Physics 211, Fall 2008

Quiz 6, Form: $\boxed{A}$

Name: Key

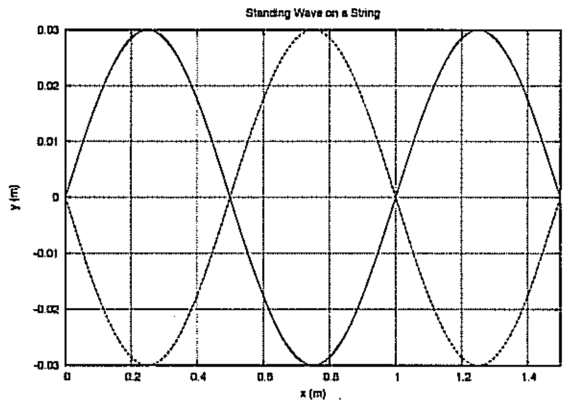
Date:

$I_0 = 1 \times 10^{-12}$ J/*second*/m^2

$v_{air} = 340$m/s

Section 1. Multiple Choice

1. For a standing wave on a string that looks like the one below,



what harmonic is this?

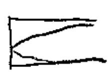
(a) n=1
(b) n=2
(c) n=3
(d) n=4
(e) n=5

2. What is the wavelength of the standing wave in the previous question?

(a) 3.0 m
(b) 0.5 m
(c) 1.5 m
(d) 0.75 m
(e) 1 m

3. A pipe has a closed end and an open end. For air in the pipe ($v = 340$ m/s), what is the frequency of the fundamental if the length of the pipe is 0.1 m?

(a) 680 Hz
(b) 1700 Hz
(c) 425 Hz
(d) 850 Hz
(e) 1133 Hz



$\frac{1}{4}\lambda = L$

$\lambda = 4L = 0.4$m

$f = \frac{v}{\lambda} = \frac{340}{0.4}$

$= 850$ Hz

4. Suppose that in lab, you measure x(t) for a simple harmonic oscillator. The best-fit function is $x = 0.03\cos(2t+1)$ where x is in meters and t is in seconds. What is the angular frequency?

(a) 0.03 rad/s
(b) 2 rad/s
(c) 2π rad/s
(d) 1 rad/s
(e) zero

5. Suppose that when listening to music normally in the car, the sound level is 80 dB. However, your friend with the super-cool, shake-the-car speakers turns it up to 110 dB. By what factor did he increase the intensity of the sound?

$110 - 80 = 30$dB

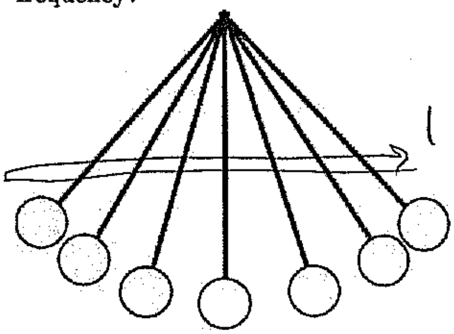
(a) 10
(b) 100
(c) 110
(d) 1,000
(e) 10,000

each additional 10dB is a factor of 10 in intensity, so $10^3 = 1000$

6. Sound is a

(a) longitudinal wave
(b) transverse wave
(c) neither of the above because it can be both a longitudinal and a transverse wave

7. A pendulum swings back and forth in simple harmonic motion ~~and~~ as shown below. It takes 0.25 s to swing from its furthest point on the right to the equilibrium position. What is its frequency?



1 cycle

(a) 4 Hz
(b) 2 Hz
(c) 1 Hz
(d) 0.5 Hz
(e) 0.25 Hz

Δt for $\frac{1}{4}$ cycle is 0.25 s

so $T = 4(0.25\text{ s}) = 1\text{ s}$

$f = \frac{1}{T} = 1\text{ Hz}$

8. Spring A has twice the stiffness of Spring B. If the same mass is attached to each spring and oscillates, the angular frequency of Spring A is

(a) $(1/\sqrt{2})\omega_B$
(b) $\sqrt{2}\omega_B$
(c) $(1/2)\omega_B$
(d) $2\omega_B$
(e) equal to ω_B.

$\omega = \sqrt{\frac{k}{m}}$

$\sqrt{2k} = \sqrt{2}\sqrt{k}$

so $\omega_A = \sqrt{2}\,\omega_B$

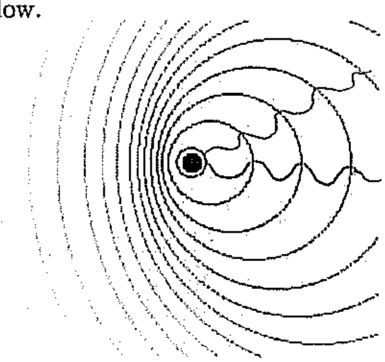
9. For a sound source moving toward a detector, the detected frequency is

(a) lower than the source frequency.
(b) higher than the source frequency.
(c) the same as the source frequency.

10. For a sound source moving toward a detector, the detected wavelength is

(a) shorter than the wavelength of the source.
(b) longer than the wavelength of the source.
(c) the same as the wavelength of the source.

11. A source is emitting a constant frequency sound wave in all directions as it moves, as shown below.



What direction is the velocity of the source?

(a) There is not enough information from the picture to answer the question.
(b) Neither because the source is stationary.
(c) to the right
(d) to the left

12. On the end of a pipe that is closed, the displacement of the air is

(a) Neither a node nor an antinode, because it could be in between a node and antinode.
(b) It could be either a node or antinode depending on the wavelength of the standing wave
(c) an antinode
(d) a node

13. A 0.5-kg object hangs from a spring of stiffness 10 N/m. You pull it down 0.075 cm from equilibrium and release it from rest. It oscillates in simple harmonic motion. What is its angular frequency?

(a) 14.1 rad/s
(b) 11.5
(c) 1.43 rad/s
(d) 2.24 rad/s
(e) 4.47 rad/s

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{10}{0.5}}$

$= \sqrt{20}$

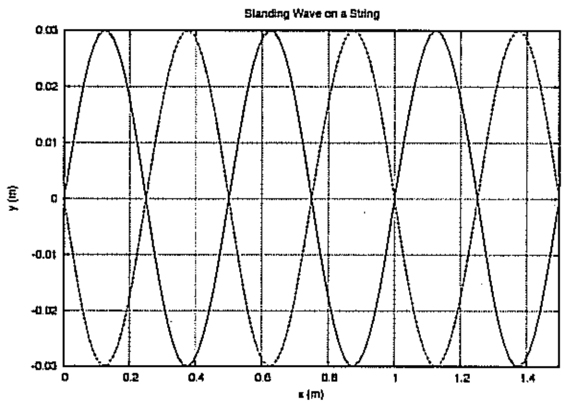
14. An oscillator has an angular frequency of 4 rad/s. What is its frequency in Hz?

(a) 1.57 Hz
(b) 4.0 Hz
(c) 0.25 Hz
(d) 1.27 Hz
(e) 0.637 Hz

$\omega = 2\pi f$

$f = \frac{\omega}{2\pi} = \frac{4}{2\pi}$

15. Suppose that in a particular experiment, one sets up a standing wave on a string that looks like the picture shown below.



How many nodes are there?

(a) 7
(b) 6
(c) 12
(d) 3
(e) 14

$\lambda = 4L$

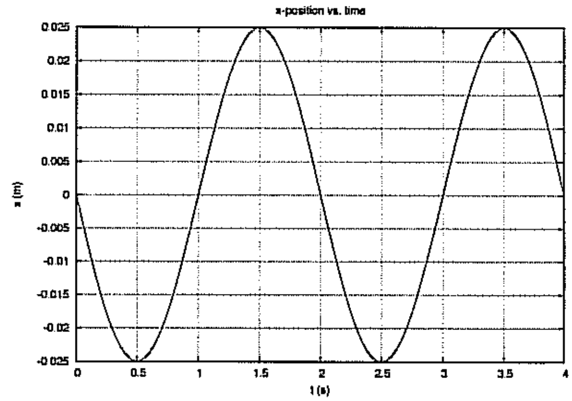
or

$\lambda = 2L$

16. For the previous question, suppose that you want a standing wave that is a *higher* harmonic. What should you do to the tension in the string (assuming that the frequency and length stay the same)?

(a) increase the tension
(b) decrease the tension
(c) none of the above because changing the tension will not change the harmonic of the standing wave

17. The graph of x(t) for a simple harmonic oscillator is shown below.



What is the amplitude of the oscillation?

(a) 1.25 m
(b) 0.05 m
(c) 2.5 m
(d) 0.80 m
(e) 0.025 m

18. For the oscillator in the previous question, what is its period?

(a) 1.5 s
(b) 0.025 s
(c) 2.0 s
(d) 3.5 s
(e) 1.0 s

19. Which will have a fundamental frequency that is *lower*, a pipe that is (a) open at one end and closed at the other or (b) a pipe that is open at both ends? (Assume that all other characteristics are identical.)

longer λ is lower f

(a) The pipe that is closed at one end and open at the other.
(b) The pipe that is open at both ends.
(c) Neither, because they will have the same fundamental frequency.

20. String Y is thicker than String Z, but they are both made of the same material. Which guitar string will have a *higher* fundamental frequency?

$f = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

(a) String Y
(b) String Z

lower μ is higher f

(c) Neither because they will both have the same fundamental frequency.

Think of guitar strings

21. A simple harmonic oscillator consists of a 0.5 kg mass on a spring of stiffness 8 N/m. If you pull it back 0.05 m from equilibrium and release it from rest, what will be its maximum speed?

(a) 0.80 m/s
(b) 0.20 m/s
(c) 0.89 m/s
(d) 0.63 m/s
(e) 0.40 m/s

$\frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$

$v = \sqrt{\frac{k}{m}}\,A$

$= \sqrt{\frac{8}{0.5}}\,(0.05)$

$= 4(0.05)$

$= 0.2\ \frac{m}{s}$

22. For the oscillator in the previous question, if you double its amplitude by pulling it back 0.1 m and release it from rest, the total energy of the oscillator will increase by a factor of

(a) 1/2
(b) 2
(c) 4
(d) 8
(e) none of the above, because the total energy will be the same

$E = \frac{1}{2}kA^2$

$(2A)^2 = 4A^2$

23. If you double the amplitude of oscillation of a harmonic oscillator, by what factor will the frequency change?

(a) 2
(b) 1/2
(c) $\sqrt{2}$
(d) $1/\sqrt{2}$
(e) None of the above; the frequency is independent of the amplitude.

24. A person is tuning his guitar. The low E string is tuned to 156 Hz. When playing the same note on another string, he hears a beat frequency of 4 Hz. What is the frequency of the other string?

$f_{beat} = |f_1 - f_2| = 4\ Hz$

(a) 152 Hz
(b) 160 Hz
(c) It could be either 152 Hz or 160 Hz
(d) None of the above.

25. A simple harmonic oscillator has a period of 2.0 s. What is its frequency in Hz?

(a) 2.0 Hz
(b) 2π Hz
(c) $\pi/2$ Hz
(d) 0.5 Hz
(e) 4.0 Hz

$T = 2.0\ s$

$f = \frac{1}{T} = \frac{1}{2}\ Hz$

Section 2. Problem Solving

26. A pedestrian standing at the curb hears the horn of a car approaching her at 26 m/s. For her, the horn has a frequency of 600 Hz.

(a) At what frequency does the driver hear the horn?

$f_d = 600$ Hz

$f_s = ?$

$V = 340 \frac{m}{s}$

$V_s = 26 \frac{m}{s}$

$V_d = 0$

$$f_d = \left(\frac{V \mp V_d}{V \mp V_s}\right) f_s$$

$$600 = \left(\frac{340}{340 - 26}\right) f_s$$

$$f_s = \frac{600\,(340-26)}{340}$$

$$\boxed{f_s = 554 \text{ Hz}}$$

+10

$f_d > f_s$ as expected.

(b) After the car passes her, the horn is still blaring. At what frequency does she hear the horn this time?

$$f_d = \left(\frac{V}{V + V_s}\right) f_s$$

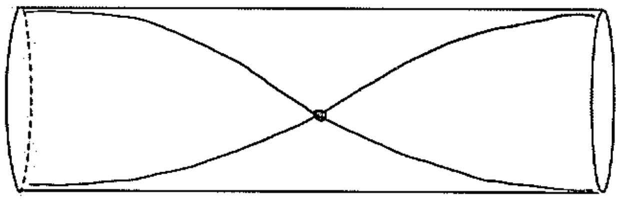
$$= \left(\frac{340}{340+26}\right)(554) = \boxed{515 \text{ Hz}}$$

+10

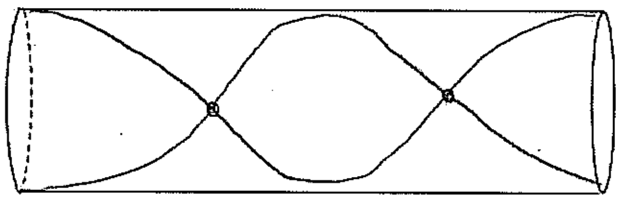
20

27. Sketch the displacement as a function of x for the first four harmonics of a longitudinal standing wave in a pipe of length L that is open on both ends.

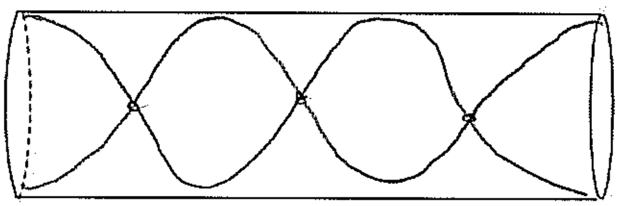
displacement is an antinode at both ends



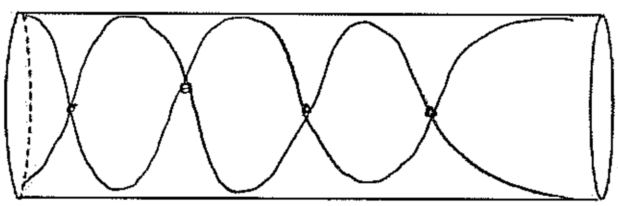
n=1



n=2



n=3



n=4

(little off...)
not a great sketch

+5

+5 each

28. A spring is attached between the end of an air track and a 1.2 kg cart. The cart is pulled back 0.4 m from its equilibrium position and released from rest. It oscillates with a period of 3.0 s. x is the position of the cart at any time t, with $x = 0$ defined as the equilibrium position of the cart.

(a) What is the angular frequency of the oscillator?

$T = 3\,s$ $\qquad \omega = 2\pi f$

$f = \frac{1}{T} = \frac{1}{3}\,Hz$ $\qquad \omega = 2\pi\left(\frac{1}{3}\right) = \boxed{2.09\ \frac{rad}{s}}$

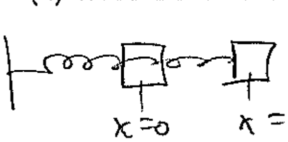
(b) What is the stiffness of the spring?

$\omega = \sqrt{\frac{k}{m}}$ $\qquad k = \omega^2 m = (2.09)^2(1.2\,kg) = \boxed{5.24\ \frac{N}{m}}$

(c) What is the total energy of the oscillator?

$E = \frac{1}{2}kA^2 = \frac{1}{2}(5.24)(0.4)^2 = \boxed{0.419\ J}$

(d) What is the maximum speed of the cart?



$\cancel{KE_i}^{0} + PE_i = KE_f + \cancel{PE_f}^{0}$

$\frac{1}{2}kA^2 = \frac{1}{2}mv_{max}^2$ $\qquad$ so $\quad V_{max} = \sqrt{\frac{k}{m}}\,A$

$\boxed{V_{max} = 0.836\ \frac{m}{s}}$

(e) When the cart is at x=0.2 m, what percentage of the total energy is elastic potential energy and what percentage is kinetic energy?

at $x = 0.2\,m$, $\quad PE = \frac{1}{2}kx^2 = 0.1048\ J$

it is $\boxed{\frac{0.1048}{0.419} = 25\%}$ of the total Energy

thus KE is what is left or 75% of the total Energy

25