Physics 1520, Spring 2014

Quiz 1B, Form: A

Name: Key

Date:

Section 1. Multiple Choice

Questions 1–2: The equations for two traveling waves traveling on the same string are:

Wave 1: $y(x,t) = (5.0\text{ cm})\cos((2.09\text{ rad/s})t - (1.05\text{ rad/m})x)$

Wave 2: $y(x,t) = (5.0\text{ cm})\cos((1.57\text{ rad/s})t - (0.785\text{ rad/m})x)$

1. What is the ~~wavelength~~ speed of Wave 2?
   - (a) 1.2 m/s
   - (b) 1.6 m/s
   - [✓ (c)] 2.0 m/s
   - (d) 8.0 m/s
   - (e) 4.0 m/s

$v = \lambda f$

$\omega = 2\pi f$

$f = \frac{1.57 \frac{rad}{s}}{2\pi} = 0.25\,Hz$

$k = \frac{2\pi}{\lambda}$

$\lambda = \frac{2\pi}{k} = \frac{2\pi}{0.785 \frac{rad}{m}}$

$= 8.0\,m$

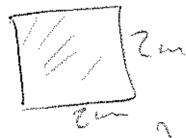
2. Which wave has a higher speed?
   - (a) Wave 1
   - (b) Wave 2
   - [✓ (c)] Neither, because they have the same speed.

speed only depends on medium

$v = \lambda f$
$= (8.0\,m)(0.25\,Hz) = \boxed{2\frac{m}{s}}$

3. The intensity of the Sun at Earth's surface is approximately 1400 W/m^2. Suppose that you have a square solar panel on your roof that is 2 m long and 2 m wide. Assuming that all of the sunlight incident on the solar panel is absorbed, how much solar energy is absorbed by this panel in 8 hours?
   - (a) 12 J
   - (b) 4.0×10^7 J
   - (c) 4.8×10^4 J
   - (d) 5.6×10^3 J
   - [✓ (e)] 1.6×10^8 J

$I = \frac{P}{A}$



$P = IA = \left(1400 \frac{W}{m^2}\right)(2\,m)(2\,m)$

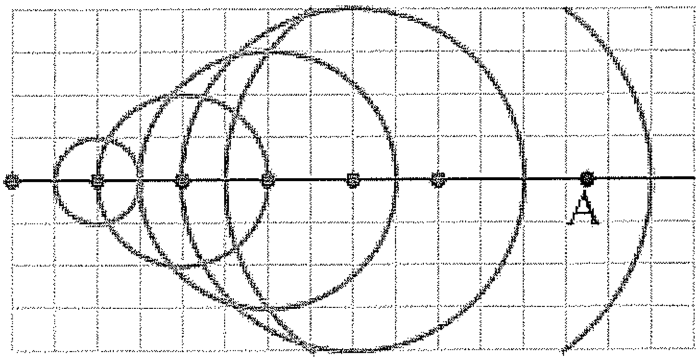
$= 5600\,W = 5600\,\frac{J}{s}$

$P = \frac{\Delta E}{\Delta t}$

$\Delta E = P\Delta t = \left(5600\,\frac{J}{s}\right)(8\,h)\left(\frac{3600\,s}{h}\right)$

$= \boxed{1.6 \times 10^8\,J}$

Questions 4–5: Suppose that in the picture below, each gridline has a length and width of 1 m. The dots represent a source of sound as it travels. The dots are shown 1 second apart.



4. What is the speed of sound in this medium?
   - (a) 1 m/s
   - (b) 0.5 m/s
   - (c) 10 m/s
   - (d) 2.0 m/s
   - (e) 5 m/s

1st wavecrest travels 5 m in 5 s.
$V = 1 \frac{m}{s}$

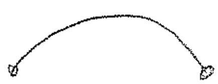
5. An observer at A will measure a frequency that is
   - (a) the same as the source frequency.
   - (b) lower than the source frequency.
   - (c) higher than the source frequency.

Source is moving away from A

Questions 6–7: A banjo D string is 0.69 m long and has a fundamental frequency of 294 Hz.

6. What is the speed of a wave on the string?
   - (a) 203 m/s
   - (b) 135 m/s
   - (c) 426 m/s
   - (d) 406 m/s
   - (e) 294 m/s

$L = 0.69 m$



$n = 1$

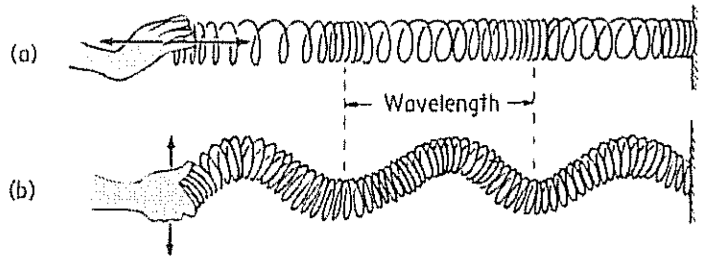
$\lambda = 2L = 2(0.69 m) = 1.38 m$

$v = \lambda f = (1.38 m)(294 Hz) = 406 \frac{m}{s}$

7. If you press on the string at a fret, the speed of a wave on the string will
   - (a) increase.
   - (b) decrease.
   - (c) stay the same.

F_T stays the same
String just gets shorter.

8. The image below shows two different types of sinusoidal waves produced on a slinky. Which wave is the same type of wave as sound?



longitudinal

transverse

(a) Wave (a) ⊙ — Sound is a longitudinal wave

(b) Wave (b)

(c) Neither

9. Radio waves traveling through ice have a speed of 1.7×10^8 m/s. A radio wave pulse sent into the Antarctic ice reflects off the rock at the bottom and returns to the surface in 32.9 μs. How deep is the ice?

(a) 2800 m ⊙

(b) 9700 m

(c) 1940 m

(d) 1030 m

(e) 5600 m

$V = 1.7\times10^8 \frac{m}{s}$

$\Delta t_{\text{to rock}} = \frac{32.9}{2}\mu s = 16.45\times10^{-6} s$

$d = V\Delta t = (1.7\times10^8 \frac{m}{s})(16.45\times10^{-6} s)$

$= 2797\ m$

Questions 10–11: A large goose lands in an olympic-sized pool and bobs up and down for a short time. You notice that the first wave created by the goose reaches the end of the pool in 8.0 s. The distance between two consecutive wave crests is 0.8 m, and in 2.0 s you see five consecutive wave crests hit the end of the pool.

10. What is the period of the waves?

(a) 0.4 s

(b) 2.0 s

(c) 0.5 s ⊙

(d) 2.5 s

(e) 0.33 s

4 cycles $\Delta t = 2.0 s$ $\Delta t = 8 s$

$T = \frac{2.0\ s}{4\ cycles} = 0.5\ s$

11. How far from the end of the pool did the goose land?

(a) 0.1 m

(b) 3.2 m

(c) 10 m

(d) 12.8 m ⊙

(e) 6.4 m

$f = \frac{1}{T} = \frac{1}{0.5 s} = 2\ Hz$

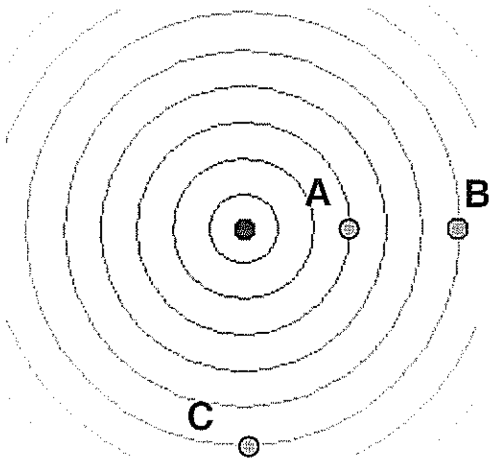
$\lambda = 0.8\ m$

$v = \lambda f = 1.6 \frac{m}{s}$

$V = \frac{d}{\Delta t}$

$d = (1.6 \frac{m}{s})(8 s) = 12.8\ m$

Questions 12–14: Suppose that a speaker on a stage emits sound of a single frequency as shown below. Person A, Person B, and Person C are at the locations shown below. The distance from the source to Person A is half the distance from the source to Person B. And persons B and C are at the same distance from the source.



12. If the intensity of the sound at person A is 4 W/m^2, what is the intensity at person B?
   - (a) 1 W/m^2
   - (b) 2 W/m^2
   - (c) 8 W/m^2
   - (d) 16 W/m^2
   - (e) the same at person A, 4 W/m^2

$I = \frac{P_{source}}{4\pi r^2}$ $\quad I \propto \frac{1}{r}$

$r_B = 2r_A$ so $I_B = \frac{1}{4} I_A$

$= \frac{1}{4}(4 \frac{W}{m^2}) = 1 \frac{W}{m^2}$

13. What is the sound level, in dB, that would be measured by a sound meter at location A?
   - (a) 6 dB
   - (b) 40 dB
   - (c) 120 dB
   - (d) 126 dB
   - (e) 132 dB

$\beta = 10 dB \log_{10}\left(\frac{I}{I_0}\right)$

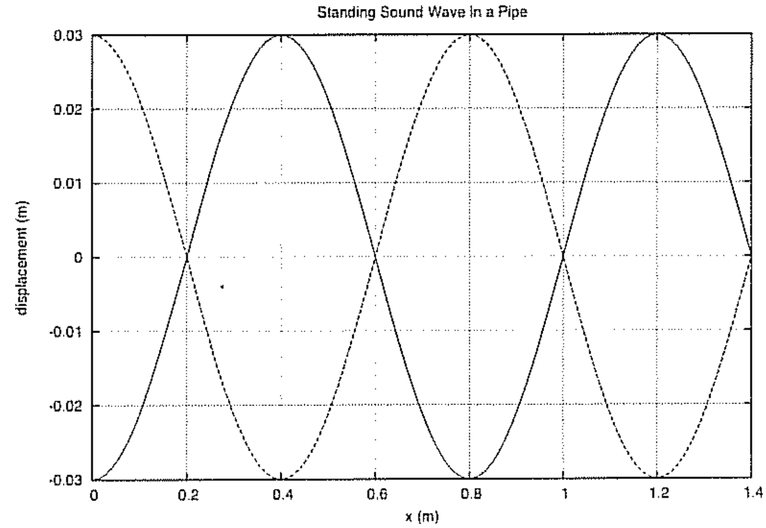
$= 10 dB \log\left(\frac{4}{10^{-12}}\right) = 126 dB$

14. Which person's ear drum will absorb the most energy in one second? (Assume that their ear drums have the same area.)
   - (a) Person A
   - (b) Person B
   - (c) Neither, they will absorb the same energy in one second.

$P_{absorbed} = I A_{ear\ drum}$

$I_A > I_B$ so person A absorbs more energy per sec.

Questions 15–18: A standing wave is produced in air in the pipe of a musical instrument. A graph of the *displacement* of the air as a function of location along the pipe is shown below.



15. Is the left end of the pipe closed or open?

    (a) closed
    (b) open
    (c) It could be open or closed.

displacement is an antinode at an open end.

16. What is the harmonic n of this standing wave?

    (a) 3
    (b) 4
    (c) 5
    (d) 7
    (e) 9

$n = 1$ $n = 5$ $n = 3$ $n = 7$

17. What is the wavelength of the waves that produce this standing wave?

    (a) 0.6 m
    (b) 1.4 m
    (c) 1.6 m
    (d) 0.4 m
    (e) 0.8 m

From graph, $\lambda = 0.8\,m$

Also $\lambda = \frac{4L}{n} = \frac{4(1.4\,m)}{7} = \boxed{0.8\,m}$

18. What is the frequency of the waves that produce this standing wave?

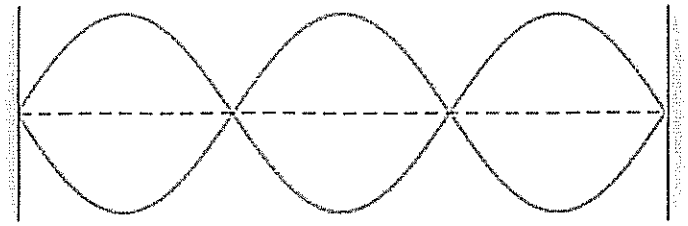
    (a) 1720 Hz
    (b) 245 Hz
    (c) 490 Hz
    (d) 429 Hz
    (e) 123 Hz

$v = 343\,\frac{m}{s}$

$v = \lambda f = (0.8\,m)(f)$

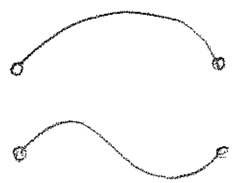
$f = \frac{343\,\frac{m}{s}}{0.8\,m} = \boxed{429\,Hz}$

Questions 19–20: A string has a linear density (the mass per unit length) of 1.0×10^{-2} kg/m and is under a tension of 100 N. The string is 1.5 m long, is fixed at both ends, and is vibrating in the standing wave pattern shown below. (As usual, the transverse displacements are exaggerated in the drawing.)



19. What harmonic n is this?

(a) 2
(b) 3
(c) 4
(d) 5
(e) 6



$n = 1$

$n = 2$

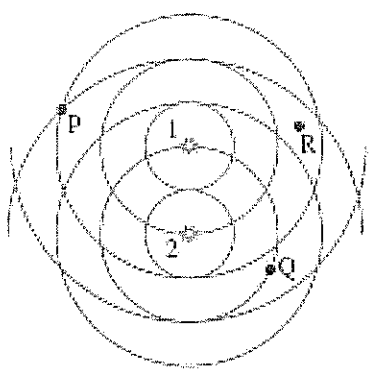
$n = $ # antinodes

20. What is the wavelength of the waves that produce the standing wave?

(a) 0.25 m
(b) 0.5 m
(c) 1.0 m
(d) 1.5 m
(e) 3.0 m

$\lambda = \frac{2L}{n} = \frac{2}{3}(1.5\,m) = 1\,m$

21. Two identical sources (1 and 2) emit waves in 3D as shown below. The path length difference at point Q is



$L_1 = 3.5\lambda$

$L_2 = 2\lambda$

$\Delta L = 1.5\lambda$

(a) 1λ
(b) 1.5λ
(c) 2λ
(d) 2.5λ
(e) 3λ

Questions 22–25: A dolphin sends out high-frequency sound waves to help it locate its prey. The waves reflect off a moving fish, returning to the dolphin Doppler-shifted because of the motion of the fish. The shift in frequency tells the dolphin how fast the fish is going.

Consider the situation of sound waves emitted by a *stationary* dolphin that reflect off a fish while the fish is *moving away from* the dolphin.

22. Which statement is correct?

    (a) The frequency of waves detected by the fish is lower than the frequency emitted by the dolphin.

    (b) The frequency of waves detected by the fish is higher than the frequency emitted by the dolphin.

    (c) The frequency of waves detected by the fish is the same as the frequency emitted by the dolphin.

23. Which statement is correct?

    $v = \lambda\uparrow f\downarrow$

    (a) The wavelength of waves reaching the fish is shorter than the wavelength coming from the dolphin .

    (b) The wavelength of waves reaching the fish is longer than the wavelength coming from the dolphin.

    (c) The wavelength of waves reaching the fish is the same as the wavelength coming from the dolphin

24. Which statement is correct?

    (a) The frequency of waves returning to the dolphin is lower than the frequency of waves reaching the fish. source moving away from observer

    (b) The frequency of waves returning to the dolphin is higher than the frequency of waves reaching the fish .

    (c) The frequency of waves returning to the dolphin is the same as the frequency of waves reaching the fish .

25. Assume the fish is traveling away from the dolphin at a speed of exactly $0.01v$, where v is the speed of sound in water (1400 m/s). The dolphin emits sound of frequency 200 kHz. What frequency does the fish hear?

    (a) 2 kHz

    (b) 202 ~~Hz~~ KHz

    (c) 196 ~~Hz~~ KHz

    (d) 204 ~~Hz~~ KHz

    (e) 198 kHz

$$f' = f\left(\frac{V \pm V_o}{V \mp V_s}\right)$$

$$= 200\,\text{kHz}\left(\frac{1400 - 14}{1400}\right)$$

$$= \boxed{198\ \text{kHz}}$$

$V_o = 0.01(1400\ \tfrac{m}{s}) = 14\ \tfrac{m}{s}$

$V_s = 0$

$f = 200\ \text{KHz}$

Quiz 1

micro = 1×10^{-6}
nano = 1×10^{-9}
c = 3×10^{8} m/s
$v_{air} = 343$ m/s at room temperature and 1 atm.

displacement of the medium: $y(x,t) = A\cos(\omega t \pm kx)$ where $k = 2\pi/\lambda$ is the wavenumber and ω is the angular frequency.

$v = \sqrt{\frac{F_T}{\mu}}$ for a wave on a string.

$I = \frac{P}{A}$ and $P = \frac{\Delta E}{\Delta t}$. The intensity at a distance r from a point source of waves is $I = \frac{P_{source}}{4\pi r^2}$.

$f' = f\left(\frac{v \pm v_o}{v \mp v_s}\right)$ The upper sign in each case corresponds to the detector and source moving toward each other. The lower sign in each case corresponds to the detector and source moving away from each other.

$\lambda_n = \frac{2L}{n}$ and $f_n = n\frac{v}{2L}$ with $n = 1, 2, 3, ...$ if the standing wave has nodes on both ends or antinodes on both ends.

$\lambda_n = \frac{4L}{n}$ and $f_n = n\frac{v}{4L}$ with $n = 1, 3, 5, ...$ if the standing wave has a node on one end and an antinode on the other end.

$f_n = nf_1$ are the frequencies of the harmonics of a standing wave.

sound level: $\beta = (10 \text{ dB})\log_{10}\left(\frac{I}{1\times 10^{-12}\text{ W/m}^2}\right)$ relative sound level: $\Delta\beta = (10 \text{ dB})\log_{10}\left(\frac{I_f}{I_i}\right)$

Interference of two sources that are in phase:

Constructive: path difference $= |L_1 - L_2| = \Delta L = m\lambda$

Destructive: path difference $= |L_1 - L_2| = \Delta L = \left(m + \frac{1}{2}\right)\lambda$