MECH 420 – Prelab 4

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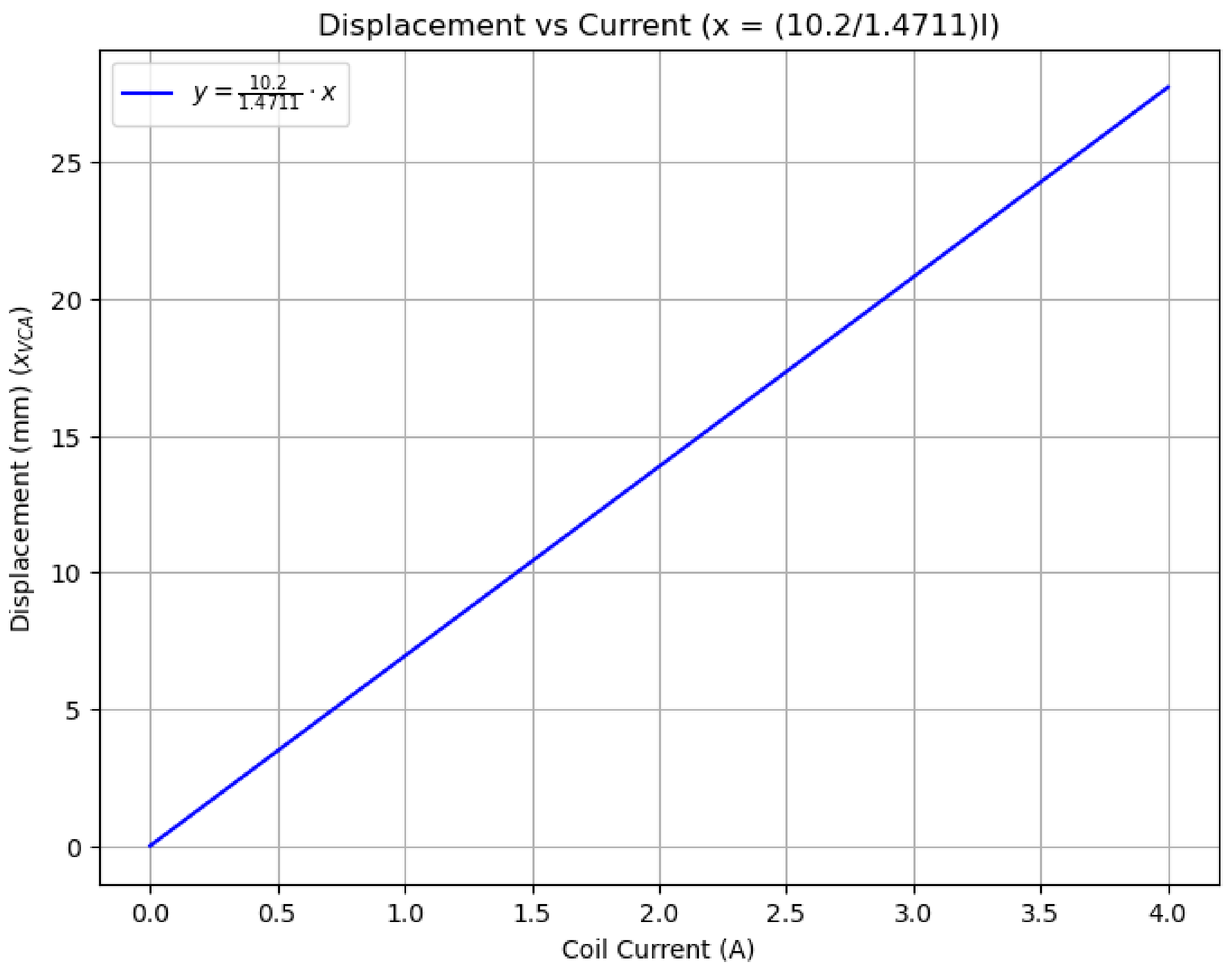
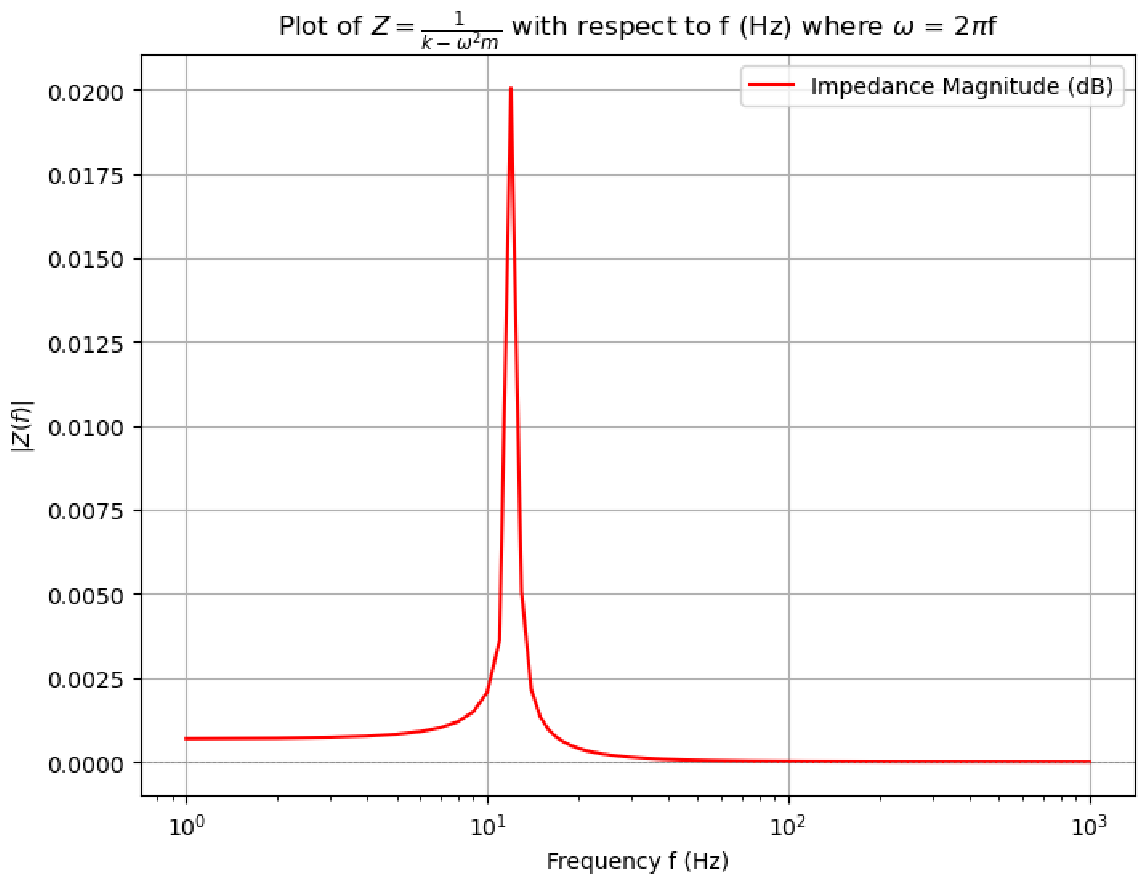
1) Plot the relationship for a displacement range and I_{coil}.

The spring constant for the stiffest spring: 1.4711 N/mm



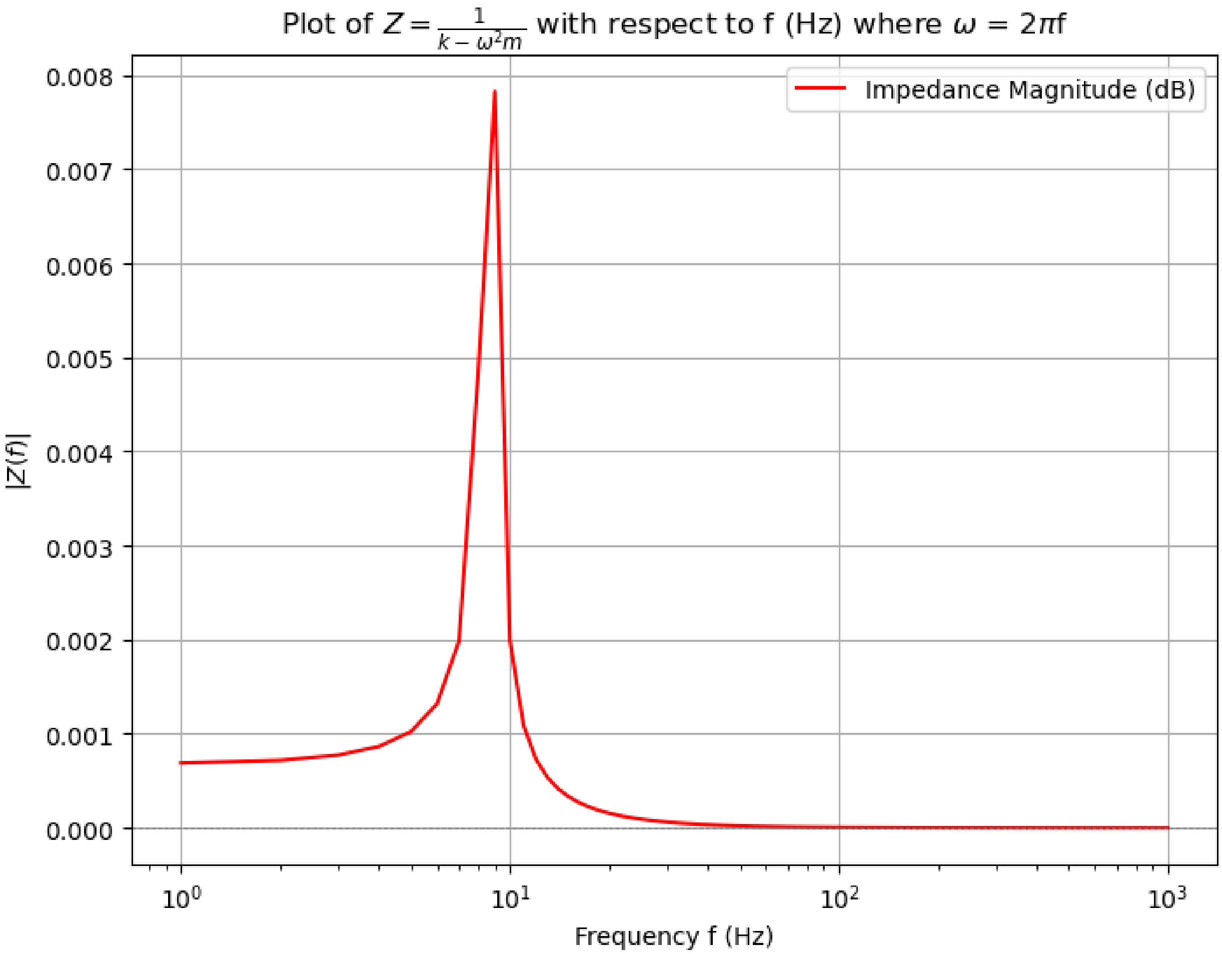
The equation is $X_{VCA} = \frac{Bl}{k} I$

2) For a moving mass m = 0.25 kg (neglecting friction) and for the same spring as in 1), determine the Input Impedance of the VCA coil as a function of f for 1 Hz < f < 1kHz and plot its magnitude as a function of frequency.



We can see that there is a resonant frequency at 76.7 Hz given by $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$, which can be seen by the peak in magnitude at that frequency.

3) How will the resonant frequency change if mass $m_1 = 0.25$ kg is added?



As total mass increases to 0.5 kg, the resonant frequency is given by $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ which then leads to a new frequency of 54.2 Hz as the mass is doubled, which can be seen by the left shift in the peak. The magnitude of the peak is also smaller than the peak with a lower mass.

4) The system (without added mass) should be excited by a square wave signal with 50% duty cycle. Choose a cycle time for this signal such that only the fundamental frequency and the first upper harmonic are both below the resonant frequency.

Square Wave Frequency Components:

Fundamental frequency: $f_1 = \frac{1}{T}$

3rd harmonic frequency: $f_3 = 3 \times f_1 = \frac{3}{T}$

For requirements, f_1 & f_3 need to be below f_{res}:

$$f_1 < f_{res} \qquad f_3 < f_{res}$$

Derive cycle time T:

$$\frac{1}{T} < f_{res} \Rightarrow T > \frac{1}{f_{res}}$$

$$\frac{3}{T} < f_{res} \Rightarrow T > \frac{3}{f_{res}}$$

54.2 Hz

$$T > 0.055 s$$

To ensure only the fundamental & first harmonic fall below the resonant frequency, choose cycle time:

$$\boxed{T > 0.055 \text{ seconds}}$$