ME756A: Principles of Vibration Control

Total marks: 75 **<u>Assignment-1</u>** **Last date: 04/02/2019**

Q1. For a case of Quadratic damping, the damping force is proportional to the square of the difference in the velocities of the ends of the damper. **[15 marks]**

It is given by

$$F_d = \alpha_q \, sgn(v) v^2$$

where, Signum function, $sgn(v) = \begin{cases} -1 \; for \; v > 0 \\ 0 \; for \; v = 0 \\ 1 \; for \; v < 0 \end{cases}$

Here $v = \dot{x}$ and α_q is a constant.

Calculate equivalent viscous damping constant $\boldsymbol{c_{eq}}$.

Also, determine the expression for steady state amplitude $|X|$ for a SDOF system given as

$$m\ddot{x} + c_{eq}\dot{x} + kx = F_o sin\omega t$$

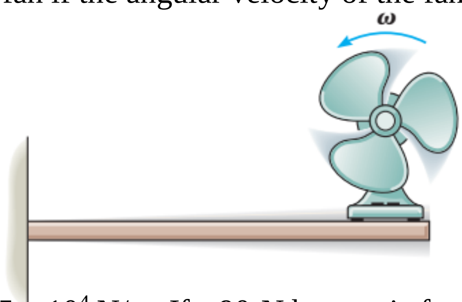
Q2. Using the equivalent viscous damping formulation, determine an expression for the steady-state amplitude under harmonic excitation for a linear system with both Coulomb and Viscous damping. **[10 marks]**

Q3. Consider a circular cylinder of length **L** and diameter **D** placed in a steady flow of mass density **ρ** and velocity ***v***, the vortices are shredding alternately (related by Strouhal no., **S**) on the downstream leading to the generation of harmonic force of amplitude $\mathbf{F_o}$ which is related to the drag coefficient $\mathbf{C_D}$ (recall from fluid mechanics course). Show that excitation amplitude is proportional to the square of the frequency and determine the constant of proportionality assuming S = 0.2, C_D=1. **[10 marks]**

Q4. The fan has a mass of 25 kg and is fixed to the end of a horizontal beam that has a negligible mass. The fan blade is mounted eccentrically on the shaft such that it is equivalent to an unbalanced 3.5-kg mass located 100 mm from the axis of rotation. If the static deflection of the beam is 50 mm as a result of the weight of the fan. **[10 marks]**

(a) Determine the angular velocity of the fan blade at which resonance will occur.

(b) Determine the amplitude of steady-state vibration of the fan if the angular velocity of the fan blade is 10 rad/s.



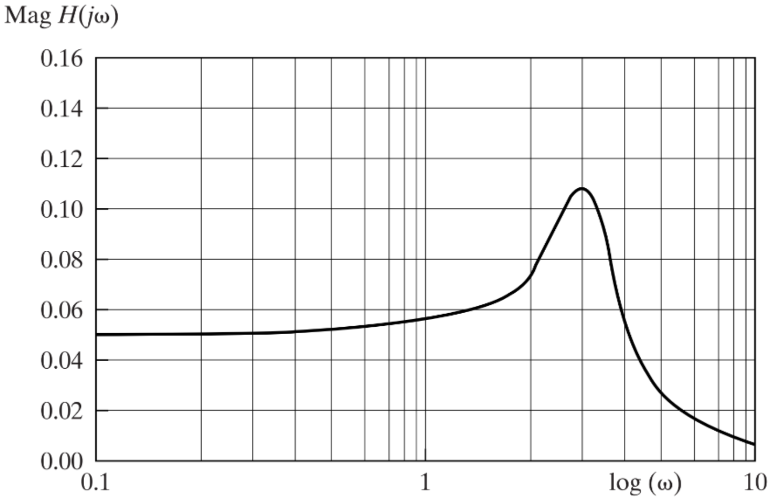
Q5. A coulomb damped system has a mass 10 kg and stiffness 1.5×10^4 N/m. If a 90-N harmonic force drives the mass at 25 Hz, Calculate the equivalent viscous damping coefficient if μ = 0.1. **[5 marks]**

Q6. A system is having an unknown damping mechanism and is driven harmonically at 10 Hz with an adjustable magnitude. The magnitude is changed, and the energy lost per cycle and amplitudes are measured for five different magnitudes. The measured quantities are: **[5 marks]**

X (m)	0.01	0.02	0.04	0.08	0.15
ΔE (J)	0.25	0.45	0.8	1.16	3.0

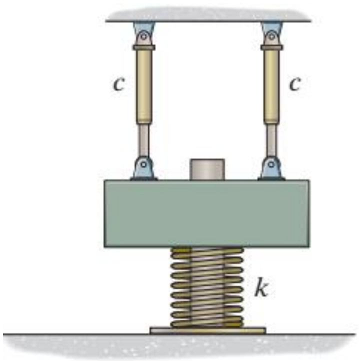
Predict whether damping is viscous or coulomb.

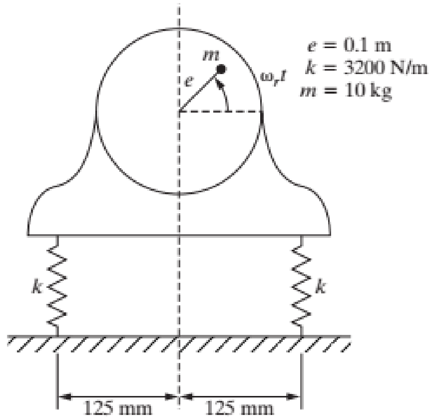
Q7. An experimental magnitude plot is shown below. Determine **ω, ζ, c, m, and k**. Assume that the units correspond to m/N along the vertical axis. **[5 marks]**



Q8. Two identical dashpots are arranged parallel to each other as shown in the figure below. Show that if the damping coefficient, $c < \sqrt{mk}$, then the block of mass **m** will vibrate as an underdamped system.

[5 marks]





Q9. An electric motor shown above has an eccentric mass of 10 kg (10% of the total mass of 100 kg) and is set on two identical springs (k = 3200 N/m). The motor runs at 1750 rpm, and the mass eccentricity is 100 mm from the center. The springs are mounted 250 mm apart with the motor shaft in the center. Neglect damping and determine the amplitude of the vertical vibration. **[5 marks]**

Q10. The system shown below produces a forced oscillation of varying frequency. As the frequency is changed, it is noted that at resonance, the amplitude of the displacement is 10 mm. As the frequency is increased several decades past resonance, the amplitude of the displacement remains fixed at 1 mm. Estimate the damping ratio for the system. **[5 marks]**