3.25 A four-cylinder automobile engine is to be supported on three shock mounts, as indicated in Fig. 3.41. The engine block assembly weighs 500 lb. If the unbalanced force generated by the engine is given by 200 sin $100\,\pi\, t$ lb, design the three shock mounts (each of stiffness k and viscous damping constant c) such that the amplitude of vibration is less than 0.1 in.

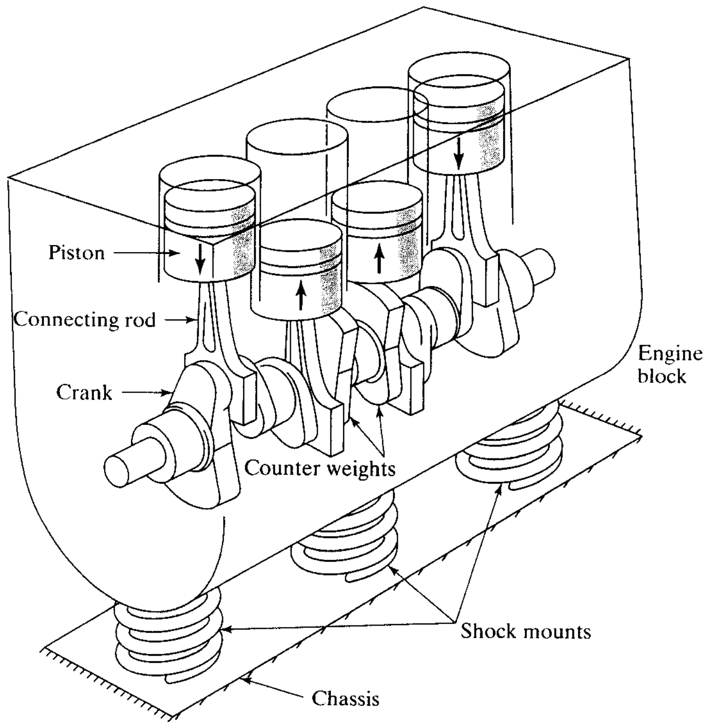

FIGURE 3.41 Four-cylinder automobile engine.

3.26 The propeller of a ship, of weight 10^5 N and polar mass moment of inertia 10,000 kg-m^2, is connected to the engine through a hollow stepped steel propeller shaft, as shown in Fig. 3.42. Assuming that water provides a viscous damping ratio of 0.1, determine the torsional vibratory response of the propeller when the engine induces a harmonic angular displacement of 0.05 sin 314.16 t rad at the base (point A) of the propeller shaft.

3.27 Find the frequency ratio $r = \omega/\omega_n$ at which the amplitude of a single degree of freedom damped system attains the maximum value. Also find the value of the maximum amplitude.

3.28 Figure 3.43 shows a permanent-magnet moving coil ammeter. When current (I) flows through the coil wound on the core, the core rotates by an angle proportional to the magnitude of the current that is indicated by the pointer on a scale. The core, with the coil, has a mass moment of inertia J_0, the torsional spring constant of k_t, and the torsional damper has a damping constant of c_t. The scale of the ammeter is calibrated such that when a d.c. current of magnitude 1 ampere is passed through the coil, the pointer indicates a current of 1 ampere. The meter has to be recalibrated for measuring the magnitude of a.c. current. Determine the steady-state

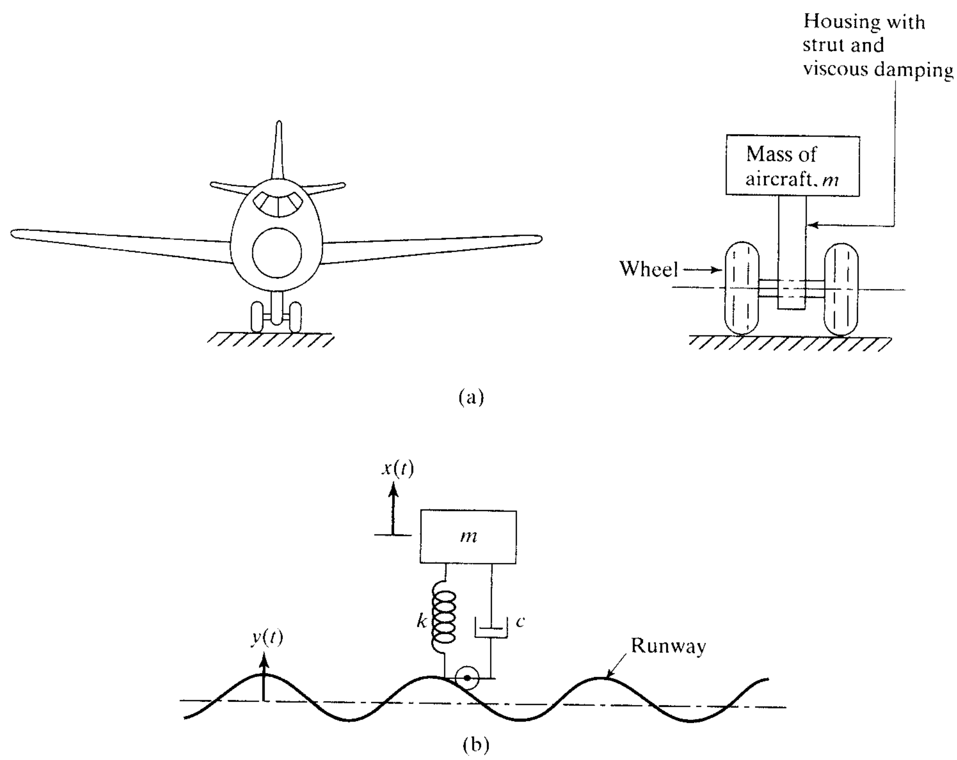

FIGURE 3.45 Modeling of landing gear.

3.36 A precision grinding machine (Fig. 3.46) is supported on an isolator that has a stiffness of 1 MN/m and a viscous damping constant of 1 kN-s/m. The floor on which the machine is mounted is subjected to a harmonic disturbance due to the operation of an unbalanced engine in the vicinity of the grinding machine. Find the maximum acceptable displacement amplitude of the floor if the resulting amplitude of vibration of the grinding wheel is to be restricted to 10^{-6} m. Assume that the grinding machine and the wheel are a rigid body of weight 5000 N.

3.37 Derive the equation of motion and find the steady-state response of the system shown in Fig. 3.47 for rotational motion about the hinge O for the following data: $k = 5000$ N/m, $l = 1$ m, $c = 1000$ N-s/m, $m = 10$ kg, $M_0 = 100$ N-m, $\omega = 1000$ rpm.

3.38 An air compressor of mass 100 kg is mounted on an elastic foundation. It has been observed that, when a harmonic force of amplitude 100 N is applied to the compressor, the maximum steady-state displacement of 5 mm occurred at a frequency of 300 rpm. Determine the equivalent stiffness and damping constant of the foundation.

3.39 Find the steady-state response of the system shown in Fig. 3.48 for the following data: $k_1 = 1000$ N/m, $k_2 = 500$ N/m, $c = 500$ N-s/m, $m = 10$ kg, $r = 5$ cm, $J_0 = 1$ kg-m^2, $F_0 = 50$ N, $\omega = 20$ rad/s.

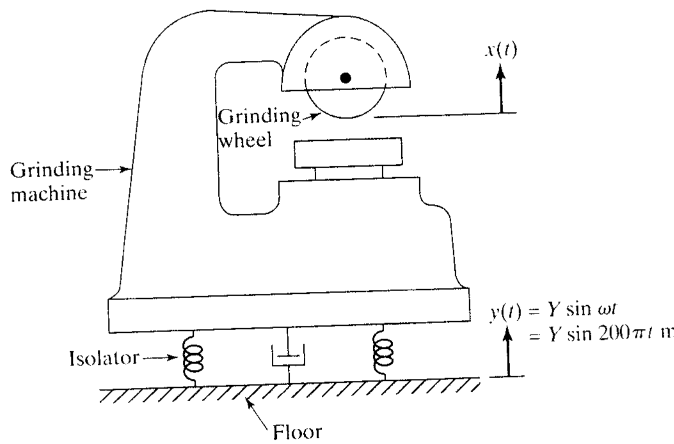

FIGURE 3.46

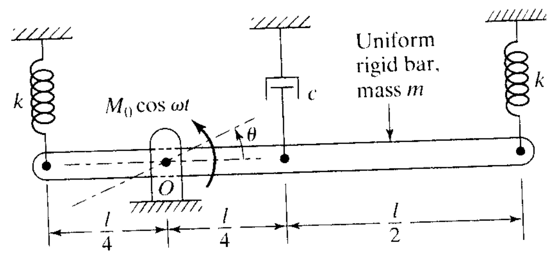

FIGURE 3.47

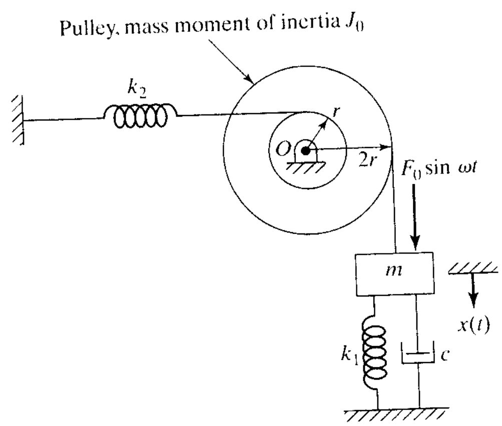

FIGURE 3.48

amplitude of vibration of the automobile at a speed of 60 km/hour. If the speed of the automobile is varied, find the most unfavorable speed for the passengers.

3.45 Derive Eq. (3.74).

3.46 A single-story building frame is modeled by a rigid floor of mass m and columns of stiffness k, as shown in Fig. 3.51. It is proposed that a damper shown in the figure is attached to absorb vibrations due to a horizontal ground motion $y(t) = Y \cos \omega t$. Derive an expression for the damping constant of the damper that absorbs maximum power.

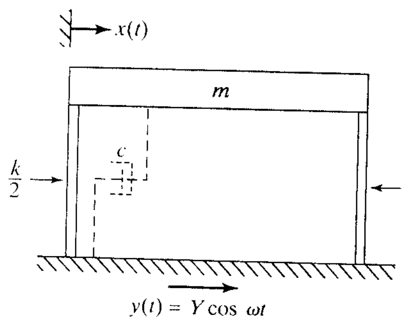

FIGURE 3.51

3.47 A uniform bar of mass m is pivoted at point O and supported at the ends by two springs, as shown in Fig. 3.52. End P of spring PQ is subjected to a sinusoidal displacement, $x(t) = x_0 \sin \omega t$. Find the steady-state angular displacement of the bar when $l = 1$ m, $k = 1000$ N/m, $m = 10$ kg, $x_0 = 1$ cm, and $\omega = 10$ rad/s.

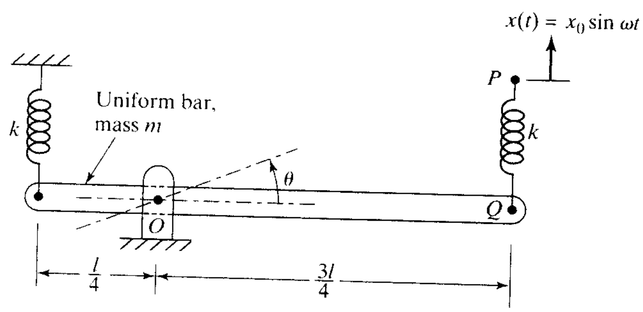

FIGURE 3.52

3.48 A uniform bar of mass m is pivoted at point O and supported at the ends by two springs, as shown in Fig. 3.53. End P of spring PQ is subjected to a sinusoidal displacement, $x(t) = x_0 \sin \omega t$. Find the steady-state angular displacement of the bar when $l = 1$ m, $k = 1000$ N/m, $c = 500$ N-s/m, $m = 10$ kg, $x_0 = 1$ cm, and $\omega = 10$ rad/s.

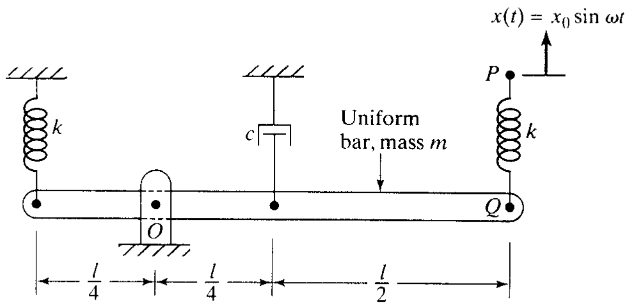

FIGURE 3.53

3.49 Find the frequency ratio, $r = r_m$, at which the displacement transmissibility given by Eq. (3.68) attains a maximum value.

3.50 An automobile, weighing 1000 lb empty and 3000 lb fully loaded, vibrates in a vertical direction while traveling at 55 mph on a rough road having a sinusoidal wave form with an amplitude Y ft and a period 12 ft. Assuming that the automobile can be modeled as a single degree of freedom system with stiffness 30,000 lb/ft and damping ratio $\zeta = 0.2$, determine the amplitude of vibration of the automobile when it is (a) empty and (b) fully loaded.

3.51 A single-cylinder air compressor of mass 100 kg is mounted on rubber mounts, as shown in Fig. 3.54. The stiffness and damping constants of the rubber mounts are given by 10^6 N/m and 2000 N-s/m, respectively. If the unbalance of the compressor is equivalent to a mass 0.1 kg located at the end of the crank (point A), determine the response of the compressor at a crank speed of 3000 rpm. Assume $r = 10$ cm and $l = 40$ cm.

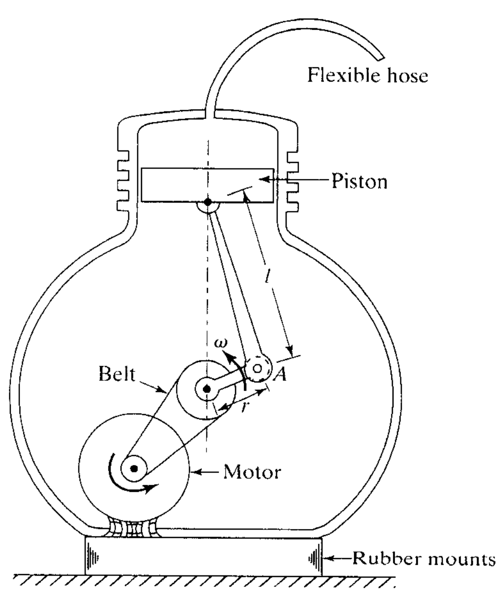

FIGURE 3.54

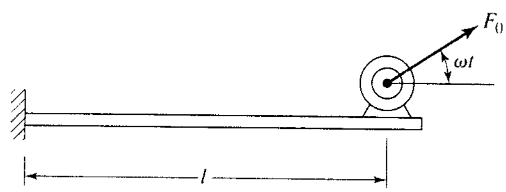

FIGURE 3.57

3.56 A centrifugal pump, weighing 600 N and operating at 1000 rpm, is mounted on six springs of stiffness 6000 N/m each. Find the maximum permissible unbalance in order to limit the steady-state deflection to 5 mm peak-to-peak.

3.57* An air compressor, weighing 1000 lb and operating at 1500 rpm, is to be mounted on a suitable isolator. A helical spring with a stiffness of 45,000 lb/in., another helical spring with a stiffness of 15,000 lb/in., and a shock absorber with a damping ratio of 0.15 are available for use. Select the best possible isolation system for the compressor.

3.58 A variable-speed electric motor, having an unbalance, is mounted on an isolator. As the speed of the motor is increased from zero, the amplitudes of vibration of the motor have been observed to be 0.55 in. at resonance and 0.15 in. beyond resonance. Find the damping ratio of the isolator.

3.59 An electric motor weighing 750 lb and running at 1800 rpm is supported on four steel helical springs, each of which has eight active coils with a wire diameter of 0.25 in. and a coil diameter of 3 in. The rotor has a weight of 100 lb with its center of mass located at a distance of 0.01 in. from the axis of rotation. Find the amplitude of vibration of the motor and the force transmitted through the springs to the base.

3.60 A small exhaust fan, rotating at 1500 rpm, is mounted on a 0.2 in. steel shaft. The rotor of the fan weighs 30 lb and has an eccentricity of 0.01 in. from the axis of rotation. Find (a) the maximum force transmitted to the bearings, and (b) the horsepower needed to drive the shaft.

3.61 A rigid plate, weighing 100 lb, is hinged along an edge (P) and is supported on a dashpot with $c = 1$ lb-sec/in. at the opposite edge (Q), as shown in Fig. 3.58. A small fan weighing 50 lb and rotating at 750 rpm is mounted on the plate through a spring with $k = 200$ lb/in. If the center of gravity of the fan is located at 0.1 in. from its axis of rotation, find the steady-state motion of the edge Q and the force transmitted to the point S.

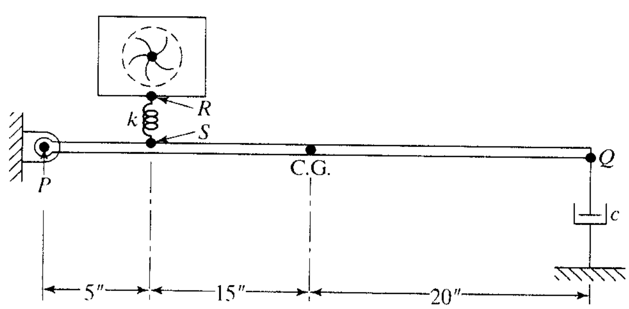

FIGURE 3.58