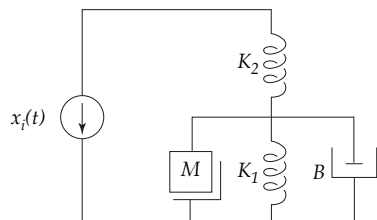**Pre-Lab Problem**
Work through this section before going to the lab.

For the system shown below, derive the transfer function, relating the output position of the mass x_m to the input position source x_i:

$$T(s) = \frac{X_m(s)}{X_i(s)},$$

..

$$M = 0.89 \text{ kg}$$
$$K_1 = K_2 = 400 \text{ N/m}$$
$$B = 6.65 \frac{\text{N s}}{\text{m}}$$

What are the natural frequency ω_n, resonance freqe-uncy ω_r, and damping ratio ζ of the system?

Use MATLAB to compute the Bode diagram (magnitude and phase), over the frequency range $[10^1 - 10^2]$ r/s. For example, after defining the system (as usual) in a MATLAB script, plot the Bode diagram using:

```
w=logspace(1,2);
bode(sys,w)
grid
```

NOTE: Bring a printed copy of the Bode diagram to the lab.

Laboratory Procedure

a) Connect outputs #1 & #2 of the mechanical system to the corresponding input channels of the Lab-VIEW interface. These signals are the outputs of position transducers (potentiometers) connected to the motion source (#1), and to the mass (#2) of the mechanical system. The motor rotation and linkage produce and a very nearly sinusoidal input motion.

b) Set the mechanical damper to its minimum value, CCW.

c) Adjust the frequency of the input by adjusting the rotational speed of the motor. Use LabVIEW to display the waveforms, and compare the input/output magnitudes and phases.

Make measurements of the magnitude $\frac{|X_m(s)|}{|X_i(s)|}$ and phase, for the input motor speeds shown in the table.

Motor RPM	Freq. (Hz)	Freq. (r/s)	Mag.	Phase (deg)
119	2	12.5		
191	3.2	20		
282	4.7	30		
382	6.4	40		
477	8	50		

d) Convert the measured magnitude to dB. Compare theory and experiment by plotting (by hand, is OK) the experimental magnitude (dB) and phase (deg) points on your calculated Bode plot.

> **Caution:**
> Improper use of the mechanical apparatus may be dangerous. Be very careful not to put fingers, or other objects, in places where they may be pinched or hit by the mechanism.
> Be sure to rotate the speed control knob fully in the counter clockwise direction (low speed) before turning on or off the motor amplifier.
> Do not operate the motor at speeds greater than **500 RPM**, as indicated by the display on the motor amplifier.