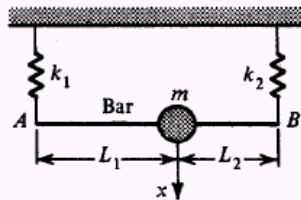




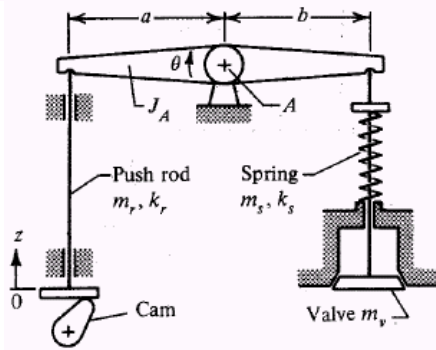
Mechanical Vibrations
Homework 2

Please solve the following problems from chapter 3 of the text book:
Problem 3,7,8,11,12,19,24,29,34,39,45,54

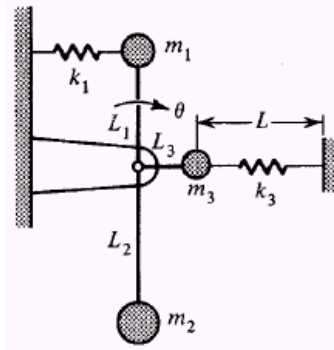
- 3-3** A mass m is attached to a rigid bar of negligible mass as shown in Fig. P3-2(a). Find the natural frequency of the system, if (a) the bar is constrained to remain horizontal while m oscillates vertically; (b) the bar is free to pivot at the hinges A and B . (c) Show that the natural frequency determined in part a is higher than that of part b.



- 3-7** An engine valve arrangement is shown in Fig. P3-3(b), where J_A is the mass moment of inertia of the rocker arm about the pivot A . Assume the effective mass m , and the effective stiffness k , of the pushrod are known. Reduce the valve arrangement to an equivalent mass-spring system.
- 3-8** A mechanism is shown schematically in Fig. P3-4(a). Assuming that the tension of the spring k_3 is constant, derive the equation of motion of the system.

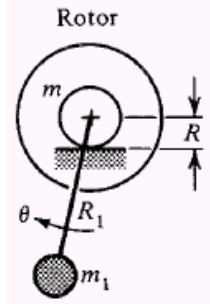


P3-3(b)

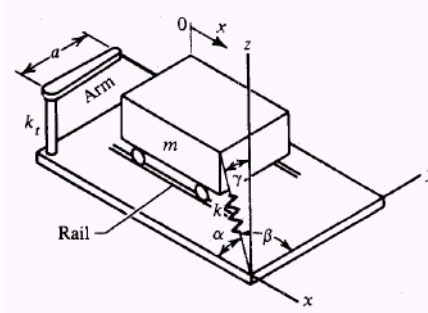


P3-4(a)

- 3-11** The mass moment of inertia J_0 of the rotor of an electrical generator of mass m is found by attaching a small mass m_1 at a distance R_1 from its longitudinal axis and timing the periods of oscillation. The test setup is shown in Fig. P3-5(b). (a) Find J_0 of the rotor. (b) Show that small variation of R will have the least effect when $R_1 = (m/m_1 + 1)R$.
- 3-12** A machine component is shown in Fig. P3-6(a). The mass m is constrained by rails to move only in the x direction. Neglecting the mass of the arm, find the equation of motion.



P3-5(b)



P3-6(a)

3-19 Derive the equations of motion for the systems in Fig. P3-8. Assume the bars are rigid and of negligible mass.

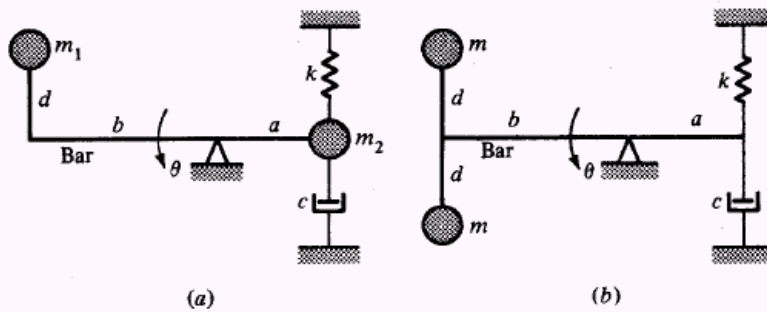


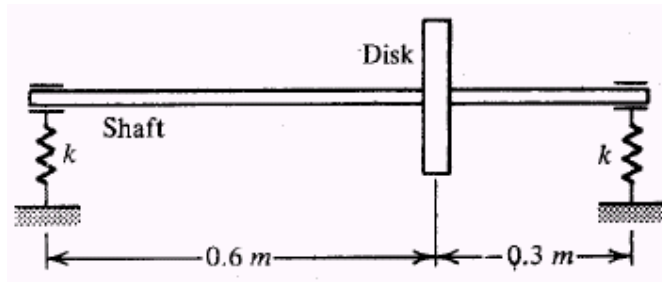
FIG. P3-8.

3-24 A wide-flange I beam is cantilevered from the foundation of a building. The beam is 2 m in length with a total mass of 60 kg. The I of the beam section is $30 \times 10^6 \text{ mm}^4$. A construction worker places a small electric motor of 4 kg at the end of the beam. The mass of the armature of the motor is 1.5 kg with an eccentricity of 0.05 mm. If the motor speed is 3,600 rpm, estimate the amplitude of vibration at the end of the beam.

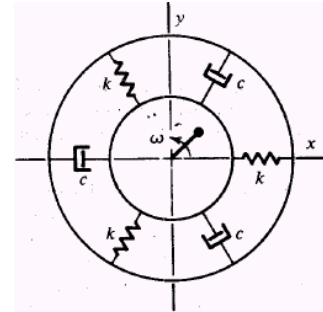
3-29 A variable-speed counter-rotating eccentric-weight exciter is attached to a machine to determine its natural frequency. With the exciter at 1,000 rpm, a stroboscope shows that the eccentric weights of the exciter are at the top the instant the machine is moving upward through its static equilibrium position. The amplitude of the displacement is 12 mm. The mass of the machine is 500 kg and that of the exciter is 20 kg with an unbalance of $0.1 \text{ kg} \cdot \text{m}$. Find (a) the natural frequency of the machine and its mounting and (b) the damping factor of the system.

3-34 A 180-kg steel disk is mounted on a 100-mm OD and 75-mm ID shaft as shown in Fig. P3-10(b). (a) Neglecting the flexibility of the bearing supports, find the critical speed of the assembly. (b) If the bearings are flexible with a spring constant $k = 70 \times 10^6 \text{ N/m}$ in any direction normal to the shaft axis, find the change in critical speed. Assume that the mass of the shaft and the gyroscopic effect of the disk are negligible.

3-39 A 50-kg rotor is mounted as shown in Fig. P3-11(a). It has an unbalance of $0.06 \text{ kg} \cdot \text{m}$ and operates at 800 rpm. If the dynamic amplitude of the rotor is to be less than 6 mm and it is desired to have low transmissibility, specify the springs and the dampers for the mounting.

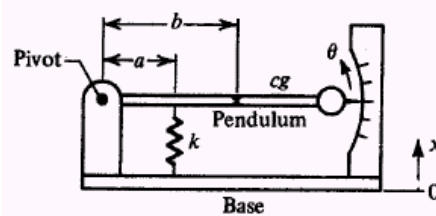


P3-10(b)



P3-11(a)

3-45 A vibrometer for measuring the rectilinear motion $x(t)$ is shown in Fig. P3-12(b). The pivot constrains the pendulum to oscillate in the plane of the paper and viscous damping exists at the pivot. Derive the equation of motion of the system.



3-54 If the system in Fig. 3-38 is actuated by a cam with the profile as shown in Fig. P3-13(c), find the steady-state response of the system. Assume that $m = 170 \text{ kg}$, $k_1 = k = 7 \text{ kN/m}$, $c = 1.7 \text{ kN} \cdot \text{s/m}$, total cam lift = 50 mm, and the cam speed = 60 rpm.

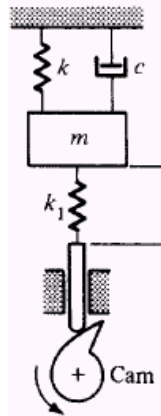
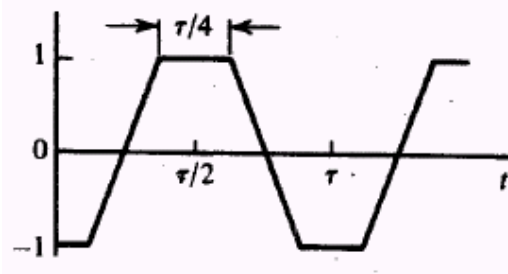


Fig3-38



P3-13(c)