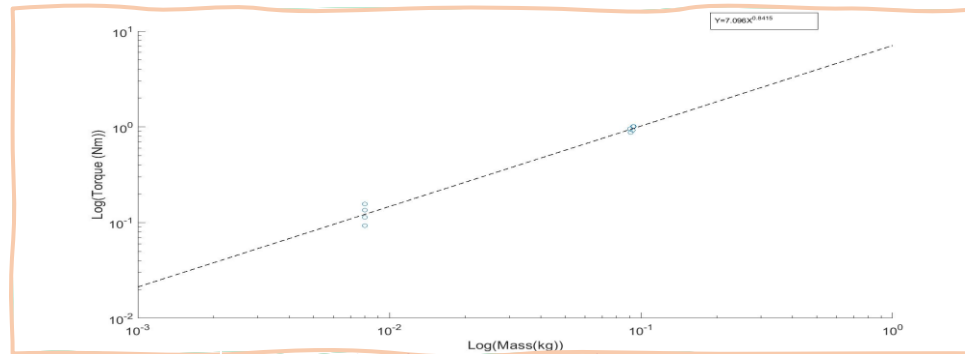


Introduction

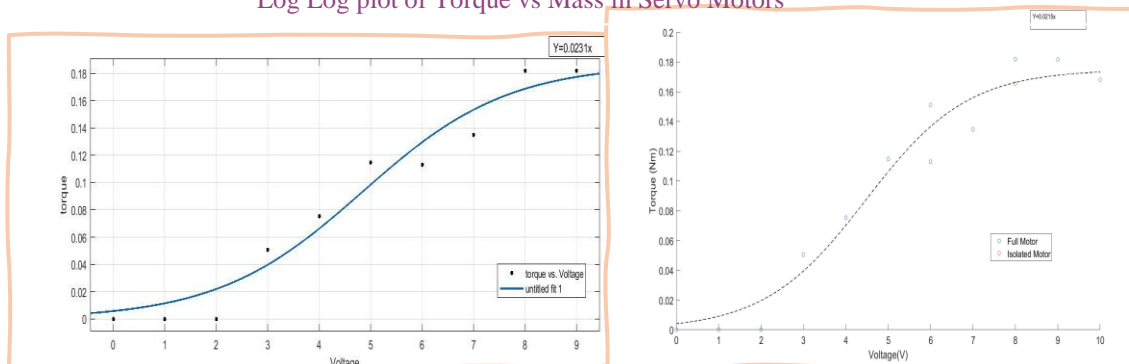
- Motors, biological and human made, use different mechanisms to produce an enormous range of mass-specific power. [1]
- The maximum force a motor can produce from the size scale of molecular motors to jet engines have been observed to lie on a scaling relationship between maximum force produced and the mass of the motor.
- Servo Motors have been tested by exceeding the safety limitations placed by the manufacturers to verify if the motor falls on the relationship observed between maximum force and mass of the motor. [1]
- Linear motors that use force production to accomplish steady translational motion of a load has observed higher with mass-specific net force output than rotary motors that generate force using cyclic motion. [1]
- Maximum force of the Servo Motors, classified as rotary motors, have been investigated for to check if it aligns with the linear or rotary motor plot. [1]

Methodology

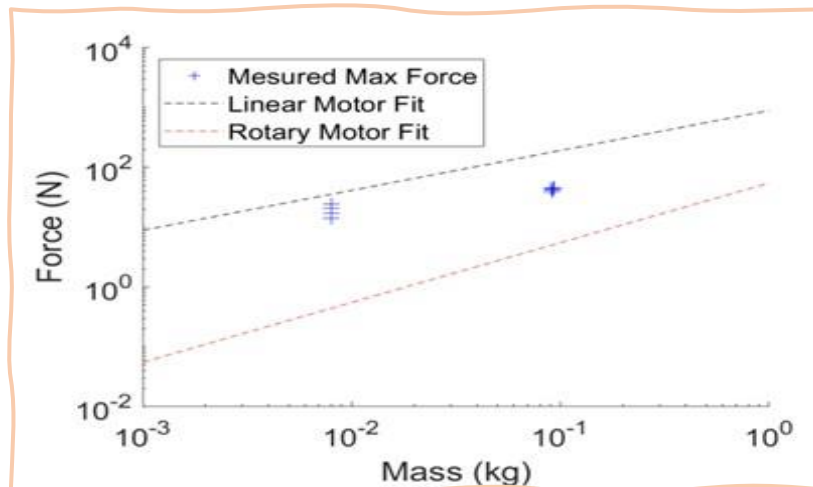
- Servo motors were connected to the Arduino power supply and computer and the motor was loaded with weight to determine its maximum force output.
- The circuit board of the motor overheated after certain Voltage and motors were further tested without circuit board.



Log Log plot of Torque vs Mass in Servo Motors



Torque vs Voltage plot of Servo motor a) with only circuit board and b) without circuit board included



Max Force vs mass plot of servo motor compared to linear and rotary motor fit

Results

- Linear Scaling relationship is observed between maximum torque exerted by the motor and mass of the motor.
- Maximum torque of a Servo Motor can be exceeded by surpassing the safety rated voltage 6.0V of the motor until motor fails to overheating of the circuit board at 9.0V.
- Bypassing the circuit board, voltage intake exceeded 9.0V till 12.0V and maximum torque achieved was approximately constant.
- Maximum torque achieved by the motor and lever arm of the motor was used to calculate the maximum force produced by a specific mass of the motor which aligned closely to linear motor fit than rotary motor fit.

Conclusion

- Power input is a limiting factor for maximum force exerted by the motor being that by increasing the power the motor will be able to exert a higher torque.
- An efficient cooling system for the specific motor experimented could result in looking into other limiting factors that restrict the motors besides overheating of motor parts.

References

- [1] Marden, J. H., & Allen, L. R. (2002). Molecules, muscles, and machines: universal performance characteristics of motors. *Proceedings of the National Academy of Sciences of the United States of America*, 99(7), 4161–4166. <https://doi.org/10.1073/pnas.022052899>