Mechanical Vibrations
Homework 3

Please solve the following problems from chapter 3 and 4 of the text book:
Chapter 3: Problems 41,44,45,46,54,59,62
Chapter 4: Problem 5

3-41 An instrument in an aircraft is to be isolated from the engine vibrations, ranging from 1,800 to 3,600 cycles per minute. If the damping is negligible and the instrument is of 20-kg mass, specify the springs for the mounting for 80 percent isolation.

3-44 A body m, mounted as shown in Fig. P3-12(a), is dropped on a floor. Assume that, when the base first contacts the floor, the spring is unstressed and the body has dropped through a height of 1.5 m. Find the acceleration $\ddot{x}(t)$ of m. If $m = 18$ kg, $c = 72$ N · s/m, and $k = 1.8$ kN/m, determine the maximum acceleration of m.

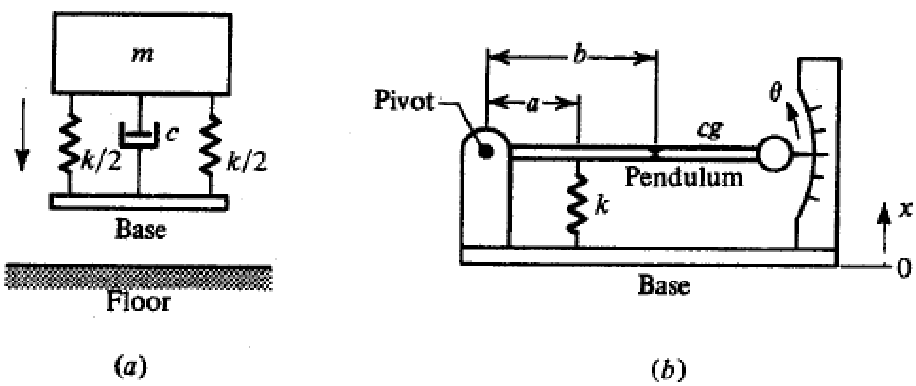


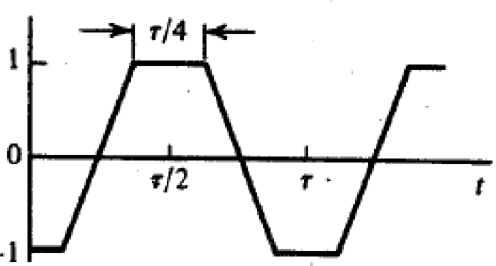
FIG. P3-12.

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.

3-46 A torsiograph is a seismic instrument to measure the speed fluctuation of a rotating shaft. A torsiograph consisting of a hollow cylinder of 0.5 kg with a 40-mm radius of gyration is mounted coaxially with the shaft and connecting to it by a spiral spring. Assuming that (1) viscous damping exists between the cylinder and the shaft, (2) the average shaft speed is 600 rpm, and (3) the frequency of fluctuations varies from 4 to 8 times the shaft speed, specify the spring constant and the damping coefficient if the torsiograph is to measure relative displacement.

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 $m = 170$ kg, $k_1 = k = 7$ kN/m, $c = 1.7$ kN · s/m, total cam lift = 50 mm, and the cam speed = 60 rpm.

$m = 20$ kg (44 lb_m) and $k_1 = k = 3.5$ kN/m (20 lb_f/in.). The damping coefficient is $c = 0.2$ kN · s/m (1.14 lb_f-sec/in.). Find the response $x(t)$.



(c)

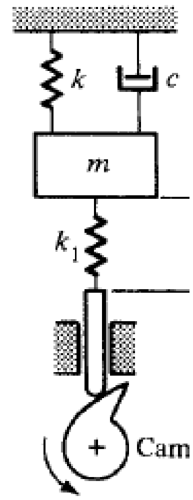


FIG. 3-38.

3-59 For the system with Coulomb friction shown in Fig. 3-45, assume that $m = 9$ kg, $k = 7$ kN/m, and the friction coefficient $\mu = 0.15$. If the initial conditions are $x(0) = 25$ mm and $\dot{x}(0) = 0$, find: (**a**) the decrease in displacement amplitude per cycle, (**b**) the maximum velocity, (**c**) the decrease in velocity amplitude per cycle, and (**d**) the position at which the body m would stop.

3-62 A machine of 350-kg mass and 1.8-kg · m eccentricity is mounted on springs and a damper with velocity squared damping. The damper consists of a 70-mm diameter cylinder-piston arrangement. The piston has a nozzle for the passage of the damping fluid, the density of which is $\rho = 960$ kg/m^3. The natural frequency of the system is 5 Hz. Assuming that the equivalent viscous-damping factor $\zeta_{eq} = 0.2$ at resonance, determine: (**a**) the resonance amplitude; (**b**) the diameter of the nozzle if the pressure drop across the nozzle is $p = (\rho/2)(\text{velocity})^2$, where (velocity) is that at the throat of the nozzle.

4-5 For each of the systems shown in Fig. P4-1, specify the coordinates to describe the system, write the equations of motion, and find the frequency equation.

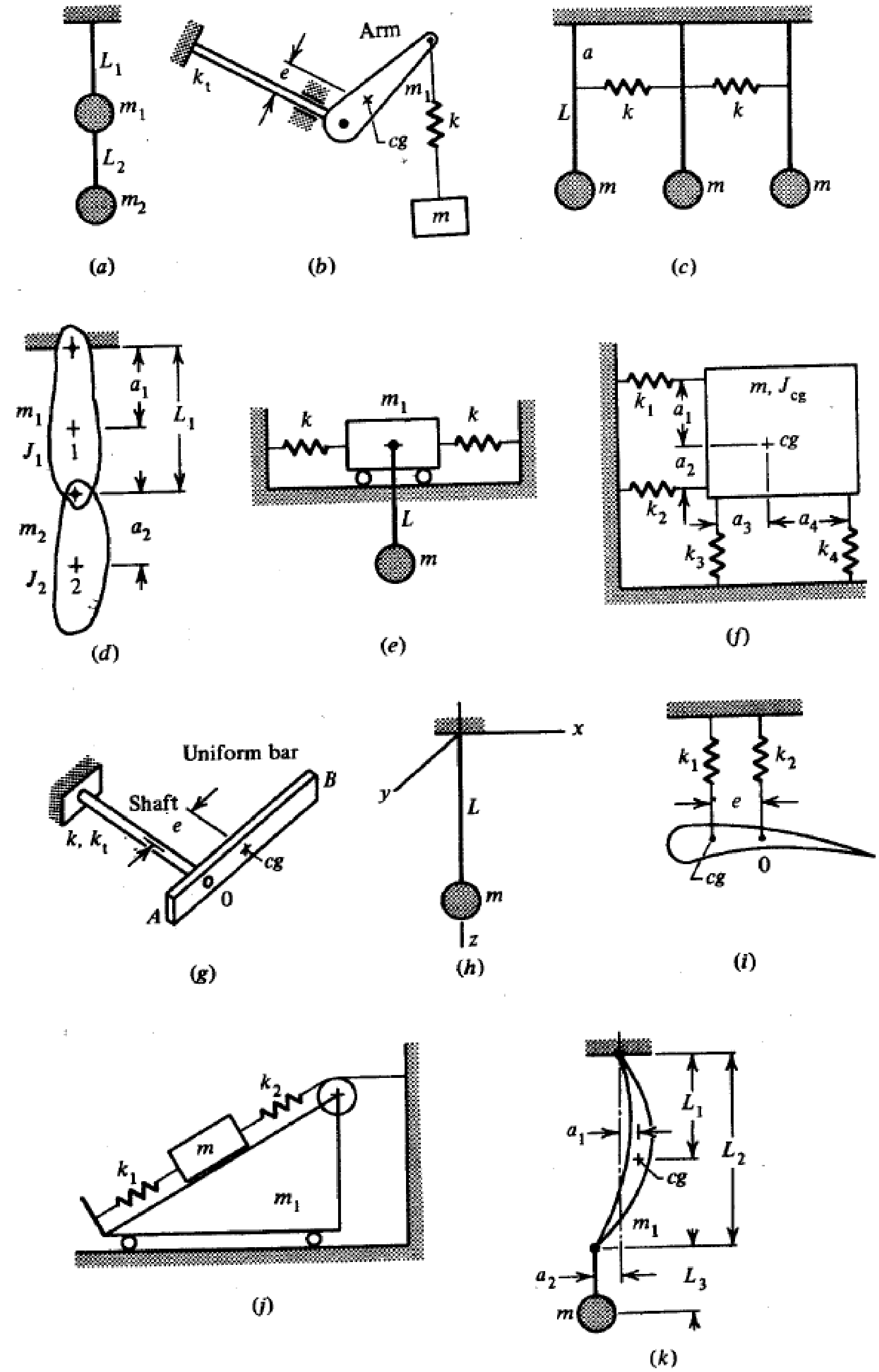


FIG. P4-1. *Vibratory systems.*