Chapter 13 Problems

1, 2, = straightforward, intermediate,

Section 13.1 Hooke's Law

1. A 0.60-kg block is attached to a spring with force constant 130 N/m so that the object is allowed to move on a horizontal frictionless surface. The object is released from rest when the spring is stretched 0.13 m. At that instant, find (a) the force on the block and (b) its acceleration at that instant.

2. When a 4.25 kg object is placed on top of a vertical spring, the spring compresses a distance of 2.62 cm. What is the force constant of the spring? (b) how would your answer change is the distance was doubled?

3. A ball dropped from a height of 4.00 m makes a perfectly elastic collision with the ground. Assuming that no mechanical energy is lost due to air resistance, (a) show that the motion is periodic and (b) determine the period of the motion. (c) Is the motion simple harmonic? Explain.

4. A load of 50 N attached to a spring hanging vertically stretches the spring 5.0 cm. The spring is now placed horizontally on a table and stretched 11 cm. (a) What force is required to stretch the spring by that amount? (b) Plot a graph of force (on the *y*-axis) versus spring displacement from the equilibrium position along the *x*-axis.

5. A spring is hung from a ceiling, and an object attached to its lower end stretches the spring by a distance of 5.00 cm from its unstretched position when the system is in equilibrium. If the spring constant is 47.5 N/m, determine the mass of the object.

Section 13.2 Elastic Potential Energy

8. A spring-loaded pellet gun is designed to fire 3.0 g projectiles horizontally at a speed of 45.0 m/s. (a) If the spring is compressed to its maximum design difference of 8.0 cm, what spring constant is required? (b) What maximum force is required to load the gun?

9. A slingshot consists of a light leather cup containing a stone. The cup is pulled back against two parallel rubber bands. It takes a force of 15 N to stretch either one of these bands 1.0 cm. (a) What is the potential energy stored in the two bands together when a 50-g stone is placed in the cup and pulled back 0.20 m from the equilibrium position? (b) With what speed does the stone leave the slingshot? (c) How would the speed change if the force to stretch the spring was cut in half?

10. An archer pulls her bowstring back 0.400 m by exerting a force that increases uniformly from zero to 230 N. (a) What is the equivalent spring constant of the bow? (b) How much work is done in pulling the bow? (c)If the archer pulls the bow half the distance how does that change the spring constant and work?

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Homework 2: Section 13.2 => 13 – 16
Homework 3: Section 13.4 => 18, 19, 26, 29
Homework 4: Sections 13.5 & 13.8 => 34 – 36, 41, 43 - 45
Homework 5: Section 13.11 & Additional Problems => 61, 63, 65, 67, 70

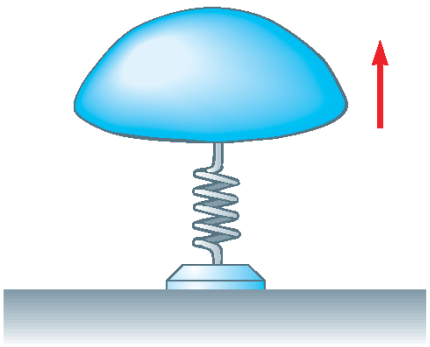

Figure P13.11

13. A 10.0-g bullet is fired into, and embeds itself in, a 2.00-kg block attached to a spring with a force constant of 19.6 N/m and whose mass is negligible. How far is the spring compressed if the bullet has a speed of 300 m/s just before it strikes the block and the block slides on a frictionless surface? [*Note:* You must use conservation of momentum in this problem.]

14. An object-spring system moving with simple harmonic motion has an amplitude A. (a) What is the total energy of the system in terms of k and A only? (b) Suppose at a certain instant the kinetic energy is twice the elastic potential energy. Write an equation describing this situation, using only the variables for the mass m, velocity, v, spring constant k, and position x. (c) Using the results of parts (a) and (b) and the conservation of energy equation, find the positions x of the object when its kinetic energy equals twice the potential energy stored in the spring. *(The answer should be in terms of A only.)*

15. A horizontal block-spring system with the block on a frictionless surface has total mechanical energy E = 47.0 J and a maximum displacement from equilibrium of 0.240 m. (a) What is the spring constant? (b) What is the kinetic energy of the system at the equilibrium point? (c) If the maximum speed of the block is 3.45 m/s, what is its mass? (d) What is the speed of block when its displacement is 0.160 m. (f) Find the potential energy stored in the spring when x = 0.160 m (g) Suppose the same system is released from rest at x = 0.240 m on a rough surface so that it loses 14.0 J by the time it reaches its first turning point (after passing through the equilibrium at x = 0). What is its position at that instant?

16. A 0.250 kg block resting on a frictionless, horizontal surface is attached to a spring having a force constant of 83.8 N/m as in Figure P13.16. A horizontal force F causes the spring to stretch a distance of 5.46 cm from its equilibrium position. (a) Find the value of F. (b) What is the total energy stored in the system when the spring is stretched? (c) Find the magnitude of the acceleration of the block immediately after the applied force is removed. (d) Find the speed of the block when it first reaches the equilibrium position. (e) If the surface is not frictionless but the block still reaches the equilibrium position, how would your answer to part (d) change?

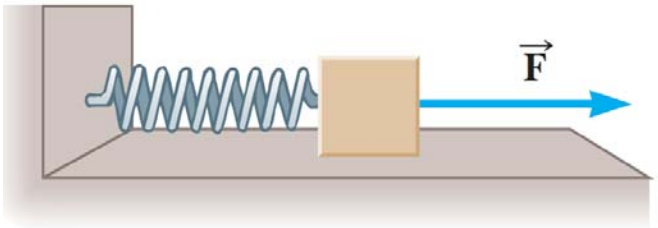

Figure P13.16

Section 13.3 Comparing Simple Harmonic Motion with Uniform Circular Motion
Section 13.4 Position, Velocity, and Acceleration as a Function of Time

18. An object–spring system oscillates with an amplitude of 3.5 cm. If the spring constant is 250 N/m and the object has a mass of 0.50 kg, determine (a) the mechanical energy of the system, (b) the maximum speed of the object, and (c) the maximum acceleration of the object.

19. At an outdoor market, a bunch of bananas is set into oscillatory motion with an amplitude of 20.0 cm on a spring with a force constant of 16.0 N/m. It is observed that the maximum speed of the bunch of bananas is 40.0 cm/s. What is the weight of the bananas in newtons?

26. When four people with a combined mass of 320 kg sit down in a car, they find that the car drops 0.80 cm lower on its springs. Then they get out of the car and bounce it up and down. What is the frequency of the car's vibration if its mass (when it is empty) is 2.0×10^3 kg? (B) How would the frequency change is the mass was doubled?

29. A 326 g object is attached to a spring and executes simple harmonic motion with a period of 0.250 s. If the total energy of the system is 5.83 J, find (a) the maximum speed of the object, (b) the force constant of the spring, and (c) the amplitude of the motion.

Section 13.5 Motion of a Pendulum

34. A man enters a tall tower, needing to know its height. He notes that a long pendulum extends from the ceiling almost to the floor and that its period is 15.5 s. (a) How tall is the tower? (b) If this pendulum is taken to the Moon, where the free-fall acceleration is 1.67 m/s^2, what is the period there?

35. A simple pendulum makes 120 complete oscillations in 3.0 min at a location where g = 9.80 m/s^2. Find (a) the period of the pendulum and (b) its length. (c) If the period is doubled how does this change the length?

36. A "seconds" pendulum is one that moves through its equilibrium position once each second. (The period of the pendulum is 2.000 s.) The length of a seconds pendulum is 0.9927 m at Tokyo and 0.9942 m at Cambridge, England. What is the ratio of the free-fall accelerations at these two locations?

Section 13.6 Damped Oscillations
Section 13.7 Waves
Section 13.8 Frequency, Amplitude, and Wavelength

41. The sinusoidal wave shown in Figure P13.41 is traveling in the positive x direction and has a frequency of 18.0 Hz. Find the (a) amplitude, (b) wavelength, (c) period, and (d) speed of the wave.

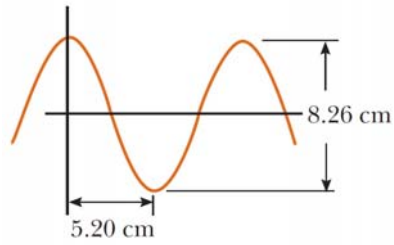

FIGURE P13.41

43. A certain FM radio station broadcasts jazz music at a frequency of 101.9 MHz. Find (a) the wave's period and (b) its wavelength. (Radio waves are electromagnetic waves that travel at the speed of light, 3.0 X 10^8 m/s)

44. The distance between two successive minima of a transverse wave is 2.76 m. Five crests, or maxima, pass a given point along the direction of travel every 14.0 s. Find (a) the frequency of the wave and (b) the wave speed. How would the speed change if the frequency tripled

45. A harmonic wave is traveling along a rope. It is observed that the oscillator that generates the wave completes 40.0 vibrations in 30.0 s. Also, a given maximum travels 425 cm along the rope in 10.0 s. What is the wavelength?

Section 13.10 Interference of Waves
Section 13.11 Reflection of Waves

61. A wave of amplitude 0.30 m interferes with a second wave of amplitude 0.20 m traveling in the same direction. What are (a) the largest and (b) the smallest resultant amplitudes that can occur, and under what conditions will these maxima and minima arise?

Additional Problems

63. An object of mass 2.0 kg is oscillating freely on a vertical spring with a period of 0.600 s. Another object of unknown mass on the spring oscillates with a period of 1.05 s. Find (a) the spring constant k and (b) the unknown mass.

65. A simple pendulum has a mass 1.20 kg and a length 0.700 m. (a) What is the period of the pendulum near the surface of Earth? (b) If the same mass were attached to a spring what spring constant would result in the period of motion found in part (a)? How would the period change if the mass tripled?

67. A 3.00-kg object is fastened to a light spring, with the intervening cord passing over a pulley (Fig. P13.67). The pulley is frictionless, and its inertia may be neglected. The object is released from rest when the spring is unstretched. If the object drops 10.0 cm before stopping, find (a) the spring constant of the spring and (b) the speed of the object when it is 5.00 cm below its starting point.

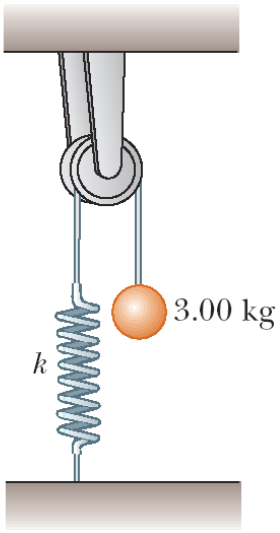

Figure P13.67

70. A spring in a toy gun has a spring constant of 9.80 N/m and can be compressed 20.0 cm beyond the equilibrium position. A 1.00-g pellet resting against the spring is propelled forward when the spring is released. (a) Find the muzzle speed of the pellet. (b) If the pellet is fired horizontally from a height of 1.00 m above the floor, what is its range? (c) How would the speed change if the mass was cut in half?