Test Problems for Oscillatory motion (L9). Make sure you know how to answer all these problems.

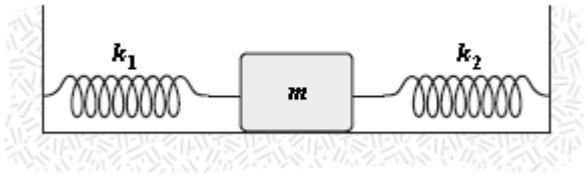
29. Ellen says that whenever the acceleration is directly proportional to the displacement of an object from its equilibrium position, the motion of the object is simple harmonic motion. Mary says this is true only if the acceleration is opposite in direction to the displacement. Which one, if either, is correct?
    a. Ellen, because ω^2 is directly proportional to the constant multiplying the displacement and to the mass.
    b. Ellen, because ω^2 is directly proportional to the mass.
    c. Mary, because ω^2 is directly proportional to the constant multiplying the displacement and to the mass.
    d. Mary, because ω^2 is directly proportional to the mass.
    e. Mary, because the second derivative of an oscillatory function like $\sin(\omega t)$ or $\cos(\omega t)$ is always proportional to the negative of the original function.

    ANS: E PTS: 1 DIF: Easy

30. John says that the value of the function $\cos[\omega(t + T) + \varphi]$, obtained one period T after time t, is greater than $\cos(\omega t + \varphi)$ by 2π. Larry says that it is greater by the addition of 1.00 to $\cos(\omega t + \varphi)$. Which one, if either, is correct?
    a. John, because $\omega T = 2\pi$.
    b. John, because $\omega T = 1$ radian.
    c. Larry, because $\omega T = 2\pi$.
    d. Larry, because $\omega T = 1$ radian.
    e. Neither, because $\cos(\theta + 2\pi) = \cos\theta$.

    ANS: E PTS: 1 DIF: Easy

The mass in the figure slides on a frictionless surface. If m = 2 kg, k_1 = 800 N/m and k_2 = 500 N/m, the frequency of oscillation (in Hz) is approximately



a. 6
b. 2
c. 4
d. 8
e. 10

ANS: C PTS: 2 DIF: Average

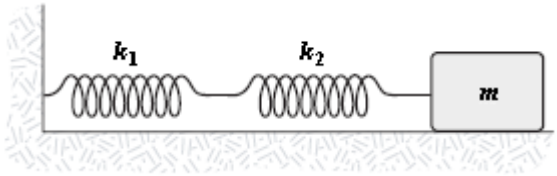
35. A damped oscillator is released from rest with an initial displacement of 10.00 cm. At the end of the first complete oscillation the displacement reaches 9.05 cm. When 4 more oscillations are completed, what is the displacement reached?
    a. 7.41 cm
    b. 6.71 cm
    c. 6.07 cm
    d. 5.49 cm
    e. 5.25 cm

ANS: C PTS: 2 DIF: Average

36. The oscillation of the 2.0-kg mass on a spring is described by $x = 3.0\cos(4.0t + 0.80)$ where x is in centimeters and t is in seconds. What is the force constant of the spring?
    a. 4.0 N/m
    b. 0.80 N/m
    c. 16 N/m
    d. 32 N/m
    e. 2.0π N/m

    ANS: D PTS: 2 DIF: Average

16. The mass in the figure below slides on a frictionless surface. When the mass is pulled out, spring 1 is stretched a distance x_1 from its equilibrium position and spring 2 is stretched a distance x_2. The spring constants are k_1 and k_2 respectively. The force pulling back on the mass is:



    a. $-k_2x_1$.
    b. $-k_2x_2$.
    c. $-(k_1x_1 + k_2x_2)$.
    d. $-\frac{k_1 + k_2}{2}(x_1 + x_2)$.
    e. $-\frac{k_1 + k_2}{k_1k_2}(x_1 + x_2)$.

    ANS: B PTS: 2 DIF: Average

    In addition, what is the period of oscillation?

17. A hoop, a solid cylinder, and a solid sphere all have the same mass m and the same radius R. Each is mounted to oscillate about an axis a distance 0.5 R from the center. The axis is perpendicular to the circular plane of the hoop and the cylinder and to an equatorial plane of the sphere as shown below. Which is the correct ranking in order of increasing angular frequency ω?

    a. hoop, cylinder, sphere
    b. cylinder, sphere, hoop
    c. sphere, cylinder, hoop
    d. hoop, sphere, cylinder
    e. sphere, hoop, cylinder

ANS: A PTS: 2 DIF: Average

31. Simple harmonic oscillations can be modeled by the projection of circular motion at constant angular velocity onto a diameter of the circle. When this is done, the analog along the diameter of the acceleration of the particle executing simple harmonic motion is
    a. the displacement from the center of the diameter of the projection of the position of the particle on the circle.
    b. the projection along the diameter of the velocity of the particle on the circle.
    c. the projection along the diameter of tangential acceleration of the particle on the circle.
    d. the projection along the diameter of centripetal acceleration of the particle on the circle.
    e. meaningful only when the particle moving in the circle also has a non-zero tangential acceleration.

    ANS: D PTS: 1 DIF: Easy

32. When a damping force is applied to a simple harmonic oscillator which has angular frequency ω_0 in the absence of damping, the new angular frequency ω is such that
    a. $\omega < \omega_0$.
    b. $\omega = \omega_0$.
    c. $\omega > \omega_0$.
    d. $\omega T < \omega_0 T_0$.
    e. $\omega T > \omega_0 T_0$.

    ANS: A PTS: 1 DIF: Easy

33. When a damping force is applied to a simple harmonic oscillator which has period T_0 in the absence of damping, the new period T is such that
    a. $T < T_0$.
    b. $T = T_0$.
    c. $T > T_0$.
    d. $\omega T < \omega_0 T_0$.
    e. $\omega T > \omega_0 T_0$.

    ANS: C PTS: 1 DIF: Easy

34. To double the total energy of a mass oscillating at the end of a spring with amplitude A, we need to
    a. increase the angular frequency by $\sqrt{2}$.
    b. increase the amplitude by $\sqrt{2}$.
    c. increase the amplitude by 2.
    d. increase the angular frequency by 2.
    e. increase the amplitude by 4 and decrease the angular frequency by $\frac{1}{\sqrt{2}}$.

    ANS: B PTS: 1 DIF: Easy

40. An archer pulls her bow string back 0.40 m by exerting a force that increases uniformly from zero to 240 N. What is the equivalent spring constant of the bow, and how much work is done in pulling the bow?

    ANS:
    600 N/m, 48 J

PTS: 2 DIF: Average

41. An ore car of mass 4 000 kg starts from rest and rolls downhill on tracks from a mine. A spring with k = 400 000 N/m is located at the end of the tracks. At the spring's maximum compression, the car is at an elevation 10 m lower than its elevation at the starting point. How much is the spring compressed in stopping the ore car? Ignore friction.

ANS:
1.4 m

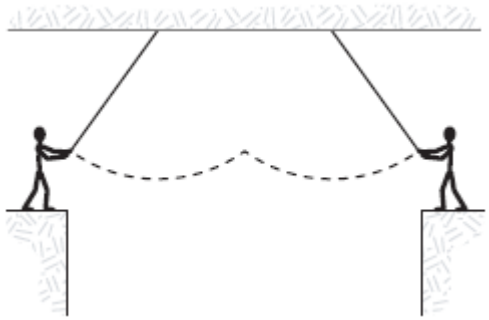
PTS: 2 DIF: Average

42. The motion of a piston in an auto engine is simple harmonic. If the piston travels back and forth over a distance of 10 cm, and the piston has a mass of 1.5 kg, what is the maximum speed of the piston and the maximum force acting on the piston when the engine is running at 4 200 rpm?

ANS:
22 m/s, 14 500 N

PTS: 2 DIF: Average

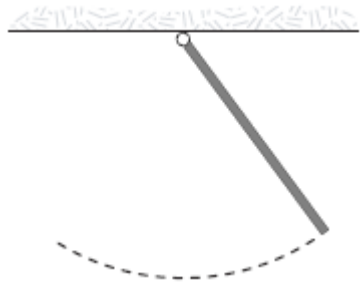
9. Two circus clowns (each having a mass of 50 kg) swing on two flying trapezes (negligible mass, length 25 m) shown in the figure. At the peak of the swing, one grabs the other, and the two swing back to one platform. The time for the forward and return motion is



a. 10 s
b. 50 s
c. 15 s
d. 20 s
e. 25 s

ANS: A PTS: 2 DIF: Average

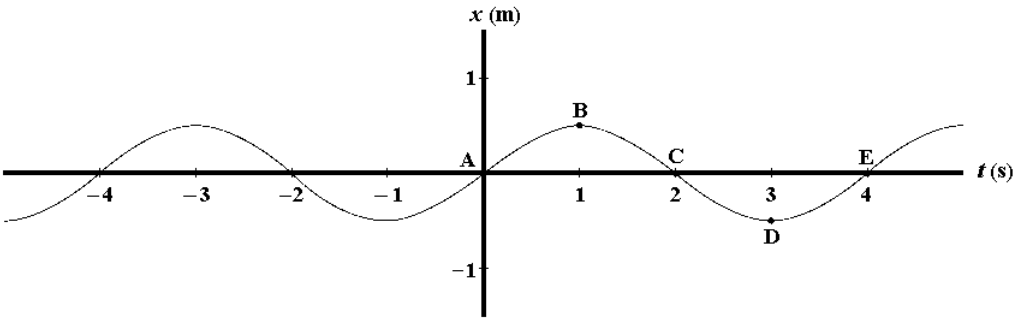
10. A uniform rod (mass m = 1.0 kg and length L = 2.0 m) pivoted at one end oscillates in a vertical plane as shown below. The period of oscillation (in s) is approximately



a. 4.0
b. 1.6
c. 3.2
d. 2.3
e. 2.0

ANS: D PTS: 2 DIF: Average

Exhibit 15-1
A graph of position versus time for an object oscillating at the free end of a horizontal spring is shown below. A point or points at which the object has positive velocity and zero acceleration is(are)



Use this exhibit to answer the following question(s).

21. Refer to Exhibit 15-1. A point or points at which the object has positive velocity and zero acceleration is(are)
a. B
b. C
c. D
d. B and D
e. A and E

ANS: E PTS: 1 DIF: Easy

22. Refer to Exhibit 15-1. The point at which the object has negative velocity and zero acceleration is
a. A
b. B
c. C
d. D
e. E

ANS: C PTS: 1 DIF: Easy

23. Refer to Exhibit 15-1. The point at which the object has zero velocity and positive acceleration is
a. A

b. B
c. C
d. D
e. E

ANS: D PTS: 1 DIF: Easy

24. Refer to Exhibit 15-1. The point at which the object has zero velocity and negative acceleration is
a. A
b. B
c. C
d. D
e. E

ANS: B PTS: 1 DIF: Easy