Chapter 18 – Harmonic Motion

Section Review 18.1

1. Which is the best example of a cycle: a turn of a bicycle wheel or a slide down a ski slope? Why?

2. Describe one example of an oscillating system you would find at King's Island?

3. What is the relationship between period and frequency?

4. Every 6 seconds a pendulum completes one cycle. What are the period and the frequency of this pendulum?

Section Review18.2

1. What is the difference between a graph of linear motion and a graph of harmonic motion?

2. A graph of the motion of a pendulum shows that it swings from +5 centimeters to -5 centimeters for each cycle. What is the amplitude of the pendulum?

3. A pendulum swings from -10 degrees to +10 degrees. What is its amplitude?

4. A graph of harmonic motion shows that the motion lasted for 10 seconds and completed 5 cycles. What is the period of this harmonic motion?

5. A graph of harmonic motion shows that one cycle lasts from 4.3 seconds to 6.8 seconds. What is the period of this harmonic motion?

6. Sketch the periodic motion for two oscillators that are 45 degrees out of phase.

7. If one oscillator was out of phase with another oscillator by 45 degrees, what fraction of a 360-degree cycle would it be out of phase: 1/8, ¼, ½, or ¾?

Section Review 18.3

1. Identify the restoring force for a pendulum, a mass on a spring, and a vibrating string.

2. You change the amplitude of a pendulum from 10 centimeters to 30 centimeters. How does this change affect the period of the pendulum? Justify your answer.

3. Is a person jumping on a trampoline an oscillator? Justify your answer.

4. If you wanted to increase the period of a pendulum, how would you change its length?

Chapter 18 Review

Reviewing Concepts

Section 18.1

1. Identify the following as examples of harmonic motion, linear motion, or both. Explain your answer.
    a. A child moving down a playground slide one time.

    b. An ocean wave rising and falling

    c. A car moving down a street

    d. A ball bouncing up and down.

2. A system with harmonic motion is called an oscillator. Oscillators can be virtually any size. List at least one example each of a very large oscillator and a very small oscillator.

3. Describe a single cycle of harmonic motion for the following situations.
    a. A spinning merry-go-round

    b. Earth orbiting the Sun

    c. A clock pendulum

4. Using a person on a swing as an example of harmonic motion, describe the terms:
    a. Period

    b. Frequency

    c. Cycle

    d. Amplitude

5. Your favorite radio station is 106.7. What are the units of this number and what do they mean in terms of harmonic motion?

6. What is the mathematical relationship between frequency and period for a harmonic motion system?

7. Name a unit used to measure the following.
    a. Amplitude
    b. Frequency
    c. Period
    d. Mass

Section 18.2

8. Describe how you would determine the period and the amplitude of an oscillator from a graph of its harmonic motion. You may use a diagram to help answer this question.

9. Two players dribble a basketball at the same time. How does the motion of the basketballs compare if they are in phase? Out of phase?

10. Explain why circular motion, like the motion of a Ferris wheel, is an example of harmonic motion.

Section 18.3

11. If the lengths of the ropes on a swing are made longer…
    a. What happens to the period of the swing?

    b. What happens to the frequency of the swing?

12. Pushing a child on a playground swing repeatedly at the natural frequency causes resonance, which increases the amplitude of the swing, and the child goes higher. If the pushes provide the periodic force of the system, what provides the restoring force?

13. Identify the equilibrium position for the following situations.
    a. A person on a swing

    b. A person bungee jumping

    c. A guitar string being plucked

14. What is resonance and how is it created? Give an example of a resonant oscillating system in nature.

Solving Problems

Section 18.1

1. The wings of a honeybee move at a frequency of 220Hz. What is the period for a complete wing-beat cycle?

2. If a pendulum's period is 4 s, what is its frequency?

3. What is the period of Earth's spinning on its axis? What is its frequency? *(Hint: how long does it take for one spin?)*

4. Jason's heartbeat is 65 beats per minute.
    a. What is the frequency of his heartbeat in hertz?

    b. What is the period for each heartbeat in seconds?

5. Create a table following the format at the bottom of page 443. Fill in the period and frequency for the second hand, minute hand, and hour hand of a clock.

Section 18.2

6. The graph on page 443 shows the motion of an oscillator that is a weight hanging from a rubber band. The weight moves up and down. Answer the following questions using the graph.
    a. What is the period?
    b. What is the frequency?
    c. What is the amplitude?
    d. If you count for 5 seconds, how many cycles would you count?

7. Make a graph of three cycles of motion for a pendulum that has a period of 2 s and an amplitude of 5 cm.

8. Which of the three graphs on page 443 illustrates the harmonic motion of two children on swings, 180º out of phase? What fraction of a 360º cycle are these two graphs out of phase?

Section 18.3

9. The mass of a pendulum bob is increased by a factor of two. How is the period of the pendulum affected?

10. Describe how you might change the natural frequency of the following oscillating systems.
    a. A guitar string

    b. A playground swing

    c. A paddle ball game with a ball attached to a paddle with an elastic

    d. A diving board

11. How does decreasing the length of a pendulum affect its period?

Understanding Vocabulary

Select the correct term on page 442 to complete the sentences.

1. One complete turn of a bicycle wheel is one _____ of harmonic motion.

2. The time it takes for one cycle is called the _____.

3. The number of cycles an oscillator makes per second is called the _____.

4. Friction causes _____ in an oscillator.

5. The _____ of an oscillator describes where it is in the cycle.

6. A guitar is tuned by adjusting the _____ of the vibrating string to match a musical note.

Test Practice

1. Which of the following is *not* an example of an oscillating system?
    a. A toy car sliding down a ramp
    b. The human heart and surrounding muscles
    c. Earth's orbit around the Sun
    d. Stereo speakers

2. A hummingbird moves its wings up and down 300 times in 5 s. What is the period of this movement?
    a. 60 s b. 0.017 Hz c. 60 Hz d. 0.017 s

3. The graph on page 444 shows harmonic motion. One cycle is represented by the distance from
    a. W to X b. W to Y c. W to Z d. X to Y

4. A pendulum completes one cycle every 4 s. What is the frequency of this pendulum?
    a. 0.50 Hz b. 0.25 Hz c. 0.25 s d. 0.75 s

5. The graph at the top of page 444 represents position vs time for the amplitude of a pendulum. What is the amplitude?
    a. A b. B c. C d. D

6. The graph on page 444 shows the harmonic motion of a vibrating string. What is the period of the cycle?
    a. 2 b. 4 c. 6 d. 8

7. One cycle of harmonic motion for a certain spring has a period of 20 s. If a second, identical spring is set in motion 5 s after the first, the phase relationship between the motion of the two springs differs by _____ degrees.
    a. 25 b. 45 c. 90 d. 180

8. The graph at the bottom of page 444 shows the motion of two pendulums. What is their phase difference measured in degrees?
    a. 45 b. 90 c. 180 d. 240

9. A restoring force is any force that pulls a system with harmonic motion back toward
    a. equilibrium b. resonance c. oscillation d. gravity

10. Gravity is the restoring force for a
    a. Guitar string b. mass on a spring c. a stretched rubber band d. pendulum

11. The natural frequency of a pendulum can be increased by
    a. increasing the mass of the bob c. decreasing the mass of the bob
    b. increasing the length of the string d. decreasing the length of the string

12. A periodic force applied with the same frequency as the natural frequency of a system produces
    a. resonance b. a smaller amplitude c. damping d. equilibrium