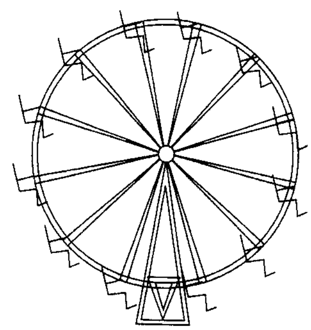
the shadow cast by a single car on the Ferris wheel would look like as a function of time. Identify the amplitude, period, and frequency of the resulting waveform.



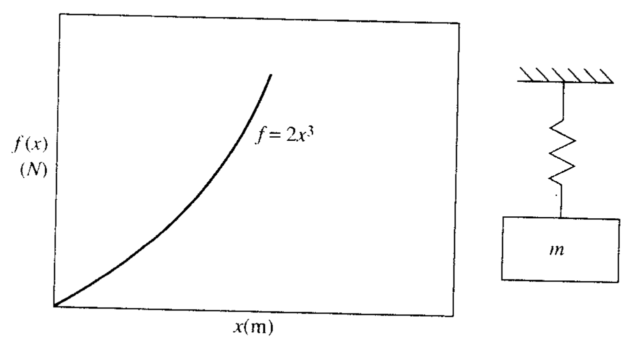
11. Consider a physical system governed by

$$m\ddot{x} + kx = 0$$

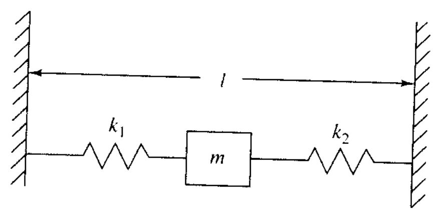
Is it possible, given some m, k, and initial conditions, for the free vibration solution to be given by

$$x(t) = 2e^{3it}?$$

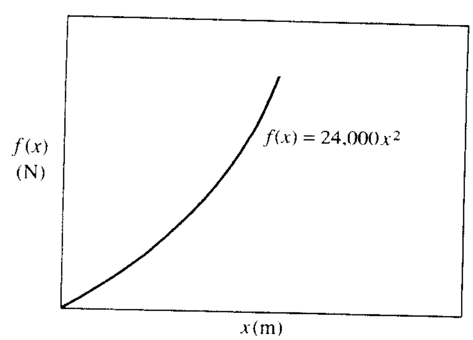
12. Determine the natural frequency of oscillation, ω_n, for small oscillations about the equilibrium position of the following spring-mass system. Note that the spring is not linear, and thus you'll have to linearize about the system's equilibrium position in order to find the equivalent linear stiffness. $m_1 = 1$ kg and $g = 9.8$ m/s^2.

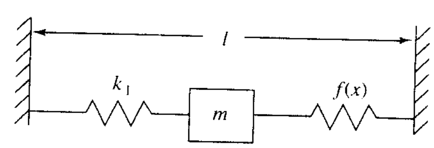


13. Consider the illustrated system having two linear springs. The unstretched length of k_1 is .5 m and the unstretched length of k_2 is .25 m. $k_1 = 1000$ N/m, $k_2 = 2000$ N/m, $m = 2$ kg, and $l = .5$ m. Find the equilibrium position of the mass and determine the natural frequency of the system. Compare this natural frequency to that associated with $l = .75$ m (i.e., no precompression in the spring).

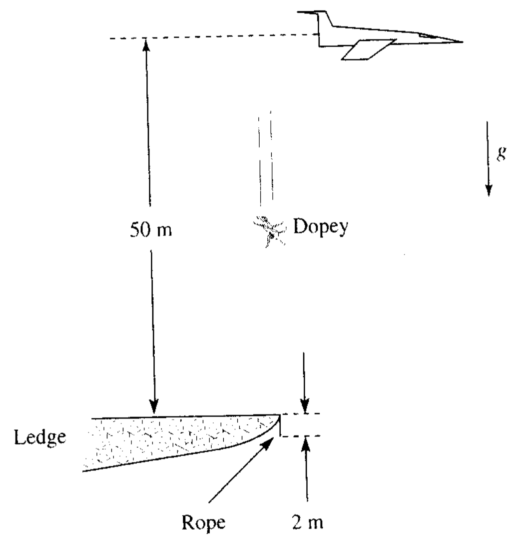


14. Consider the system in which the linear spring of Problem 13 is replaced with a nonlinear spring, as shown below. The unstretched length of k_1 is .5 m and the unstretched length of the nonlinear spring is .25 m. $k_1 = 1000$ N/m, $f(x) = 24{,}000x^2$, $m = 2$ kg, and $l = .5$ m. Find the equilibrium position of the mass and find the nonlinear spring's equivalent linear stiffness at the calculated deflection. (Hint: The linear stiffness is found by evaluating $\frac{df}{dx}$ at a given calculated deflection. This tells you the linear change of force per unit deflection). Calculate the natural frequency. Does the natural frequency change if l is set equal to .75 m? How does this situation differ from that of Problem 13?

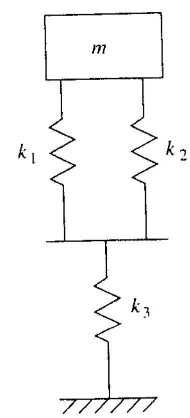




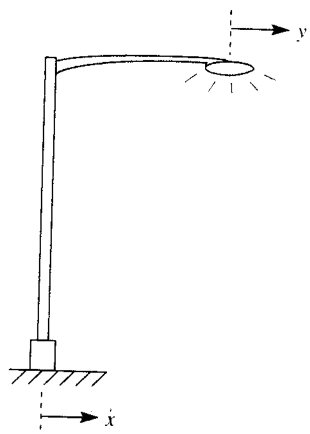
15. In an effort to add realism to cartoons, you've been asked to dynamically analyze a cartoon gag (assume that you're working during the summer as an animator). In this gag, Dopey Dog is falling from an airplane and, as he passes a ledge, grabs an elastic rope he tied there earlier. The unstretched length of the rope is 2 m and he falls 50 m before grabbing it. His mass is 35 kg and the rope can be considered massless. The spring constant of the rope is 420 N/m. Calculate Dopey's position as a function of time after he grabs the rope, and determine how long it takes for his velocity to reach zero. Assume he doesn't hit the canyon floor. (Note: Don't neglect the static offset he'd have due to gravity.) Calculate a trajectory only for motions in which the rope is under tension.



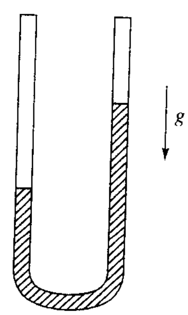
16. Determine the natural frequencies for the illustrated systems. What is the difference between the two cases? Which springs are most active and which are relatively uninvolved in the oscillations?



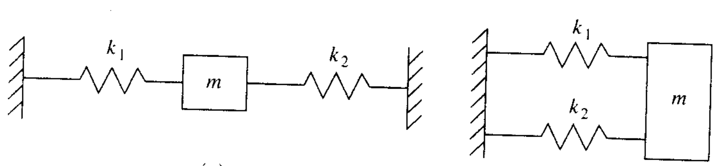
17. A static horizontal load of 50 N, applied to the lamp housing of the illustrated street lamp, caused a horizontal deflection of 4 cm. Assume that the motion of an earthquake can be modeled as a step change in position. Thus the initial conditions are $x(0) = 10$ cm and, $\dot{x}(0) = 0$ cm/s. Determine the response of the lamp housing. Consider the lamppole to be massless and the mass of the housing to be 20 kg.



18. Determine the free vibration of the illustrated system (water in a U-shaped tube). The tube has an inner area of s, the water has density ρ, and the length of the water-filled section is l.



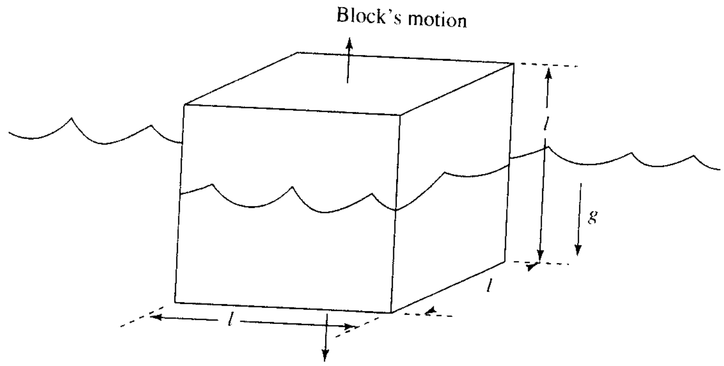
19. What is the difference between system (a) and system (b) (if any)?



(a) (b)

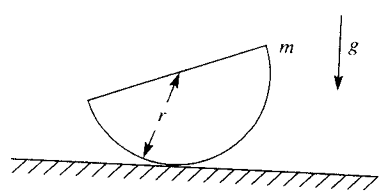
20. Consider two masses joined by a spring and sliding on a frictionless surface. If the distance between them is given by z, determine the equation of motion of the system that involves only z, m_1, and m_2. (Note: The motion will be a "breathing" action in which the masses move together and apart.)

35. Determine the frequency of oscillation of a cube of wood bobbing up and down in the water, in terms of the water's density, the wood's density, g and l.

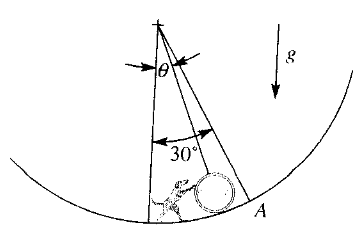


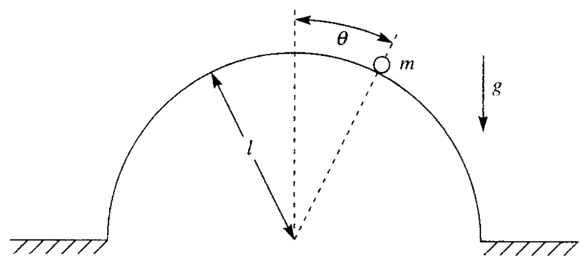
Section 1.3

36. Determine the natural frequency of oscillation for the illustrated half disc. Assume no slip conditions.

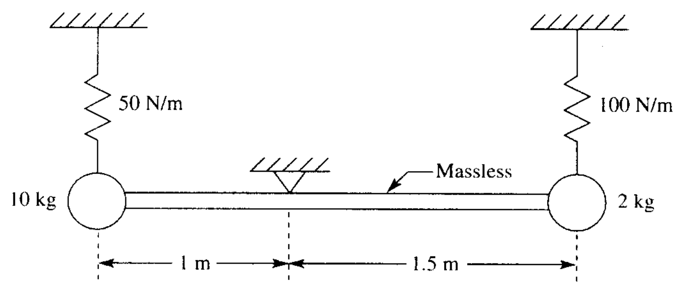


37. In this problem Dopey Dog is rolling a large cylindrical drum up a slope. The actual shape of the ground he's walking on is described by a circle, with a radius equal to $10r_1$. When Dopey reaches point A, he slips and the cylinder rolls over him. Assuming pure rolling, how long will it be before the cylinder returns to Dopey? The cylinder's mass is equal to m and it has a radius of r_1. Assume that linearization about $\theta = 0$ degrees is a valid approximation.

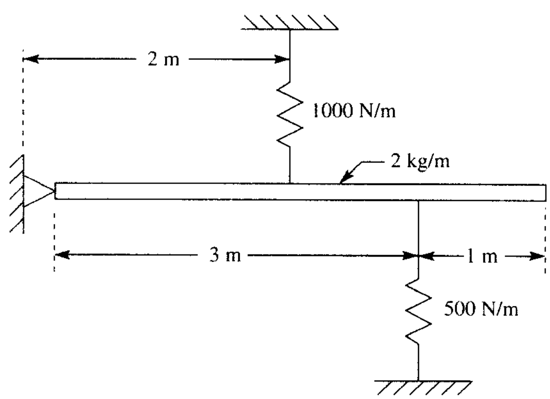




48. What is the natural frequency for the system shown?



49. What is the natural frequency for the system shown?



50. The system shown consists of a mass m that rides along a horizontal track and a tensioned string that connects the mass to the point 0. Determine the natural frequency of the system under the assumption

64. Can the frequency of oscillation for a viscously damped spring-mass damper be altered without changing the oscillation decay rate by varying the system parameters?

65. Is ζ more strongly affected by c, m, or k?

66. If the mass of a spring-mass damper is doubled in value, while the spring stiffness is halved, how will the decay rate and frequency of subsequent oscillations be affected?

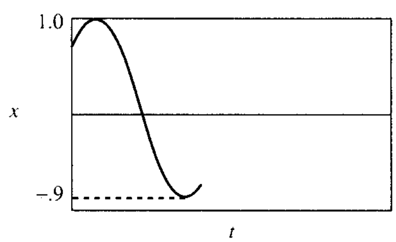
67. How many oscillation cycles will elapse if you're waiting for the oscillation amplitude of a spring-mass damper to drop by 20 percent and $\zeta = .05$? Let $\omega_n = 100$. What if ζ is decreased to .0005?

68. Oscillation amplitudes are reduced by 50 percent in 1 s for a given spring-mass damper system. Say you want to have the amplitude reduced to 25 percent of the original value in 1 s. How effective would it be to vary the value of k?

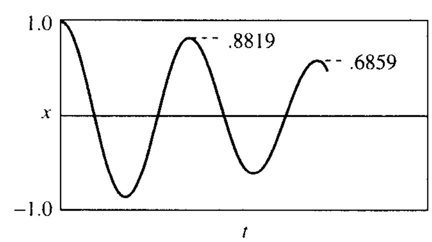
69. What does simultaneously doubling the mass and stiffness of a spring-mass damper system do to the free vibration's decay rate?

70. Consider a variation of Problem 31. This time, when the mass returns it fails to reach the friend's hand, coming up short by 27 cm. Determine the damping factor of the elastic band/mass system. The time at which the mass came closest to the friend's hand was .3 s after release.

71. Say you have only a little over one-half the time response for a linear, damped oscillator, as shown. Can you use this information to determine ζ for the system?



72. What can you say about the damping in the system that produced the following free response?



73. The dampers on automobiles are supposed to work in the same manner during compression and extension. Due to a manufacturing defect, one that you are examining is operative only during one-half the cycle (the compression stroke). If you know that the damping is viscous during compression, and you also