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Chapter Test Questions for Chapters 15-16

Necessary Formulas:

$k = -\Delta F_x/\Delta x$ $v = \lambda f$ $P = 2\pi^2\, 2\, \mu\, v\, f^2 A^2$

$T = 2\pi \sqrt{(l/g)}$ $T = 2\pi \sqrt{(I/mgd)}$

$f = v/2l$ $E = K + U_G$

1. The ________________ of any periodic motion is defined as the number of cycles per second.
    a. Amplitude
    b. Frequency
    c. Period
    d. Phase angle

2. A(n) _______________ consists of a small mass *m* suspended from a string of length *l* with negligible mass.
    a. Amplitude
    b. Physical pendulum
    c. Small angle approximation
    d. Simple pendulum

3. A(n) ____________ is a rigid body of any shape, supported at a single point, some distance from the body's center of gravity, and free to oscillate about that point.
    a. Amplitude
    b. Physical pendulum
    c. Large angle approximation
    d. Simple pendulum

4. In systems where there are factors that eventually cause the motion to stop if the system is left alone, mechanical energy is dissipated through some kind of friction and converted to internal energy. This effect is called:
    a. Damping
    b. Complex orientation
    c. Resonance
    d. Transverse waves

5. ____________________ corresponds to the fastest approach to the final equilibrium position.
    a. Critical damping
    b. Physical damping
    c. Forced oscillations
    d. Over-damping

6. When a periodic force is applied to an oscillatory system, the system responds by oscillating at the frequency of the applied force. This phenomenon is called:
    a. Damping
    b. Electromagnetic radiation
    c. Resonance
    d. Pulse Waves

7. A line of dominoes are placed on a flat table, each standing on end and closely spaced. If the domino at the left end is pushed over to the right, the effect is transmitted down the line. All dominoes fall in turn. What type of wave is produced?
    a. Periodic wave
    b. Sine wave
    c. Longitudinal wave
    d. Pulse wave

8. A mechanical wave transmits energy from one place to another while the matter through which it is transmitted __________________.
    a. Moves in the same direction
    b. Moves in the opposite direction
    c. Remains in place
    d. None of the above

9. What type of wave occurs if the motion of the medium is perpendicular to the wave motion?
    a. Longitudinal wave
    b. Pulse wave
    c. Sine wave
    d. Transverse wave

10. Waves for which the motion of the medium is parallel to the direction of wave propagation are called ________________.
    a. Pulse wave
    b. Longitudinal wave
    c. Transverse wave
    d. Sine wave

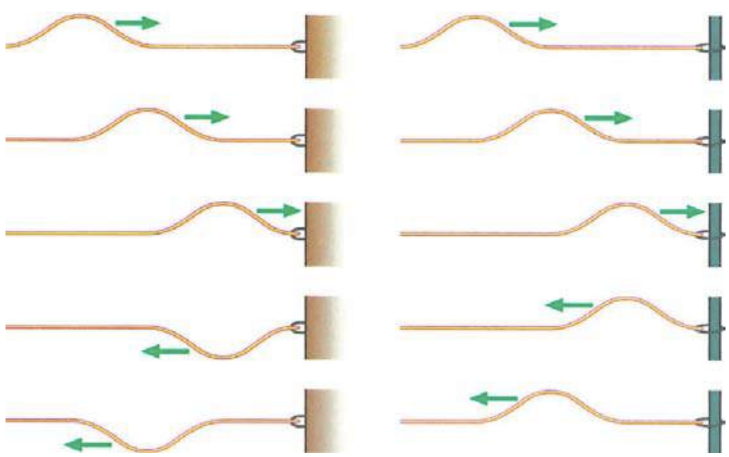
11. What is an example of a three-dimensional wave?
    a. The domino example use in #7
    b. Kids swinging a jump rope
    c. A raindrop striking the surface of a lake
    d. A sound wave in air

12. If a sound wave originates at a point and propagates outward equally in all directions, the wave disturbance takes the shape of a spherical surface centered on the source. This is called a _____________.
    a. Plane wave
    b. Spherical wave
    c. Amphibious wave
    d. Harmonic wave

13. The __________ of a wave is the distance between any two successive identical points on the wave.
    a. Frequency
    b. Period
    c. Wavelength
    d. Amplitude

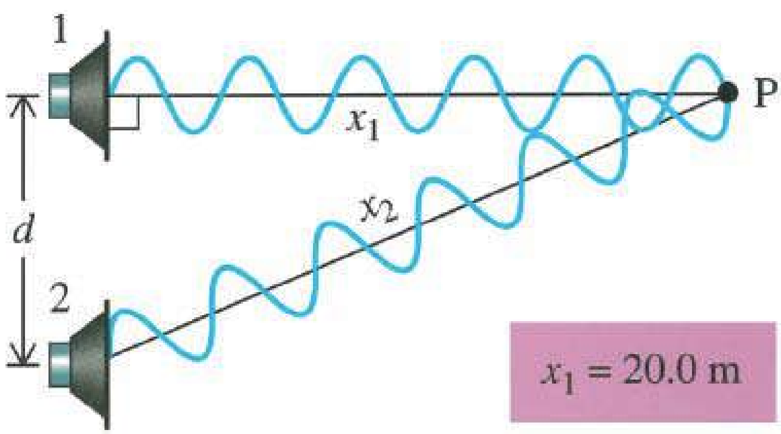
14. A vibrating tuning fork generates a ___________ sound wave. *(Hint: this wave has a sine wave shape)*
   a. Pulse
   b. Harmonic
   c. Longitudinal
   d. Periodic

15. The wave speed equals ___________ _____________.
   a. Wavelength times amplitude
   b. Wavelength divided by period
   c. Frequency times amplitude
   d. Frequency divided by 1 cycle



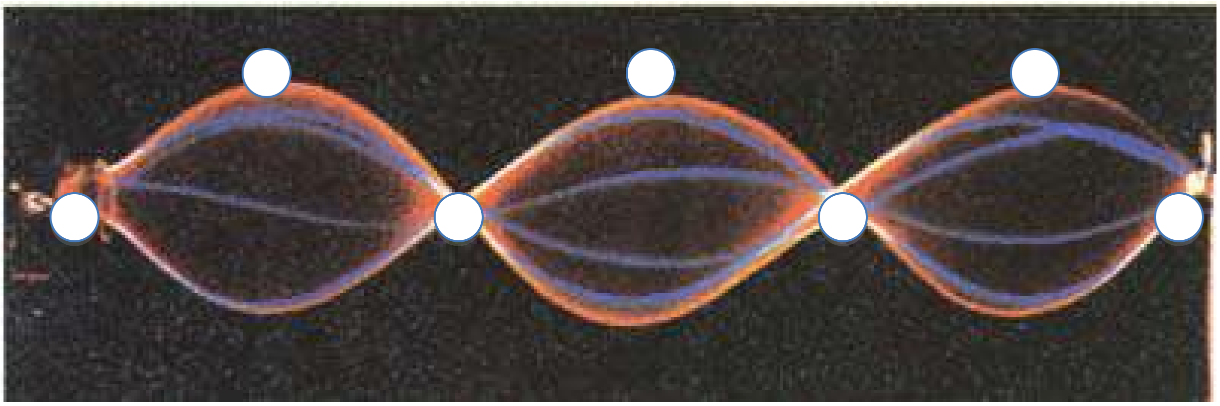
16. What process is shown in the figure above?
   a. Refraction
   b. Constructive Interference
   c. Reflection
   d. Diffraction

17. Suppose you are standing beside a highway while cars pass by at high speed. As each car approaches, it produces a sound with a high frequency, or pitch. Just as the car passes, the pitch you hear drops significantly. Although the sound produced by the engine is unchanged, the frequency of the sound you hear is higher while the car is approaching than while it is moving away. This phenomenon is known as ____________.
    a. The Doppler effect
    b. Compression
    c. Timbre
    d. Damped vibration



18. What type of interference occurs in the diagram above?
    a. No interference
    b. Constructive interference
    c. Destructive interference
    d. Total interference

19. A throbbing or pulsing variation from loud to weak to loud is called a __________.
    a. Frequency
    b. Sound wave
    c. Beat
    d. Timbre



20. How many nodes and antinodes are present in the diagram above?
    a. Four nodes and three antinodes
    b. Four nodes and four antinodes
    c. Three nodes and three antinodes
    d. Three nodes and four antinodes

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1. When a driver and four passengers having a total mass of 340 kg get into a car, the car's springs are compressed and the car is lowered by 3.00 cm. The car, which has weak shock absorbers, hits a bump and oscillates vertically with a period of 0.750 s. Find the combined mass of the car and its occupants.

2. A small child weighing 200 N sits on a swing of length 2.2 m. Find the period for small-amplitude oscillations, treating the swing as a simple pendulum.

3. A meter stick is mounted on an axle through one end and is free to swing without friction. Find the period of small-amplitude oscillations.

4. The period of walking is the time for one complete cycle, consisting of two steps. During this cycle each leg completes approximately a half cycle of pendulum-like motion: first one leg swings forward, and then the other leg swings forward. When a person walks in a natural, relaxed way, the motion of the lower half of the leg is approximately that of a free-swinging physical pendulum through most of the forward swing. Find the natural period of walking for a person whose lower leg is 0.50 m long if the amplitude is small. Assume that the moment of inertia of the lower leg is the same as that of a thin rod.

5. A small child weighing 200 N sits on a swing of length 2.2 m. Suppose that the swing in has amplitude of 15°. Find the total mechanical energy of the system.

6. Frequencies of sound produced by a piano range from about 30 Hz for the lowest notes to about 4000 Hz for the highest notes. Find the wavelength in air of a 262 Hz sound wave produced by striking middle C on a piano. What would the wavelength of this sound be under water? The speed of sound is 340 m/s in air and 1480 m/s in water.

7. Only sounds in the frequency range from about 20 Hz to about 20,000 Hz are audible to humans. Ultrasound is the name given to sound at frequencies above 20,000 Hz. Ultrasound can be used to produce images inside the human body. Ultrasound waves penetrate the body, traveling at a speed of 1500 m/s, and are reflected from surfaces inside. For a good ultrasonic picture having sufficient detail, the wavelength should be no greater than about 1.0 mm. Find the frequency of such an ultrasonic wave.

8. A 10 Hz harmonic wave of amplitude 5.0 cm travels at 30 m/s along a string having a mass density of 0.020 kg/m. Find the power transmitted.

9. A tube is completely filled with water, and a tuning fork vibrating at 512 Hz is placed above it. The level of water in the tube is gradually reduced as water is drained from the bottom until a condition of resonance is reached, at which point the sound is loudest. Find the length *l* of the air-filled cavity.

10. All the holes of a flute of length 65.6 cm are covered, and a musical note is produced when the flute is blown into. The flute acts as a pipe open at both ends. Find the frequency of the sound produced.

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1. A 5.00 kg block hung on a spring causes a 10.0 cm elongation of the spring. What is the restoring force exerted on the block by the spring?

2. Based off of the information from question #1, what will the spring's elongation be when pulled by a force of 77.7 N?

3. The reading on a metronome indicates the number of oscillations per minute. What are the period and frequency of the metronome's vibration when the metronome is set at 180?

4. On a hot summer day, a pesky little mosquito produced its warning sound near your ear. The sound is produced by the beating of its wings at a rate of about 600 wing beats per second. Assuming the sound wave moves with a velocity of 350 m/s, what is the wavelength of the wave?

5. Determine the speed of sound on a cold winter day (T=3 degrees C).

ANSWERS:

1. B
2. D
3. B
4. A
5. A
6. C
7. D
8. C
9. D
10. B
11. D
12. B
13. C
14. B
15. B
16. C
17. A
18. C
19. C
20. A

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1. **SOLUTION** The system of the car and passengers may be treated as a mass m attached to a single spring. First we must calculate the force constant of the spring. Since, according to Hooke's law, $F_x = - k\, x$, a change in position Δx is related to a change in force ΔF_x by $\Delta F_x = - k\, \Delta x$.
   When the people get into the car, the force applied to the spring changes by w, their combined weight ($\Delta F_x = w$). As a result, the spring is compressed a distance Δx = 3.00 cm. Thus,
   $k = - \Delta F_x/\Delta x = - w/\Delta x = -((340\ kg)(9.80\ m/s^2))/(-3.00 \times 10^{-2}\ m)$
   $= 1.11 \times 10^5\ N/m$

2. **SOLUTION** We find the period of a simple pendulum of length 2.2 m:
   $T = 2\pi \sqrt{(l/g)} = 2\pi \sqrt{(2.2\ m/9.8\ m/s^2)} = 3.0\ s$
   This result is completely independent of the child's weight.

3. **SOLUTION** The moment of inertia of a thin rod of mass M and length l is ½ Ml^2, and its center of gravity is at a distance $d = l/2$ from the axis of rotation. We find
   $T = 2\pi \sqrt{(I/mgd)} = 2\pi \sqrt{((Ml^2/3)/(Mgl/2))} = 2\pi \sqrt{((2/3) \times (l/g))}$
   $= 2\pi \sqrt{((2/3) \times (1.00\ m/9.80\ m/s^2))} = 1.64\ s$

4. **SOLUTION** Since we are treating the lower leg as a thin rod mounted at one end, we can apply the result found in the previous example:
   $T = 2\pi \sqrt{((2/3)/(l/g))} = 2\pi \sqrt{((2/3)/(0.50\ m/9.80\ m/s^2))} = 1.2\ s$

5. **SOLUTION** When A swing is at its maximum angle, the *y* coordinate of the child's center of gravity is 7.5 cm. At this point, the child is instantaneously at rest, and hence has no kinetic energy. The child has weight mg = 200 N. Thus:
   $$E = K + U_G$$
   $$= 0 + mgy = (200\ N)(0.075\ m)$$
   $$= 15\ J$$

6. **SOLUTION** We apply:
   $v = \lambda f$
   In air,
   $\lambda = (340 m/s)/(262\ Hz) = 1.30\ m$
   In water,
   $\lambda = (1480\ m/s)/(262\ Hz) = 5.65\ m$

7. **SOLUTION** Solving ($v = \lambda f$) for f, we obtain:
   $f = v/\lambda = (1500\ m/s)/(1.0 \times 10^{-3}\ m) = 1.5 \times 10^6\ Hz$ *(or 1.5 MHz)*

8. **SOLUTION** We find:
   $P = 2\pi^2\ 2\ \mu\ v\ f^2 A^2$
   $= 2\pi^2\ (0.020\ kg/m)(30\ m/s)(10\ Hz)^2(0.050\ m)^2$
   $= 3.0\ W$

9. **SOLUTION** What we are interested in here is the empty part of the tube. As we drain water out, we are in essence changing the length _ of a pipe closed at one end (the top of the water column causes the "pipe" to be closed at one end). Resonance occurs when the frequency of the tuning fork equals a resonant frequency of this "pipe" of length _. The wavelength of the sound produced by the tuning fork is:
   $\lambda = v/f = (344\ m/s)/(512\ Hz) = 0.672\ m = 67.2\ cm$
   We see that the shortest value of l for resonance is ¼ wavelength.
   Thus $l = \frac{1}{4}\lambda = 17$ cm.

10. **SOLUTION** We find the fundamental frequency of the flute, using the speed of sound at 20.0° C (344 m/s):
    $f_1 = v/2l = (344\ m/s)/(2(0.656\ m)) = 262\ Hz$
    This is the frequency of the musical note middle C.

1. *F restoring = Weight = mg = 5 (9.8) = 49 N*

2. *F= k x*
   77.7 = 490 x
   x = .1586 m = 15.86 cm

3. *180 beats/min = 180 beats/60sec = 3 beats/sec = 3 Hz*

4. 0.583 meters. Let λ = wavelength. Use v = f • λ where v = 350 m/s and f = 600 Hz. Rearrange the equation to the form of λ = v / f. Substitute and solve.

5. The speed of sound in air is dependent upon the temperature of air. The dependence is expressed by the equation:
   v = 331 m/s + (0.6 m/s/C) • T
   where T is the temperature in Celsius. Substitute and solve.
   v = 331 m/s + (0.6 m/s/C) • 3 C
   v = 331 m/s + 1.8 m/s
   v = 332.8 m/s