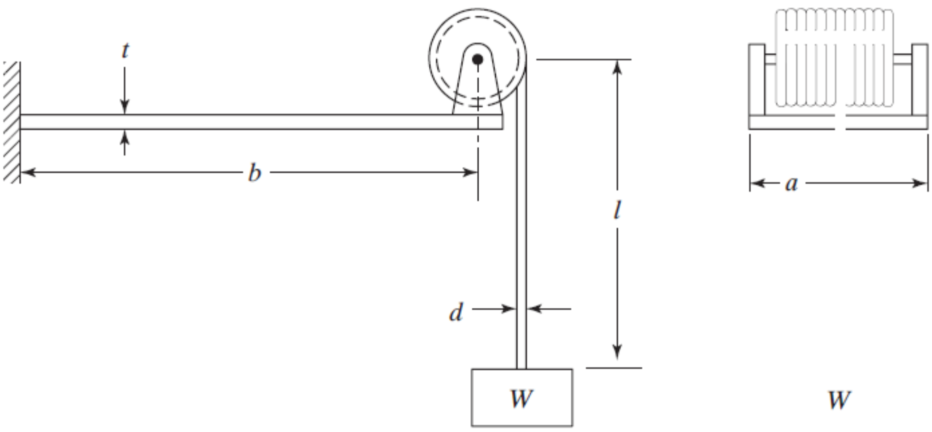
Mechanical Vibration Qualify Exam **Solution** (21 sets)

Singiresu S. Rao, Mechanical Vibrations 5th , Prentice Hall

Range: Chapters 1, 2, 3, 4

1.Page 34

A hoisting drum, carrying a steel wire rope, is mounted at the end of a cantilever beam as shown in Fig. 1.31(a). Determine the equivalent spring constant of the system when the suspended length of the wire rope is *l*. Assume that the net cross-sectional diameter of the wire rope is *d* and the Young s modulus of the beam and the wire rope is *E*.



2.Page 89

Consider a system of two springs, with stiffnesses and arranged in parallel as shown in

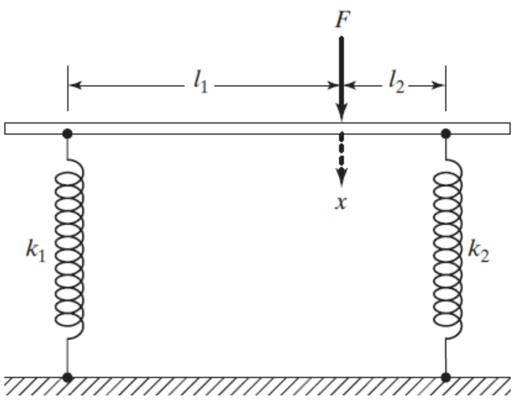
Fig. 1.68. The rigid bar to which the two springs are connected remains horizontal when the force *F* is zero.

Determine the equivalent spring constant of the system that relates the

force applied (*F*) to the resulting displacement (*x*) as F=KeX

Hint: Because the spring constants of the two springs are different and the distances L1 and L2

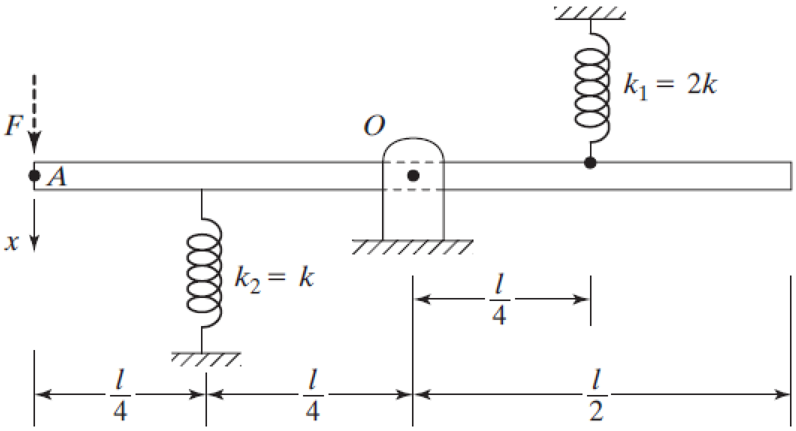
are not the same, the rigid bar will not remain horizontal when the force *F* is applied.



Parallel springs subjected to load.

3.Page 93

The static equilibrium position of a massless rigid bar, hinged at point *O* and connected with springs and is shown in Fig. 1.74. Assuming that the displacement (*x*) resulting from the application of a force *F* at point *A* is small, find the equivalent spring constant of the system, *k* that relates the applied force *F* to the displacement *x* as *F* = *kex*.



Rigid bar connected by springs.

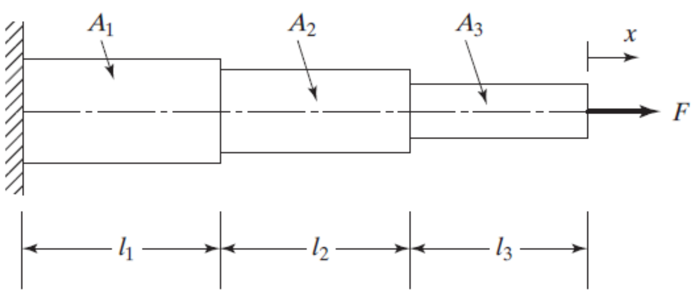
4.Page 96

Figure 1.81 shows a three-stepped bar fixed at one end and subjected to an axial force *F* at the other end. The length of step *i* is Li and its cross sectional area is Ai, i=1,2,3 All the steps are made of the same material with Young s modulus Ei=E, i=1,2,3

a. Find the spring constant (or stiffness) of step *i* in the axial direction (i=1,2,3)

b. Find the equivalent spring constant (or stiffness) of the stepped bar, in the axial direction so that F=Keq X

c. Indicate whether the steps behave as series or parallel springs.



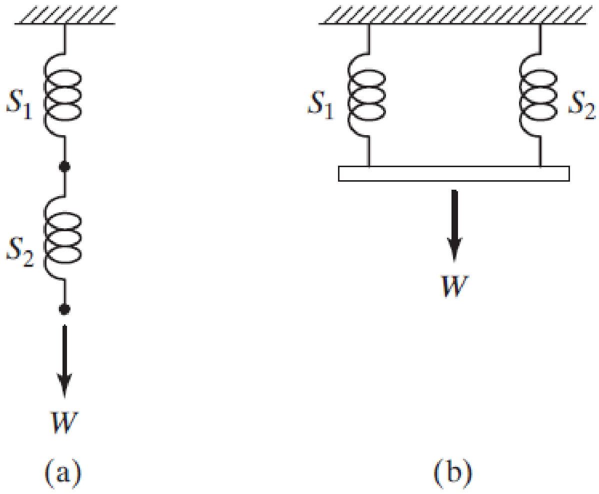
A stepped bar subjected to axial force

5.Page 99

Two nonlinear springs, S1and S2 are connected in two different ways as indicated in Fig. 1.88. The force, Fi in spring Si is related to its deflection (Xi) as

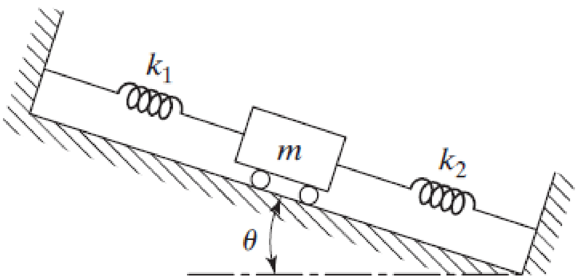
$$F_i = a_i x_i + b_i x_i^3, \qquad i = 1, 2$$

where ai and bi are constants. If an equivalent linear spring constant Keq, is defined by $W = k_{eq}x$, where x is the total deflection of the system, find an expression for Keq in each case.



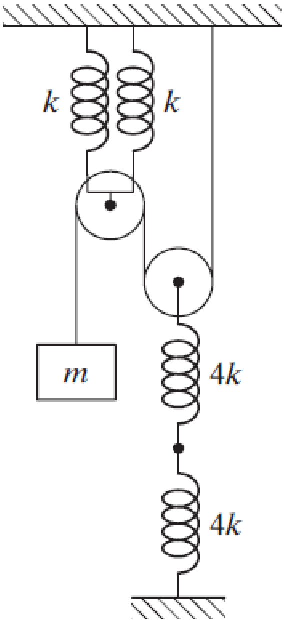
6.Page 215

Find the natural frequency of vibration of a spring-mass system arranged on an inclined plane, as shown in Fig. 2.52



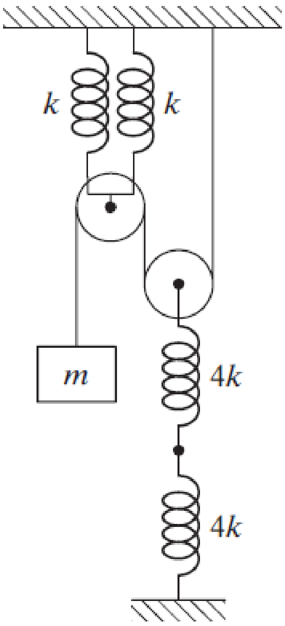
7. Page216

Find the natural frequency of the pulley system shown in Fig. 2.56 by neglecting the friction and the masses of the pulleys.



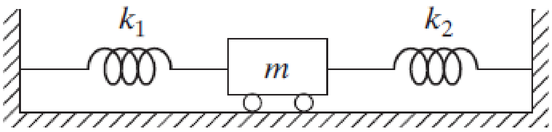
8.Page 243

Find the natural frequency of the pulley system shown in Fig. 2.56 by neglecting the friction and the masses of the pulleys. Use Rayleigh s method to solve Problem



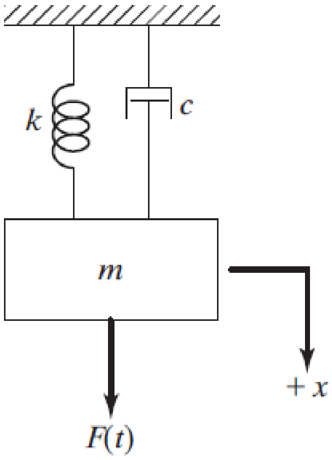
9.Page 231

Derive the equation of motion of the system shown in Fig. 2.84, using the following methods: (a) Newton s second law of motion, (b) D Alembert s principle, (c) principle of virtual work, and (d) principle of conservation of energy.



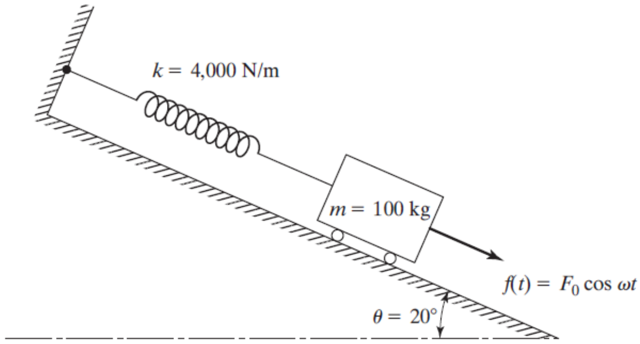
10.Page 337

In Fig. 3.1(a), a periodic force F(t)=F0cost wt is applied at a point on the spring that is located at a distance of 25 percent of its length from the fixed support. Assuming that C=0 find the steady-state response of the mass *m*.



11 Page 337

A spring-mass system, resting on an inclined plane, is subjected to a harmonic force as shown in Fig. 3.38. Find the response of the system by assuming zero initial conditions

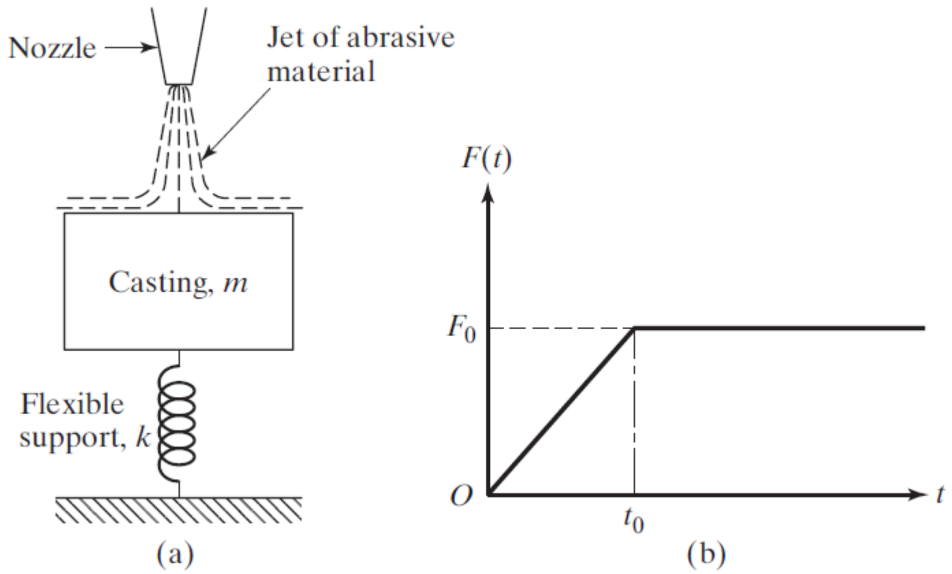


12 Page 414

Find the response of an underdamped single-degree-of-freedom system to a unit step function. Write in Laplace transfer format and do not need to solve constants.

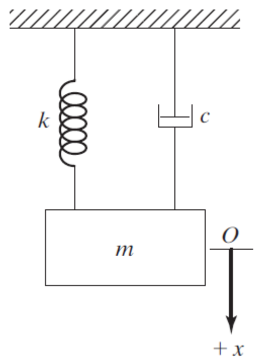
13 Page 447

Sandblasting is a process in which an abrasive material, entrained in a jet, is directed onto the surface of a casting to clean its surface. In a particular setup for sandblasting, the casting of mass *m* is placed on a flexible support of stiffness *k* as shown in Fig. 4.44(a). If the force exerted on the casting due to the sandblasting operation varies as shown in Fig. 4.44(b), find the response of the casting.



14 Page 159

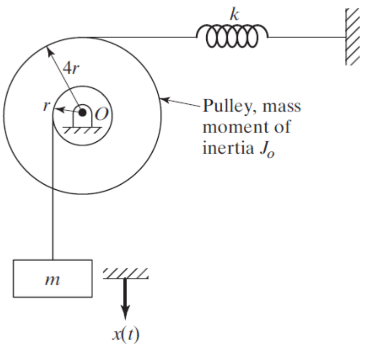
Find the general solution of free vibration with Viscous Damping. Solve the problem up to C1 and C2. Do not need to discuss underdamped, critically or overdamped damped systems

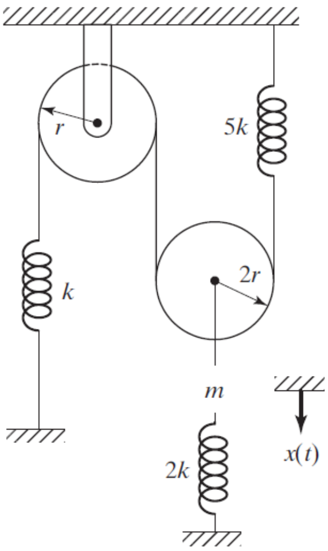


System

15 Page 232

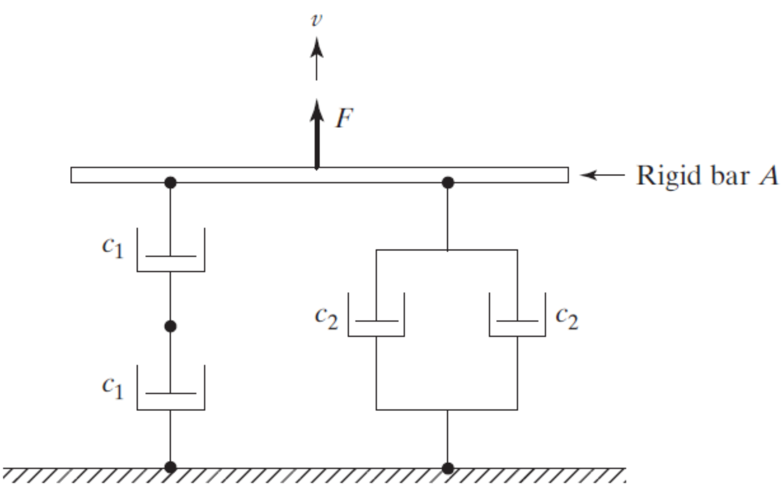
Draw the free-body diagram and derive the equation of motion using Newton s second law of motion for each of the systems shown in Figs. 2.85 and 2.86.





16 Page 111

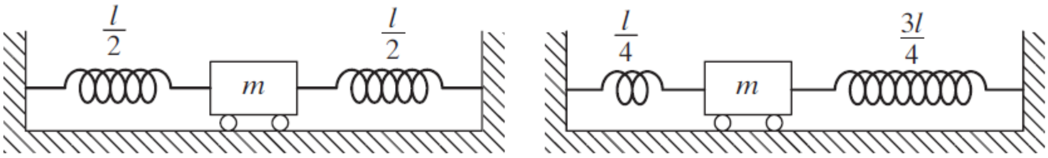
Find an expression for the equivalent translational damping constant of the system shown in Fig. 1.110 so that the force *F* can be expressed as F=Ceq v where *v* is the velocity of the rigid bar *A*.



Dampers connected in series-parallel.

17 Page 230

A helical spring of stiffness *k* is cut into two halves and a mass *m* is connected to the two halves as shown in Fig. 2.81(a). The natural time period of this system is found to be 0.5 s. If an identical spring is cut so that one part is one-fourth and the other part three-fourths of the original length, and the mass *m* is connected to the two parts as shown in Fig. 2.81(b), what would be the natural period of the system?



(a) (b)

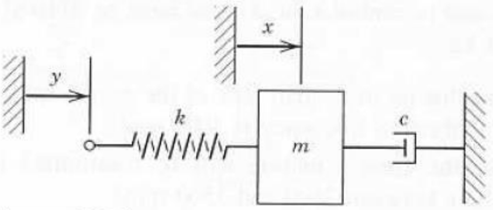
18 Page 126 (Example 3.2-4)

Figure 3.2-4*a* shows an inertia I_1 connected to a shaft with inertia I_2. The other end of the shaft is rigidly attached to the support. The applied torque is T.
(a) Develop the equation of motion.

(b) Calculate the system's natural frequency if I_1 is a cylinder 0.1 m in diameter and 0.05 m long and I_2 is a cylinder 0.05 m in diameter and 0.3 m long. Both are made of steel with a shear modulus $G = 8\times10^{10}$ N/m^2 and a density $\rho = 7800$ kg/m^3.

19

A certain mass is driven by base excitation through a spring (Figure). Its parameter values are $m = 100$ kg, $c = 400$ N·s/m, and $k = 10\ 000$ N/m. Determine its peak frequency ω_p, its peak M_p, and the lower and upper bandwidth frequencies.



20 Problem 2.15

The disk shown in Figure P2.15 has a radius of 0.25 m, a mass of 10 kg, and an inertia of 0.4 kg · m^2 about its center. The free length L of the spring is 1 m and its stiffness is 25 N/m. The disk is released from rest in the position shown and rolls without slipping. Calculate its angular velocity when its center is directly below point O. Assume that $D_1 = 2.25$ m and $D_2 = 2$ m.

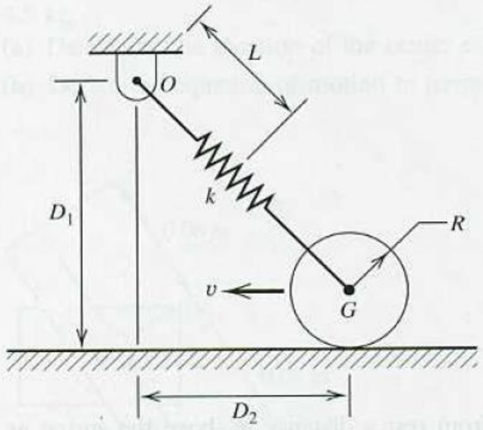
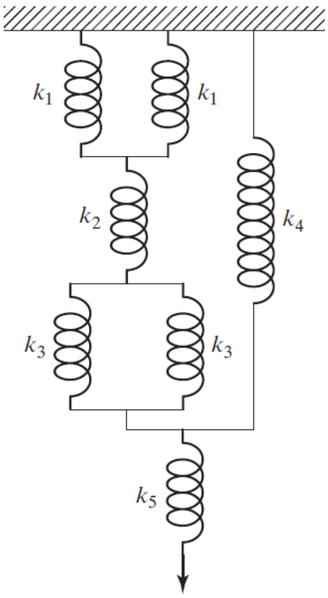


FIGURE P2.15

21

Determine the equivalent spring constant of the system shown in Fig. 1.67.



Springs in series-parallel.