MIE301 – Lab 4: Mechanism Optimization
Report

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PART I. Static Analysis

a) Write M_2 as a function of the load (link 4 weight).
Let W = weight of link 4.

$$M_2 = \frac{W}{\sin\theta_3} R \sin(\theta_3 - \theta_2)$$

b) At what value of θ_2 does the motor experience peak load? (set a = 1.5cm)

Theta2 = 0.1282 radians

c) Give the work done in lifting the weight, and the work done by the motor. (set a = 1.5cm)
Work done by lifting: 0.8318 Nm
Work done by motor: 0.8116 Nm

d) Plot the required motor torque M_2 to support the weight, over a full revolution. Assume the motor moves very slowly. Plot this moment for several offset values from offset *a* = 0 to 2 cm (with three equal intervals in between).

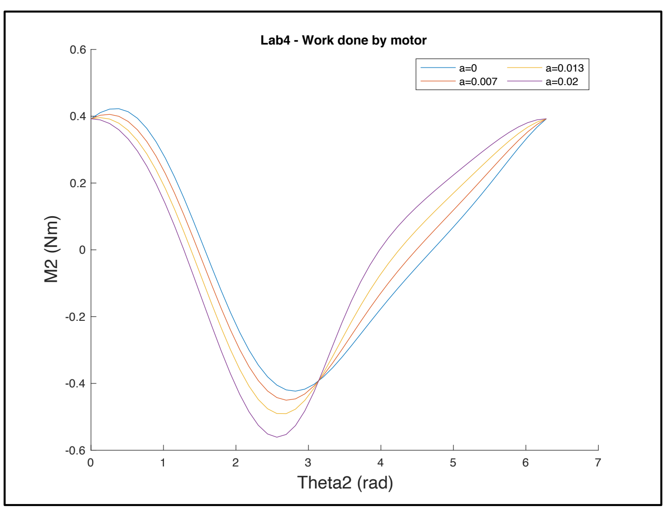

Figure-a: Required motor torque vs. angle of rotation (Static Load)

PART II. Dynamic Analysis

e) Now, assume the motor is moving quickly. Give an equation for your motor torque or explain your method if you are calculating it numerically.

We find $\overrightarrow{a_g}$ numerically by defining a time step for each rpm, then calculating velocity and acceleration between each time step. Velocity was set to 0 initially, and then it was calculated by finding $\frac{D(i)-D(i-1)}{timeStep}$.

For the acceleration at each time step, it was found by calculating $\frac{vel(i)-vel(i-1)}{timeStep}$ using the previously defined velocities at each time step. This approximates the value of $\overrightarrow{a_g}$ at each instant in time. The torque supplied by the motor was then found by applying superposition of the weight forces and the inertial forces from the slider.

$$M_2 = \frac{W + m\overrightarrow{a_g}}{\sin\theta_3} R\sin(\theta_3 - \theta_2)$$

f) For an offset $a=1.5$ cm, plot the motor torque over a full cycle for motor speeds from 10 rpm to 100 rpm (with four equal intervals in between). Plot these on one graph.

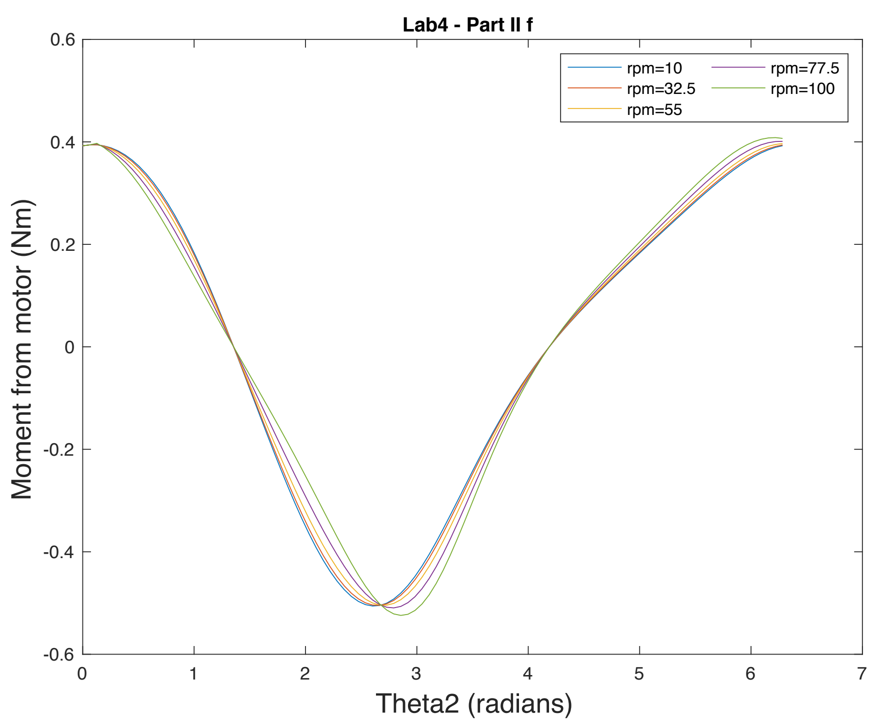

Figure-b: Required motor torque to support vs. angle of rotation for different motor speeds (Dynamic Load)

g) For what motor speeds would you consider the inertial load negligible (contributing less than 2% to the total motor load)? Hint: calculate maximum acceleration $\ddot{D}$ for different motor speeds and compare it with gravitational acceleration.

2% of g: 0.02*g = 0.1962

Only for the 10 rpm motor speed would the inertial forces be negligible. All other motor speeds have at some point in time an absolute inertial acceleration greater than 2% of g.