Answers

3. (a) 4.0 N; 8.0 N
   (b) 4.0 N; 8.0 N
4. 6.4 N

Practice

Understanding Concepts

1. Spring A has a force constant of 68 N/m. Spring B has a force constant of 48 N/m. Which spring is harder to stretch?

2. If you pull northward on a spring, in what direction does the spring exert a force on you?

3. An ideal spring has a force constant of 25 N/m.
   (a) What magnitude of force would the spring exert on you if you stretched it from equilibrium by 16 cm? by 32 cm?
   (b) What magnitude of force would you have to exert on the spring to compress it from equilibrium by 16 cm? by 32 cm?

4. **Figure 5** shows the design of a tire-pressure gauge. The force constant of the spring in the gauge is 3.2×10^2 N/m. Determine the magnitude of the force applied by the air in the tire if the spring is compressed by 2.0 cm. Assume the spring is ideal.

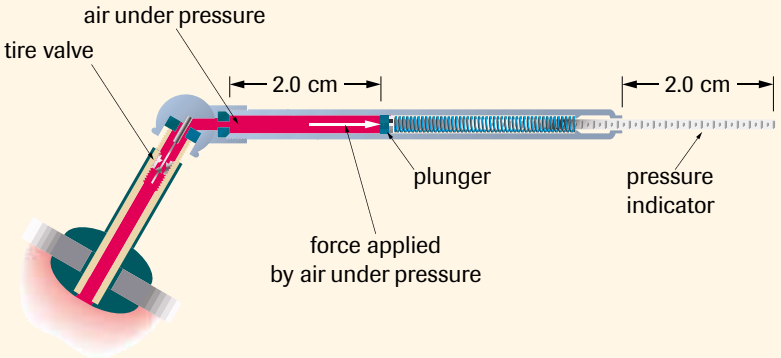

Figure 5
A pressure gauge indicates the force per unit area, a quantity measured in pascals, or newtons per square metre (1 Pa = 1 N/m^2).

5. A 1.37-kg fish is hung from a vertical spring scale with a force constant of 5.20×10^2 N/m. The spring obeys Hooke's law.
(a) By how much does the spring stretch if it stretches slowly to a new equilibrium position?
(b) If the fish is attached to the unstretched spring scale and allowed to fall, what is the net force on the fish when it has fallen 1.59 cm?
(c) Determine the acceleration of the fish after it has fallen 2.05 cm.

Applying Inquiry Skills

6. (a) Draw a graph of F_x as a function of x for an ideal spring, where F_x is the x-component of the force exerted *by* the spring *on* whatever is stretching (or compressing) it to position x. Include both positive and negative values of x.
(b) Is the slope of your graph positive or negative?

Making Connections

7. Spring scales are designed to measure weight but are sometimes calibrated to indicate mass. You are given a spring scale with a force constant of 80.0 N/m.
(a) Prepare a data table to indicate the stretch that would occur if masses of 1.00 kg, 2.00 kg, and on up to 8.00 kg were suspended from the scale at your location.
(b) Draw a scale diagram to show the calibration of the scale if it is set up to measure
(i) mass at your location
(ii) weight at your location
(c) If both springs in (b) were taken to the top of a high mountain, would they give the correct values? Explain.

Answers

5. (a) 0.0258 m
(b) 5.16 N [down]
(c) 2.02 m/s^2 [down]

Section 4.5 Questions

Understanding Concepts

Note: For the following questions, unless otherwise stated, assume that all springs obey Hooke's law.

1. Two students pull equally hard on a horizontal spring attached firmly to a wall. They then detach the spring from the wall and pull horizontally on its ends. If they each pull equally hard, is the amount of stretch of the spring equal to, greater than, or less than the first stretch? Explain your answer. (*Hint:* Draw an FBD for the spring in each case.)

2. Is the amount of elastic potential energy stored in a spring greater when the spring is stretched 2.0 cm than when it is compressed by the same amount? Explain your answer.

3. What does "harmonic" mean in the term "simple harmonic motion?"

4. State the relationship, if any, between the following sets of variables. Where possible, write a mathematical variation (proportionality) statement based on the appropriate equation.

(a) period and frequency

(b) acceleration and displacement in SHM

(c) period and the force constant for a mass on a spring in SHM

(d) the maximum speed of a body in SHM and the amplitude of its motion

5. A student of mass 62 kg stands on an upholstered chair containing springs, each of force constant 2.4×10^3 N/m. If the student is supported equally by six springs, what is the compression of each spring?

6. What magnitude of force will stretch a spring of force constant 78 N/m by 2.3 cm from equilibrium?

7. The coiled spring in a hand exerciser compresses by 1.85 cm when a force of 85.5 N is applied. Determine the force needed to compress the spring by 4.95 cm.

8. A trailer of mass 97 kg is connected by a spring of force constant 2.2×10^3 N/m to an SUV. By how much does the spring stretch when the SUV causes the trailer to undergo an acceleration of magnitude 0.45 m/s^2?

9. A grapefruit of mass 289 g is attached to an unstretched vertical spring of force constant 18.7 N/m, and is allowed to fall.
(a) Determine the net force and the acceleration on the grapefruit when it is 10.0 cm below the unstretched position and moving downward.
(b) Air resistance will cause the grapefruit to come to rest at some equilibrium position. How far will the spring be stretched?

10. A bungee jumper of mass 64.5 kg (including safety gear) is standing on a platform 48.0 m above a river. The length of the unstretched bungee cord is 10.1 m. The force constant of the cord is 65.5 N/m. The jumper falls from rest and just touches the water at a speed of zero. The cord acts like an ideal spring. Use conservation of energy to determine the jumper's speed at a height of 12.5 m above the water on the first fall.

11. A toy car is attached to a horizontal spring. A force of 8.6 N exerted on the car causes the spring to stretch 9.4 cm.
(a) What is the force constant of the spring?
(b) What is the maximum energy of the toy-spring system?

12. If the maximum amplitude of vibration that a human eardrum can withstand is 1.0×10^{-7} m, and if the energy stored in the eardrum membrane is 1.0×10^{-13} J, determine the force constant of the eardrum.

13. A 22-kg crate slides from rest down a ramp inclined at 29° to the horizontal (**Figure 15**) onto a spring of force constant 8.9×10^2 N/m. The spring is compressed a distance of 0.30 m before the crate stops. Determine the total distance the crate slides along the ramp. Friction is negligible.

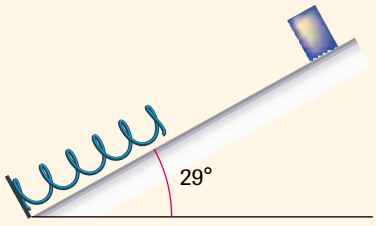

Figure 15

14. A 0.20-kg ball attached to a vertical spring of force constant 28 N/m is released from rest from the unstretched equilibrium position of the spring. Determine how far the ball falls, under negligible air resistance, before being brought to a momentary stop by the spring.

Applying Inquiry Skills

15. **Figure 16** shows the energy relationships of a 0.12-kg mass undergoing SHM on a horizontal spring. The quantity x is the displacement from the equilibrium position.
(a) Which line represents (i) the total energy, (ii) the kinetic energy, and (iii) the elastic potential energy?
(b) What is the amplitude of the SHM?
(c) What is the force constant of the spring?
(d) What is the maximum speed of the mass?

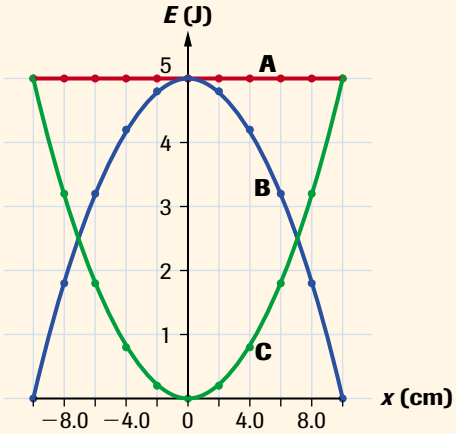

Figure 16

16. You are given a spring comprised of 24 coils that has a force constant of 24 N/m.
(a) If this spring were cut into two equal pieces, would the force constant of each new spring be equal to, greater than, or less than 24 N/m? Explain.
(b) With your teacher's permission, design and carry out an experiment to test your answer in (a). Explain what you discover.

Making Connections

17. The shock absorbers in the suspension system of a truck are in such poor condition that they have no effect on the behaviour of the springs attached to the axles. Each of the two identical springs attached to the rear axle supports 5.5×10^2 kg. After going over a severe bump, the rear end of the truck vibrates through six cycles in 3.5 s. Determine the force constant of each spring.

18. In designing components to be sent on board a satellite, engineers perform tests to ensure that the components can withstand accelerations with a magnitude as high as 25g. In one test, the computer is attached securely to a frame that is vibrated back and forth in SHM with a frequency of 8.9 Hz. What is the minimum amplitude of vibration used in this test?