Physics 1520, Fall 2013
Quiz 1A, Form: A

Name: Key

Date: _____

$I_0 = 1 \times 10^{-12}$ J/s/m^2
Assume a temperature of air such that $v_{sound\ in\ air} = 340$ m/s.

Section 1. Multiple Choice

Questions 1–4: A 0.5-kg object hangs from a spring of stiffness 10 N/m. You pull it down 7.5 cm from equilibrium and release it from rest. It oscillates in simple harmonic motion.

1. What is its angular frequency?
   - (a) 14.1 rad/s
   - (b) 11.5 rad/s
   - (c) 1.43 rad/s
   - (d) 2.24 rad/s
   - (e) 4.47 rad/s

$m = 0.5\,kg$, $A = 0.075\,m$, $k = 10\,\frac{N}{m}$

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{10}{0.5}} = 4.5\,\frac{rad}{s}$

2. What is the total energy of the oscillator?
   - (a) 0.028 J
   - (b) 0.38 J
   - (c) 0.056 J
   - (d) 0.75 J
   - (e) 5 J

$E = \frac{1}{2}kA^2 = \frac{1}{2}\left(10\,\frac{N}{m}\right)(0.075\,m)^2 = 0.028\,J$

3. What is the object's speed when the object is 3 cm from equilibrium?
   - (a) 0.13 m/s
   - (b) 0.34 m/s
   - (c) 0.12 m/s
   - (d) 0.053 m/s
   - (e) 0.31 m/s

$E = \frac{1}{2}kx^2 + \frac{1}{2}mv^2$

$\frac{1}{2}mv^2 = E - \frac{1}{2}kx^2$

$= 0.0281\,J - \frac{1}{2}(10)(0.03)^2 = 0.0236\,J$

$v = \sqrt{\frac{2(0.0236\,J)}{0.5\,kg}} = 0.307\,\frac{m}{s}$

4. If you repeat the experiment but pull it down a total of 2 cm from equilibrium and release it from rest, the angular frequency is
   - (a) greater than the previous experiment.
   - (b) less than the previous experiment.
   - (c) the same as the previous experiment.

ω does not depend on A

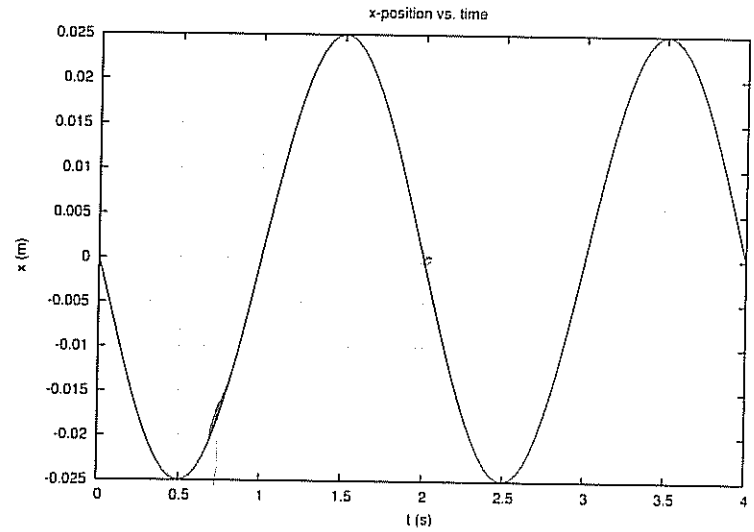
5. Spring A has twice the stiffness of Spring B. If the same mass is attached to each spring and oscillates, the angular frequency of Spring A is
   - (a) $(1/\sqrt{2})\omega_B$
   - (b) $(1/2)\omega_B$
   - (c) $2\omega_B$
   - (d) $\sqrt{2}\omega_B$
   - (e) equal to ω_B.

$\omega = \sqrt{\frac{k}{m}}$ $\quad k_A = 2k_B$

$\omega_A = \sqrt{\frac{2k_B}{m}} = \sqrt{2}\sqrt{\frac{k_B}{m}}$

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

Questions 6–8: A 0.25 kg object oscillates on a spring in simple harmonic motion. The graph of x(t) is shown below.



6. What is its frequency?

(a) 0.67 Hz
(b) 40 Hz
(c) 0.5 Hz
(d) 0.29 Hz
(e) 1.0 Hz

$T = 2\,s$

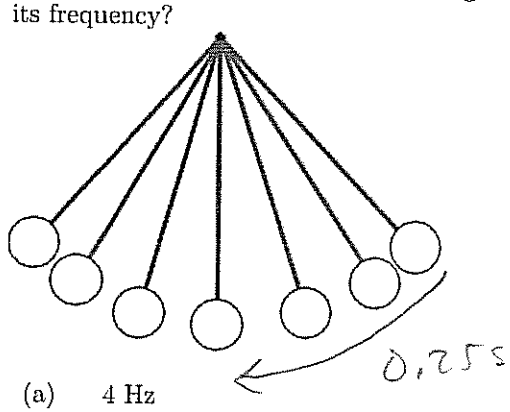
$f = \frac{1}{T} = \frac{1}{2\,s} = 0.5\,Hz$

7. The x-velocity at $t = 0.7$ s is

(a) positive
(b) negative
(c) zero

V_x is slope and is pos. / pos. slope.

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



$\frac{1}{4}$ oscillation in 0.25 s

So $T = 1\,s$

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

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

9. 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

$E_i = E_f$

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

$v_{max} = \sqrt{\frac{k}{m}}A = \sqrt{\frac{8}{0.5}}(0.05m) = 0.2\frac{m}{s}$

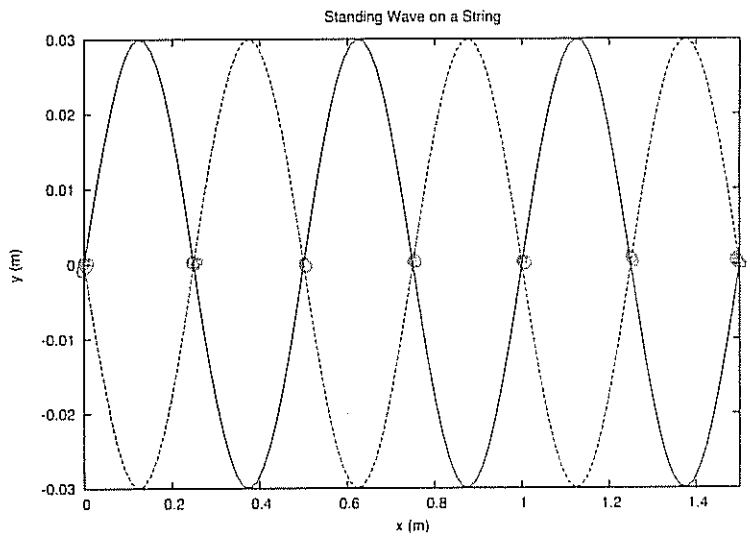
10. For the oscillator in the previous question, if you triple its amplitude by pulling it back 0.15 m when you release it from rest, the total energy of the oscillator will increase by a factor of

(a) 3
(b) 4
(c) 6
(d) 9
(e) none of the above, because the total energy will be the same

$E \propto A^2$

$(3A)^2 = 9A^2$ so E increases by 9.

Questions 11–13: Suppose that in a particular experiment, you create a standing wave on a string that looks like the picture shown below.



11. How many *nodes* are there?

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

7 nodes

12. What is the wavelength?

(a) 0.25 m
(b) 0.21 m
(c) 1.5 m
(d) 0.75 m
(e) 0.5 m

$L = 1.5m$

3λ are shown, so

$3\lambda = L$

$\lambda = \frac{L}{3} = 0.5m$

13. 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

$v = \lambda f = \frac{2L}{n} f \quad n = \frac{2Lf}{v}$ need lower v, so lower tension.

14. 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?

(a) String Y
(b) String Z
(c) Neither because they will both have the same fundamental frequency.

$f = \frac{2L}{n} v = \frac{2L}{n}\sqrt{\frac{F_T}{\mu}} \quad f \propto \frac{1}{\sqrt{\mu}}$

$\mu_Y > \mu_Z$ so $f_Y < f_Z$

15. For a standing wave in a pipe that is closed at one end, the displacement of the air at the closed end is

(a) neither a node nor an antinode.
(b) either a node or antinode depending on the wavelength of the standing wave.
(c) an antinode.
(d) a node.

air cannot oscillate at the closed end.

16. 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

17. 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

$f = \frac{n}{4L} v = \frac{1}{4(0.1\,m)}\left(340\,\frac{m}{s}\right)$

$= 850$ Hz

18. 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.)

(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.

open-open $f = \frac{1}{2L} v$

open-closed $f = \frac{1}{4L} v$

19. 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?

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

Sound level $= 10\,dB \log\left(\frac{I}{I_0}\right)$

if $\frac{I}{I_0} = 10$, level $= 10$ dB

$\frac{I}{I_0} = 100$, level $= 20$ dB

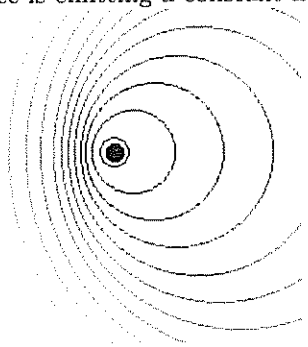
$\frac{I}{I_0} = 1000$, level $= 30$ dB

an increase in 10 dB is a factor of 10 increase in intensity

80dB − 80dB = 30dB

so 3 factors of 10 or 10^3

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



In what direction is the source traveling?

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

21. A pedestrian standing at the curb hears the horn of a car approaching her at 26 m/s. She hears a frequency of 600 Hz. At what frequency does the driver in the car hear the horn? (Use a speed of $v = 340$ m/s for sound in the air at this temperature).

(a) 646 Hz
(b) 600 Hz
(c) 574 Hz
(d) 626 Hz
(e) 554 Hz

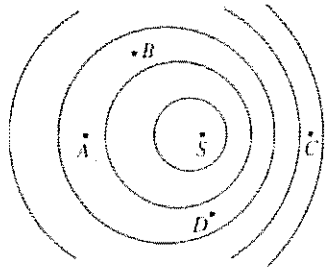
$f_d = 600\,Hz \quad f_s = ? \quad v_s = 26\ \frac{m}{s} \quad v_d = 0 \quad v = 340\ \frac{m}{s}$

$f_d = \left(\frac{v+v_d}{v-v_s}\right) f_s$

$f_s = \frac{v-v_s}{v+v_d} f_d = \left(\frac{340-26}{340}\right)(600)$

$= 554\,Hz$

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

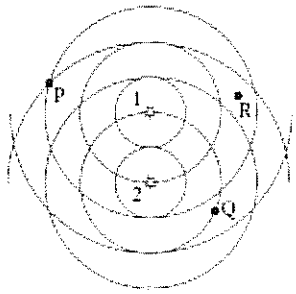


At which of the labeled points will the frequency measured by a stationary listener be greatest?

(a) A
(b) B
(c) C
(d) D
(e) It will be the same for all four points.

$v = \lambda f$ large f is small λ. (or "short" λ)

23. Two identical sources emit waves of wavelength λ shown below.

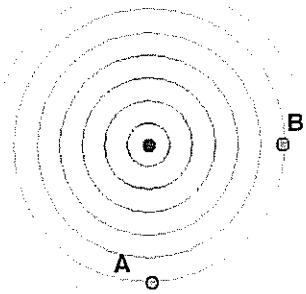


R is at a crest for source 1 and a crest for source 2. ~ ~ const. interference

At point R, the interference of the waves from the two sources is

(a) constructive
(b) destructive
(c) There's not enough information to determine the interference.

24. A point source of sound waves is shown below. Person A stands at location A and holds a microphone with a circular area of 1 cm^2. Person B stands at location B and holds a microphone with a circular area of 2 cm^2. At which microphone is the intensity of the sound the greatest?



distance to each point is the same so I is the same

(a) A
(b) B
(c) The intensity is the same at the location of each microphone.

25. Which microphone absorbs the greatest amount of energy per second?

(a) A
(b) B
(c) The microphones absorb the same amount of energy per second.

$A_B > A_A$ $P = IA$

So larger area mic absorbs more energy.