MECH 420 – Prelab 3

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1) What is the force constant Bl of the VCA according to its data sheet?

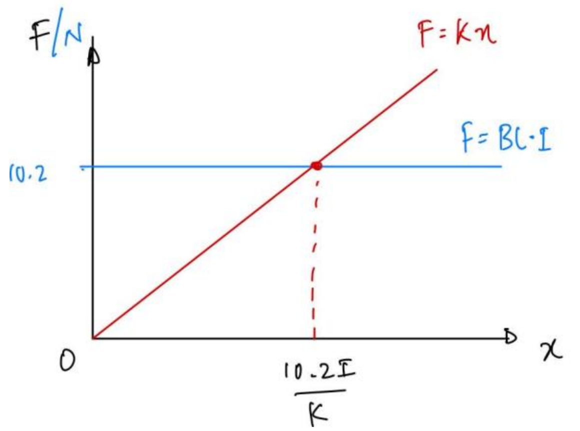
Electrical Time Constant	0.44 msec	
Motor Constant	0.85 lbs/√watt	3.8 N/√watt
Force Constant	2.3 lbs/amp	10.2 N/amp
Back EMF	0.26 V/ips	10.2 V/m/sec
Force @ 100% Duty	2.3 lbs	10.2 N

Force Constant = 2.3lbs/amp or 10.2N/amp

2) The VCA should extend a linear spring. Plot both the spring force and the VCA force as a function of position and identify the force equilibrium.

$F_{VCA} = B \cdot l \cdot I$ (constant current) $= 10.2 I$ N

$F_{spring} = Kx$



Equilibrium:

$BlI = Kx$

$x = \frac{10.2 I}{K}$

3) Where does the equilibrium shift if the VCA current is increased or decreased?

Assuming the spring remains the same, when the current is increased the equilibrium shifts to the right, along with an increase in force value. This can be demonstrated on the plot above by an upward shift in the F = Bl*I curve.

Hence, if the current is decreased the equilibrium point will shift to the left for reverse reasons mentioned above.

4) If the coil is held in place find an expression for the electric impedance of the VCA.

$$V = RI + L\frac{dI}{dt} + Bl\,U_{VCA}$$

- No Motion $\Rightarrow U_{VCA} = 0$

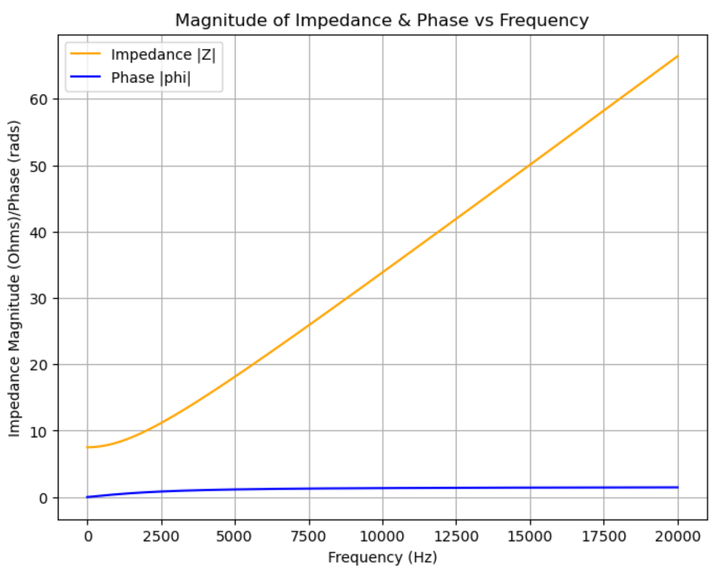
$$V = RI + L\frac{dI}{dt}$$

In frequency domain

$$V = RI + j\omega L \cdot I$$

$$Z_{elec} = R + j\omega L$$

5) Using the information from the VCA data sheet, plot the magnitude and the phase of the electric impedance as a function of frequency



The curves above are based on these equations:

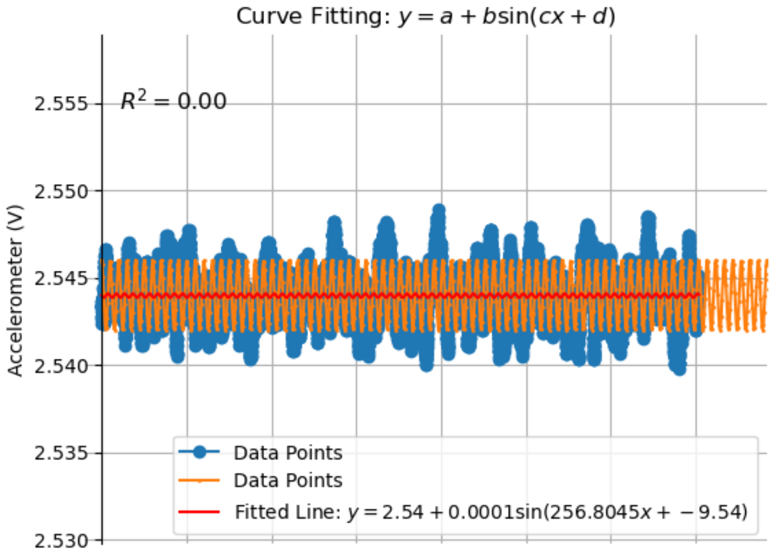
$$|Z_{elec}| = \sqrt{R^2 + (\omega L)^2} = \sqrt{(7.5\Omega)^2 + (\omega(3.3mH))^2}$$

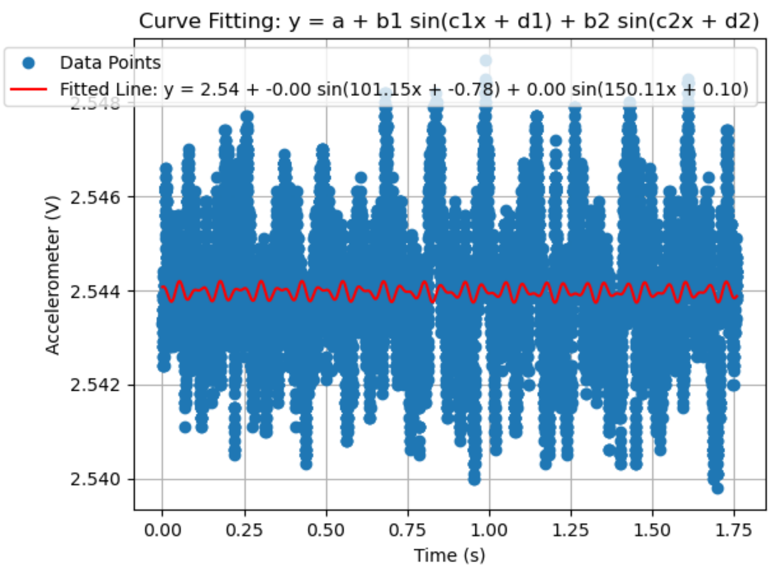
phase:

$$\varphi = \tan^{-1}\frac{\omega L}{R} = \tan^{-1}\frac{\omega(3.3mH)}{7.5\Omega}$$

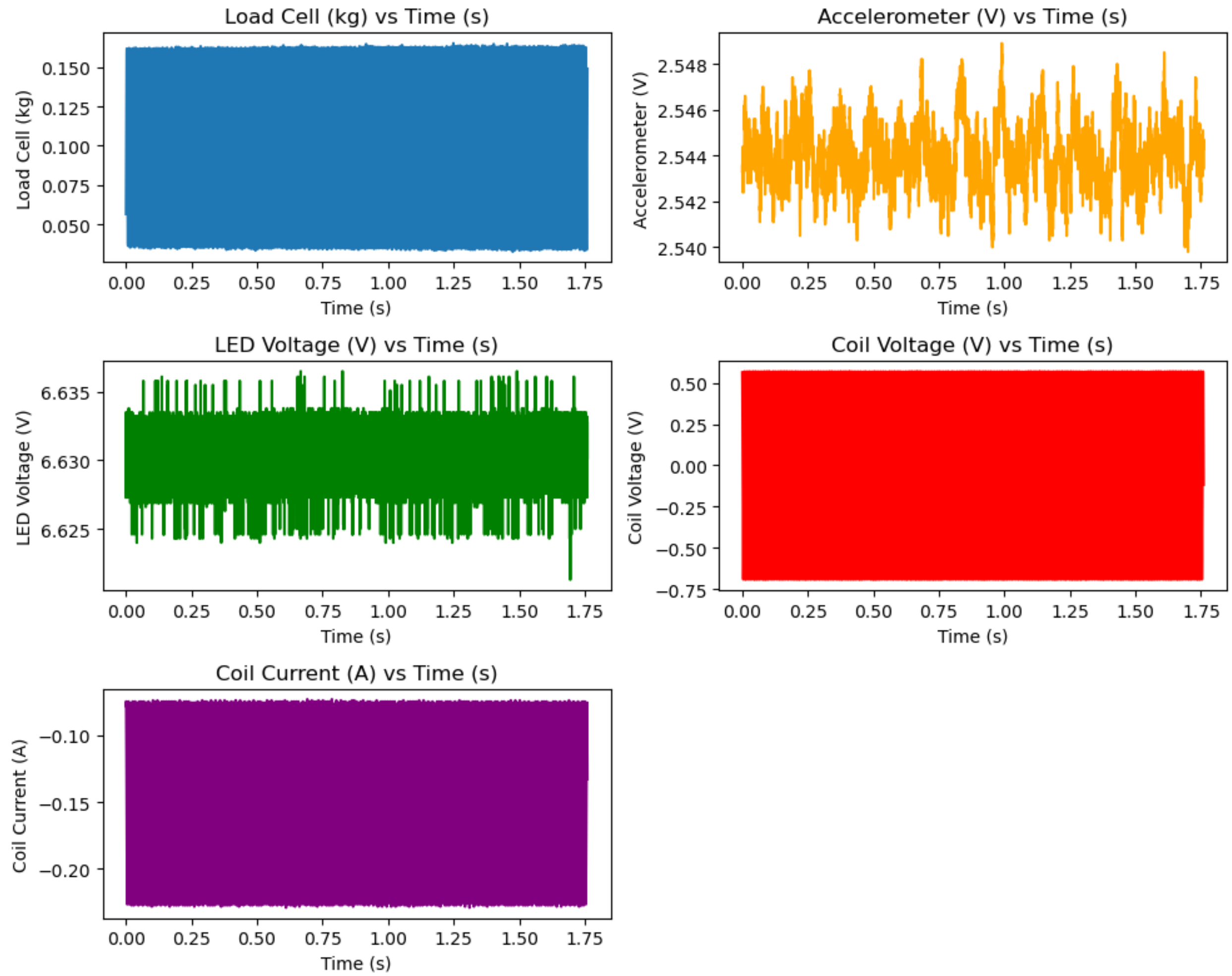
6) Curve Fit Sample Data

It was rather challenging to find a function that worked for the voltage signal for the accelerometer signal. Here are a few attempts:





7) Provide the amplitude for either signal and the phase between the signals



This is the raw data plotted. It would seem the x-axis is extremely squished, and the curve fitting function in python is able find an appropriate set of parameters.

I would guess the amplitude of the accelerometer signal is about 0.004 V and has a phase difference of 90 degrees with the associated current.