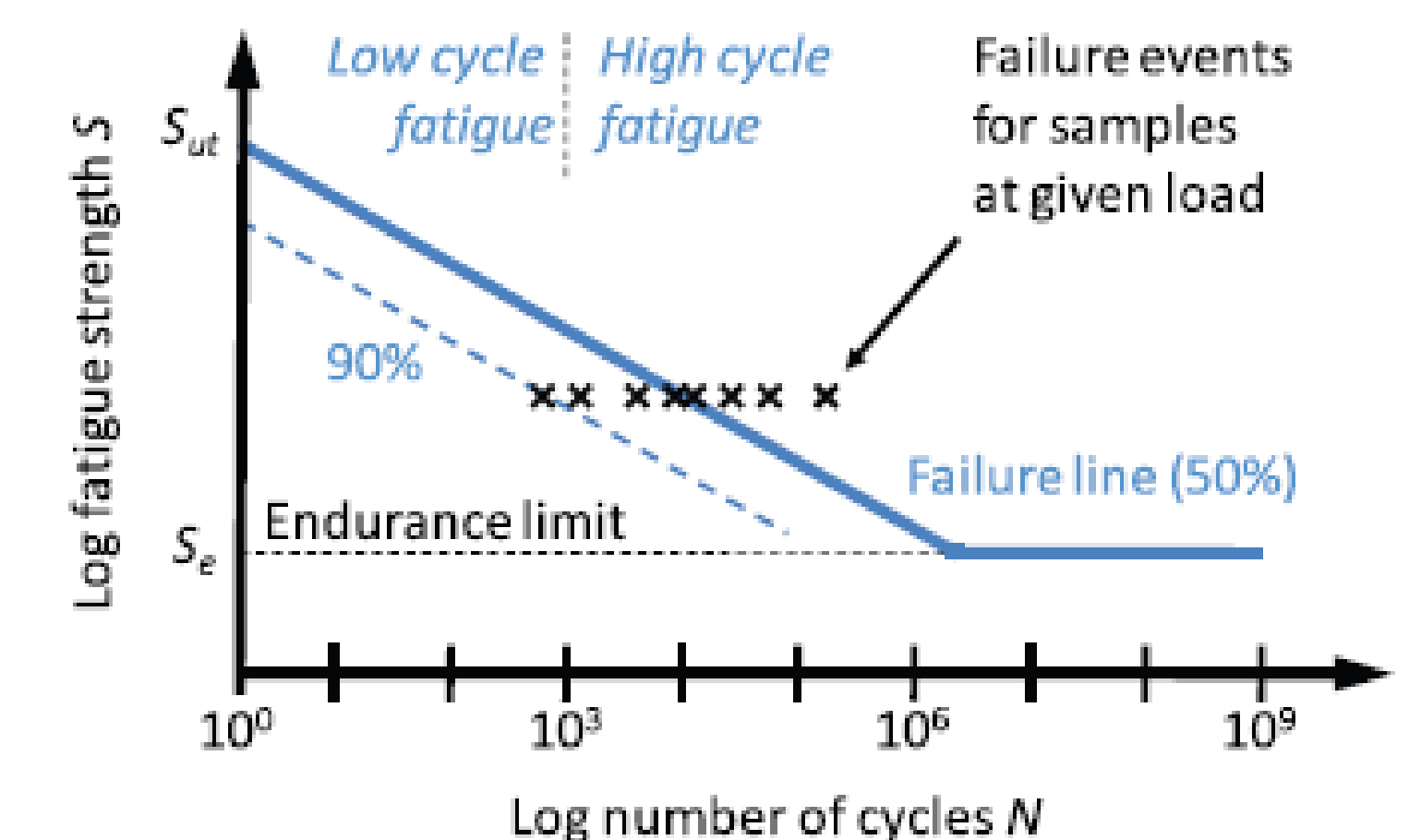
Materials and Methods



- Rotary servo motors were connected to a microcontroller board, known as Arduino Uno, and a DC power supply, which remained at a constant voltage of 4.8 volts.
- Electric motors were secured to the base to ensure no movement during operation.
- Progressively increased the load on the motor arm to observe failure.
- The length of time was recorded from initial stress to failure to determine how the motors respond to fatigue.

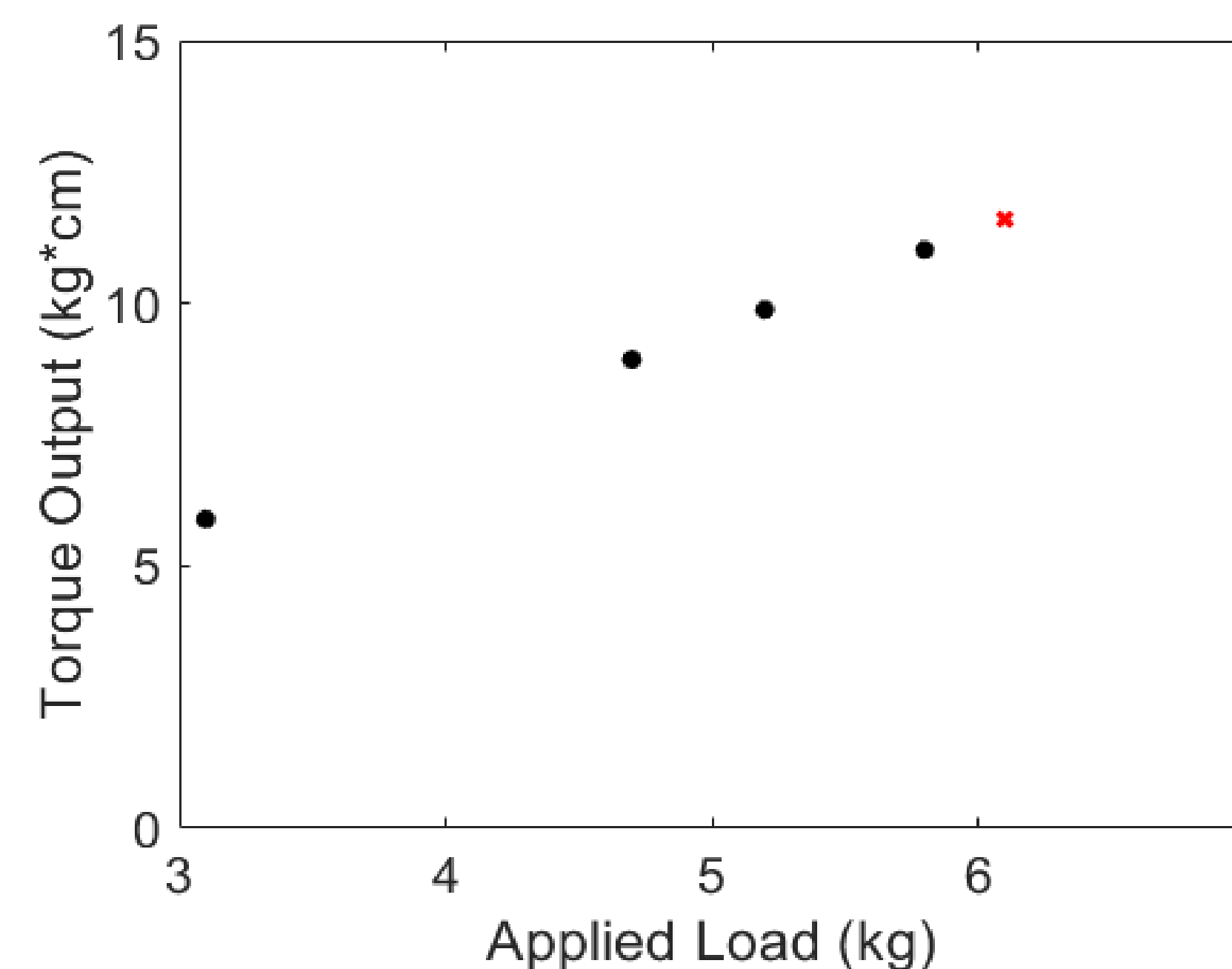
Conclusion

- Our testing of the motor suggests that neither fatigue nor mechanical failure were the main limitations for the electric servo motors.
- For future studies, we plan on investigating other potential limitations of the force production in electric motors, such as thermodynamic constraints⁴ or other mechanical limitations.^{5,6}



Results

- In order to create a S-N diagram which describes the fatigue of a material, we first needed to determine the stress required to achieve failure after one cycle.
- Initially, the motors were stressed at a starting load of 3.1 kilograms, which was based off of previous experiments, and steadily increased to 6.1 kilograms.
- If the motor was able to complete multiple cycles on a certain weight, we concluded the ultimate stress needed to be greater and subsequently increased the weight.
- The weight of 6.1 kilograms led the motor to stall, however, the motor stayed operational and there were no signs of mechanical damage.
- This suggested the limitation of the motors for force production was not fatigue, but some other factor.



References

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