APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIRST SEMESTER M. TECH DEGREE EXAMINATION

Mechanical Engineering

04ME6503 - Theory of Vibration

Max. Marks : 60 Duration: 3 Hours

PART A

Answer All Questions

Each question carries 3 marks

1 Explain these terms with their expression *a*) Natural frequency of a system ω_n *b*) Damped frequency ω_d and *c*) Critical damping constant c_c.

2 Find the equivalent spring constant of two springs in series with stiffness k_1 and k_2. Give an expression

3 A spring-mass system has a natural period of 0.21 seconds. What will be the new period if the spring constant is (*a*) increased by 50 percent and (*b*) decreased by 50 percent?

4 The ratio of successive amplitudes of a viscously damped single-degree-of-freedom system is found to be 18:1. Determine the ratio of successive amplitudes if the amount of damping is (*a*) doubled, and (*b*) halved.

5 Define magnification factor and give the expression that relates it to frequency ratio for a system with damping ratio ζ.

6 It is required to design an electromechanical system to achieve a natural frequency of 1000Hz and a *Q* factor of 1200. Determine the damping ratio and the *bandwidth* of the system.

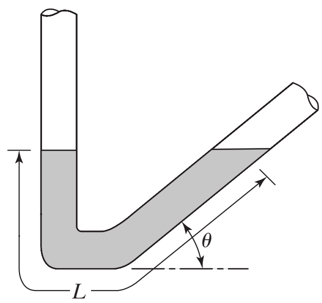
7 Find the Laplace transform of $(1 - e^{-st})$

8 An automobile having a mass of 2,000 *kg* deflects its suspension springs 0.02 *m* under static conditions. Determine the natural frequency ω_n of the automobile in the vertical direction by assuming damping to be negligible.

PART B

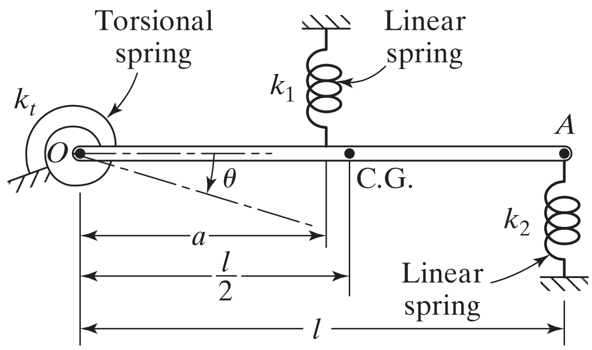
Each question carries 6 marks

9 The inclined manometer, shown below, is used to measure pressure. If the total length of mercury in the tube is *L*, find an expression for the natural frequency of oscillation of the mercury.

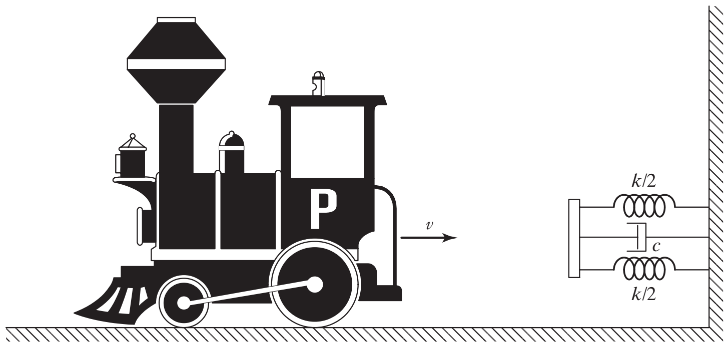


OR

10 Find the equation of motion of the uniform rigid bar *OA* of length *l* and mass *m* shown in figure and its natural frequency.



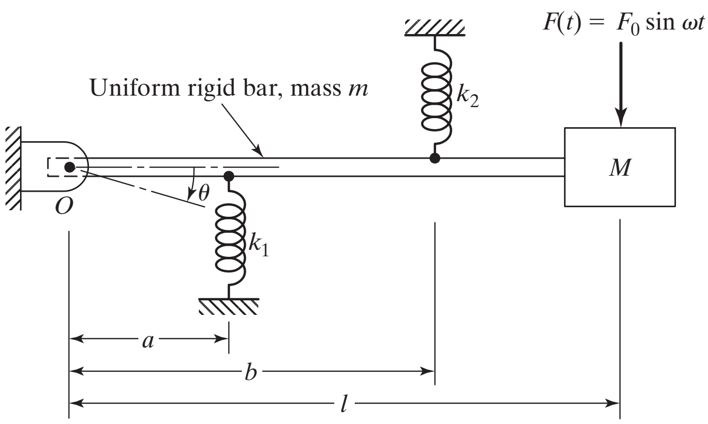
11 A railroad car of mass 2,000 kg traveling at a velocity $v = 10$ m/s is stopped at the end of the tracks by a spring-damper system, as shown below. If the stiffness of the spring is $k = 80$ N/mm and the damping constant is $c = 20$ N-s/mm, determine (*a*) the maximum displacement of the car after engaging the springs and damper and (*b*) the time taken to reach the maximum displacement.



OR

12 Find an expression for logarithmic decrement δ for free vibration with viscous damping ratio ζ. Find an approximate value for δ when damping ratio is small $\zeta << 1$

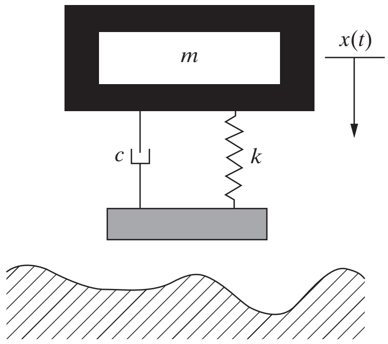
13 Derive the equation of motion and find the steady-state solution of the system shown below for rotational motion about the hinge *O* for the following data: $k = 5000$ N/m, $l = 1$ m, $m = 10$ kg, $M_0 = 100$ N-m, $v = 1000$ rpm.



OR

14 What is Quality Factor Q? How do you calculate *half-power* points? Find an expression for bandwidth for small damping ratio $\zeta << 1$?

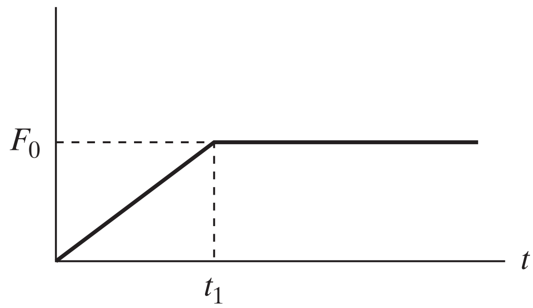
15 The vibration of a package dropped from a height of h meters can be approximated by considering the figure below. Modeling the point of contact as an impulse applied to the system at the time of contact, calculate the vibration of the mass m after the system fall from height h and hits the ground. Assume that the system is under-damped. $g = 9.8$ m/s^2



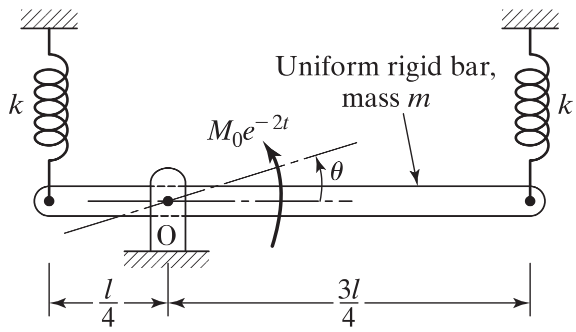
OR

16 A pulse excitation as shown below is given to an undamped spring-mass system consider two parts $t < t_1$ and $t > t_1$ and find a response to each part.

Hint: $\int x \sin(x)\, dx = x\cos(x) + \sin(x) + C$



17 Find the response of the rigid bar shown in figure using convolution integral for the following data: $k = 5000$ N/m, $l = 1$ m, m = 10 kg, $M_0 = 100$ N-m.



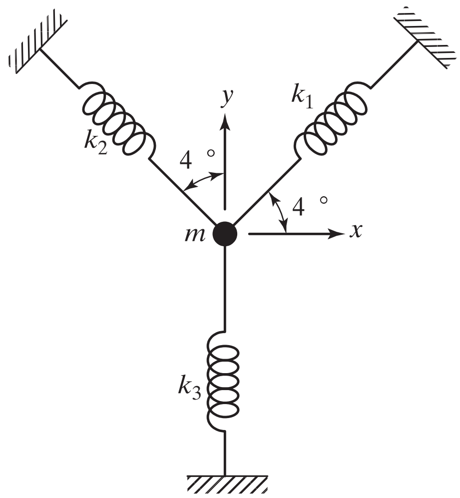
OR

18 Calculate the response of

$$3\ddot{x}(t) + 12\dot{x}(t) + 12x(t) = 3\delta(t)$$

subject to initial conditions of $x(0) = 0.01$m and $\dot{x}(0) = 0$ m/s

19 Determine the natural modes of the system when $k_1 = k_2 = k_3 = k$.



OR

20 Determine the natural frequencies and mode shapes of the system shown below.