Mechanical Vibrations
Homework 4

Please solve the following problems from chapter 4 of the text book:
Chapter 4: Problems 10-11,19-22,24,31-34

4-10 A company crates its products for shipping as shown in Fig. P4-2(*a*). The skid is securely mounted on a truck. Experience indicates that this method of crating is satisfactory. To cut the shipping cost, it is proposed to put two items in a crate as shown in Fig. P4-2(*b*). Would you approve this proposal?

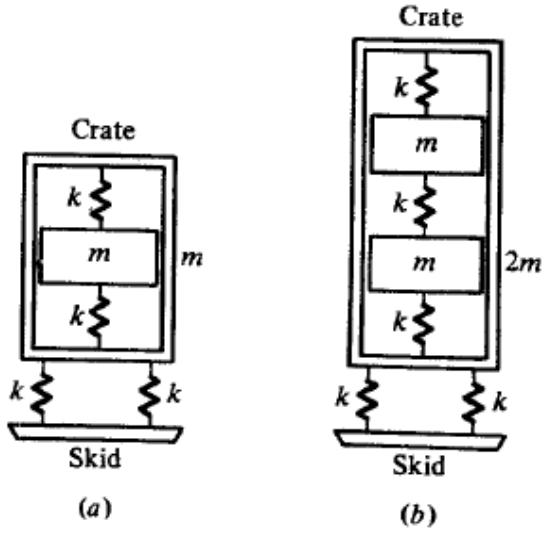


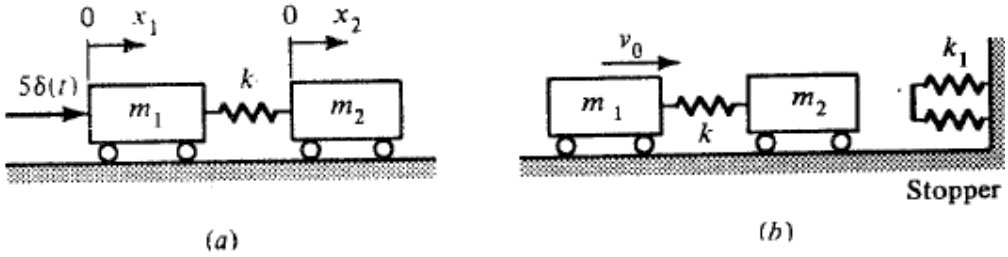
FIG. P4-2.

4-11 Consider an undamped three-degree-of-freedom system

$$\begin{bmatrix} 2 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix} \begin{bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \\ \ddot{x}_3 \end{bmatrix} + \begin{bmatrix} 4 & -1 & 0 \\ -1 & 2 & -1 \\ 0 & -1 & 4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} F_1(t) \\ F_2(t) \\ F_3(t) \end{bmatrix}$$

where $\{F(t)\}$ is a vector of transient excitations. (**a**) Find the frequency equation and the natural frequencies. (**b**) Determine the modal vectors and the modal matrix. (**c**) Verify that the modal vectors are orthogonal relative to the matrices M and K as shown in Eq. (4-40). (**d**) Write the uncoupled equations as indicated in Eq. (4-41).

4-19 Find the motions $x_1(t)$ and $x_2(t)$ of the semidefinite system shown in Fig. P4-3(a), where $\delta(t)$ is a unit impulse. Assume zero initial conditions.



(a) (b)

FIG. P4-3.

4-20 A semidefinite system strikes a stopper as shown in Fig. P4-3(b). Find the maximum force transmitted to the base of the stopper. Assume the velocity v_0 is constant and the springs are initially unstressed. Assume $m_1 = m_2$ and $k_1 = 2k$.

4-21 A branched-geared system is shown in Fig. P4-4. Assume the inertial effect of the shafts and the coupling is negligible. The gear ratio of the gears $J_b : J_c = 1:2$ and $J_b : J_d = 1:3$. The data as shown are in the SI units. (**a**)

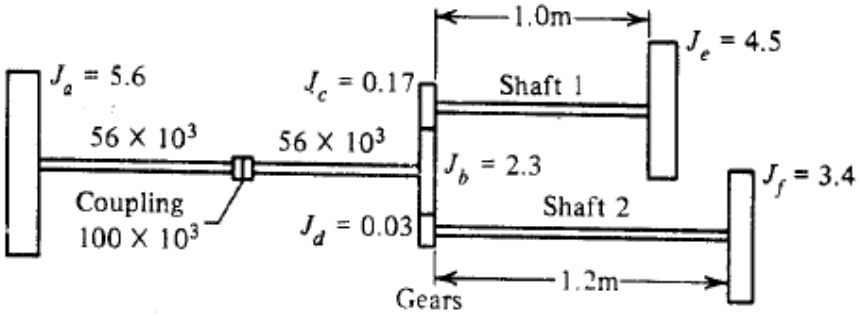
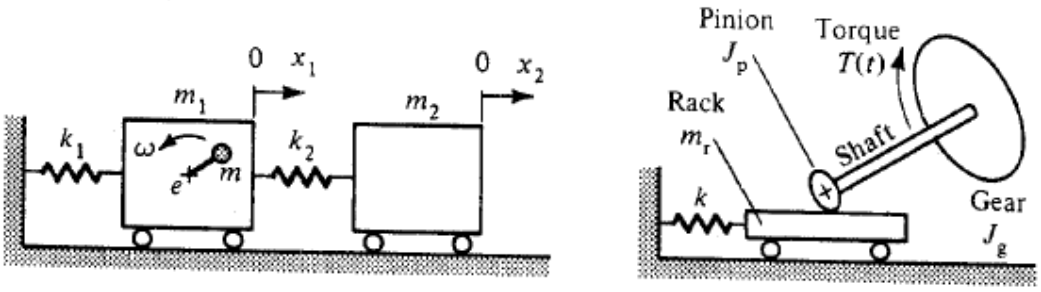


FIG. P4-4. *Branched-geared system.*

Specify the diameters of the shafts 1 and 2 such that the system has only two numerically distinct nonzero natural frequencies. (**b**) Find the natural frequencies.

4-22 Assuming harmonic excitations, find the steady-state response of each of the systems in Fig. P4-5.



(a) (b)

FIG. P4-5.

4-24 A torque $T \sin \omega t$ is applied to J_1 of the torsional system in Fig. P4-6(a). If $J_1 = 0.5\ \text{m}^2 \cdot \text{kg}$, $k_{t1} = 560 \times 10^3\ \text{m} \cdot \text{N/rad}$, $T = 226\ \text{m} \cdot \text{N}$, and $\omega = 10^3$ rad/s, specify J_2 and k_{t2} of the absorber such that the resonant frequencies are 20 percent from the excitation frequency.

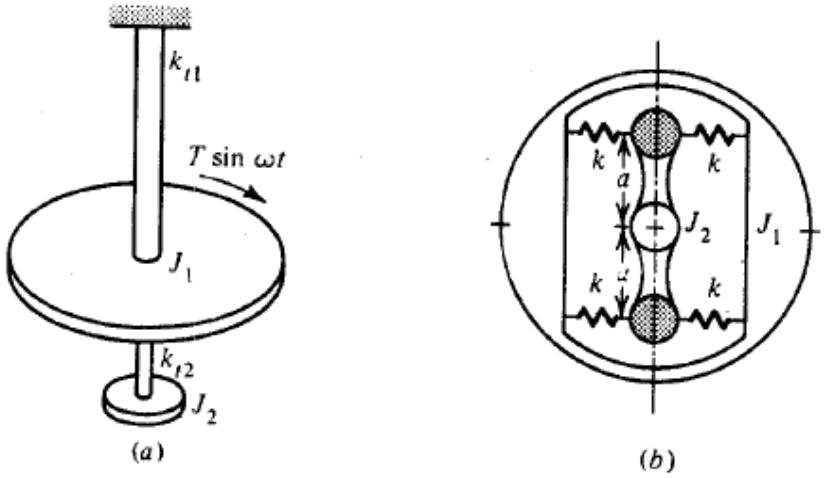
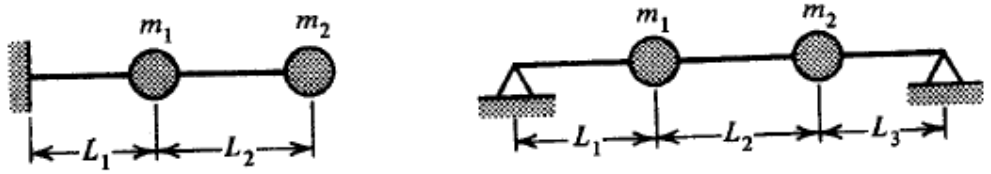


FIG. P4-6.

4-31 Find the influence coefficients for each of the systems shown in Fig. P4-7. Assume that the beams are of negligible mass.



(a) Uniform cantilever (b) Simply supported beam

FIG. P4-7.

4-32 A shaft carrying two rotating disks is shown in Fig. P4-8(a). Find the influence coefficients and the critical speeds of the assembly. Assume that (1) the deflections of the bearings and the gyroscopic effect of the disks are negligible, and (2) $L_1 = 150$ mm and $L = 600$ mm.

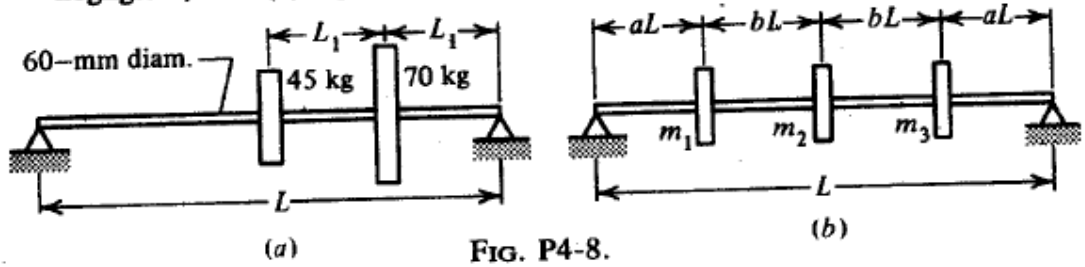


FIG. P4-8.

4-33 A shaft, with bending stiffness EI and carrying three rotating disks, is shown in Fig. P4-8(b). Assume that the mass of the shaft and the gyroscopic effect of the disks are negligible. Find the critical speeds of the assembly: (**a**) if $m_1 = m_3 = 2m_2$ and $a = b$; (**b**) if $m_1 = m_2 = m_3$ and $b = 2a$.

4-34 A continuous shaft of negligible mass and carrying two disks is shown in Fig. P4-9. Determine the influence coefficients and the critical speeds.

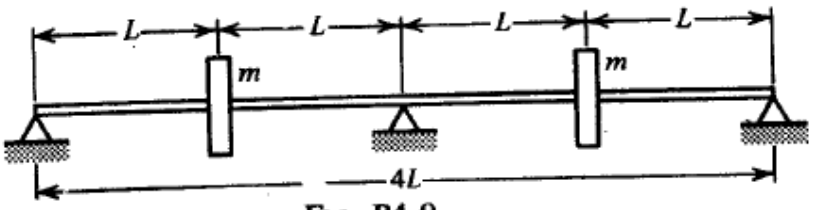


FIG. P4-9.