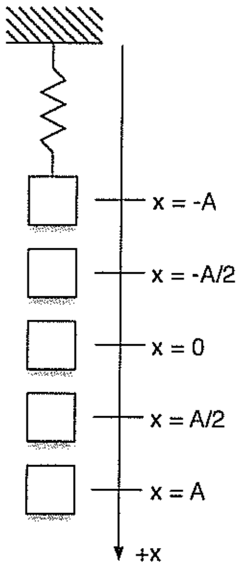
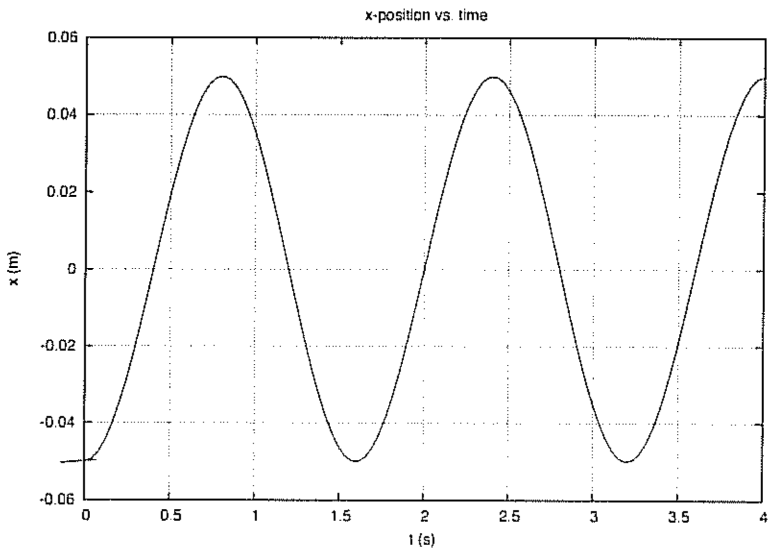
Physics 1520, Spring 2013
Quiz 1, Form: A

Name: Key
Date:

## Section 1. Test A

Questions 1–6: A 0.5 kg object oscillates on a vertically oriented spring. The $+x$ direction is defined to be in the direction that the spring stretches. $x = 0$ is defined to be the location where the object would hang at rest in equilibrium if not oscillating. A graph of $x(t)$ for the oscillator is shown.




1. Where is the object at $t = 0$?
   (a) $x = -A$
   (b) $x = -A/2$
   (c) $x = 0$
   (d) $x = A/2$
   (e) $x = A$

   $x(t=0) = -0.05$ m

2. What is the amplitude?
   (a) 0
   (b) -0.05 m
   (c) 0.05 m
   (d) 0.8 m
   (e) 0.025 m

   peak displacement on the graph

3. What is the period?
   (a) 0.05 s
   (b) 0.4 s
   (c) 0.8 s
   (d) 1.2 s
   (e) 1.6 s

   $\Delta t$ for min to min. is 1.6 s.

$M = 0.5\,kg$ $T = 1.6\,s$ $f = \frac{1}{1.6\,s} = 0.625\,Hz$

4. What is the stiffness of the spring?

   (a) 0.625 N/m
   (b) 1.97 N/m
   (c) 3.93 N/m
   (d) 1.28 N/m
   (e) 7.71 N/m

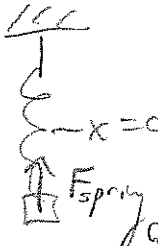
$\omega = 2\pi f = 2\pi(0.625\,Hz) = 3.93\,\frac{rad}{s}$

$\omega = \sqrt{\frac{k}{m}}$ $k = m\omega^2 = (0.5\,kg)(3.93\,\frac{rad}{s})^2 = 7.7\,\frac{N}{m}$

5. What is the first clock reading when the object is at $x = 0$ and moving in the $-x$ direction (i.e. upward)?

   (a) 0
   (b) 0.4 s
   (c) 0.8 s
   (d) 1.2 s
   (e) 1.6 s

Slope must be negative (since $v_x$ is $-$)
This occurs at $t = 1.2\,s$




6. What is the direction of the force by the spring on the object when it is at $x = A/2$?

   (a) downward
   (b) upward
   (c) neither, because it is zero when the object is at this location

$F = -kx$ so since $x$ is $+$, $F$ is $-$

Questions 7–9: An object of mass 0.4 kg oscillates on a spring of stiffness 16 N/m and amplitude 0.04 m. The period of oscillation is 1.0 s.

7. What is the total energy of the oscillator?

   (a) 0.256 J
   (b) 0.013 J
   (c) 0.040 J
   (d) 0.253 J
   (e) 0.00032 J

$E = \frac{1}{2}kA^2 = \frac{1}{2}(16\,\frac{N}{m})(0.04\,m)^2 = 0.0128\,J$

8. What is the speed of the object when it is 0.015 m from equilibrium? (Hint: use conservation of energy.)

   (a) 0.16 m/s
   (b) 0.21 m/s
   (c) 0.23 m/s
   (d) 0.25 m/s
   (e) 0.32 m/s

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

$\frac{1}{2}mv^2 = E - \frac{1}{2}kx^2 = 0.0128\,J - \frac{1}{2}(16\,\frac{N}{m})(0.015\,m)^2 = 0.011\,J$

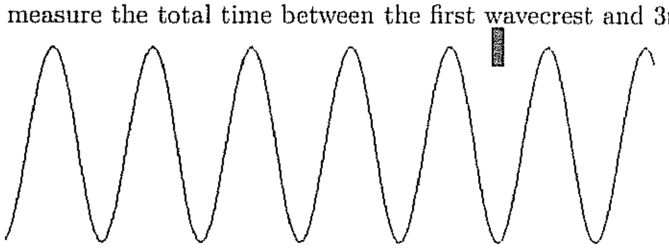
$v = \sqrt{\frac{2(0.011\,J)}{0.4\,kg}} = 0.23\,\frac{m}{s}$

9. Suppose that the total energy of the oscillator is increased. Which of the following variables would also increase?

   (a) the frequency
   (b) the amplitude
   (c) Both the frequency and the amplitude.
   (d) Neither the frequency nor the amplitude.

$E$ is independent of $f$.
and
$E \propto A^2$

10. A transverse sinusoidal wave travels to the right on a long spring like the one used in class. You set up a detector (which is the rectangle) to count wavecrests as they pass. When the first wavecrest passes the detector, you start a clock. When the 3rd wavecrest passes the detector you stop the clock. You measure the total time between the first wavecrest and 3rd wavecrest to be 6 s. What is the period?



(a) 2 s
(b) 1 s
(c) 6 s
(d) 3 s
(e) 12 s

$T = \frac{\Delta t}{\# \text{cycles}} = \frac{6s}{2} = 3s$

11. A speaker emits a sound wave in air at room temperature with a frequency of 200 Hz. The speed of the wave is 343 m/s. What is its wavelength?

(a) 0.583 m
(b) $6.86 \times 10^4$ m
(c) 343 m
(d) 200 m
(e) 1.72 m

$v = \lambda f$

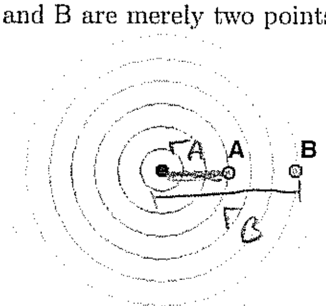
$\lambda = \frac{v}{f} = \frac{343 \frac{m}{s}}{200 Hz} = 1.72 m$

12. For the previous question, if you increase the frequency of sound emitted by the speaker to 400 Hz, the speed of the wave will be

(a) 172 m/s
(b) 686 m/s
(c) the same, 343 m/s

$v$ depends on $\sqrt{\frac{T}{\mu}}$, not $f$.

Questions 13–14: A point source of sound emits sinusoidal waves with power 100 W as shown below. Points A and B are merely two points in space.




$r_A = 3\lambda$

$r_B = 6\lambda$

so $r_B = 2r_A$

13. The intensity of of the sound at point B is ______________ the intensity at point A.

(a) 4 times
(b) equal to
(c) 1/3
(d) 1/4
(e) 1/2

$I = \frac{P}{4\pi r^2}$ so $I \propto \frac{1}{r^2}$

If you double $r$, $I$ decreases by a factor $\frac{1}{4}$.

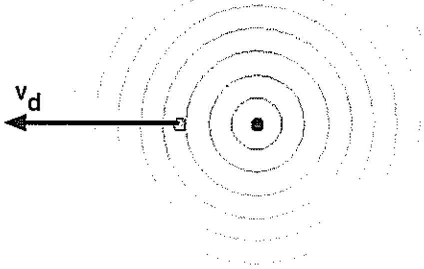
14. A small microphone with a 2.0 $cm^2$ area is 10 m from the 100 W source. How much sound energy impinges on the microphone each second?

(a) 0.16 J
(b) $1.6 \times 10^{-5}$ J
(c) 0.080 J
(d) 0.32 J
(e) 100 J

$I = \frac{P}{A} = \frac{100\,W}{4\pi(10\,m)^2} = 0.0796\,\frac{W}{m^2}$

$P = IA = (0.0796\,\frac{W}{m^2})(2\,cm^2)(\frac{1\,m}{100\,cm})^2 = 1.6 \times 10^{-5}\,W$

Questions 15–16: A car alarm on a parked car is emitting a high-pitched frequency of 600 Hz. You are driving away from the car at $v_d = 15$ m/s ($\approx 34$ mph).




15. You will measure

(a) a lower frequency
(b) a higher frequency
(c) the same frequency, 600 Hz

16. If you were to measure the time between successive peaks as they reach you, the time between peaks that you measure will be

(a) greater than if you are at rest.
(b) less than if you are at rest.
(c) the same as if you are at rest.

$T = \frac{1}{f}$ so if $f$ is lower, $T$ is larger.

17. You are at rest as you listen to a source of sound that emits a frequency of 200 Hz. But you hear (and detect with a microphone) a frequency of 220 Hz. Is the source coming toward you or away from you?

(a) toward
(b) away
(c) neither; the source is not moving

a higher frequency means that the source is coming toward the listener.

18. For the previous question, how fast is the source moving?

(a) 283 m/s
(b) 17 m/s
(c) 20 m/s
(d) 31 m/s
(e) 38 m/s

$f_d = f_s\left(\frac{V \mp V_d}{V \pm V_s}\right)$ choose the lower sign.

$V_d = 0$
$V_s = ?$
$V = 343\,\frac{m}{s}$

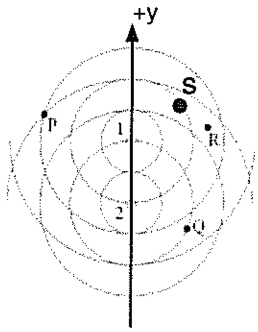
$\frac{220\,Hz}{200\,Hz} = \frac{343}{343 - V_s}$

$1.1 = \frac{343}{343 - V_s}$

$1.1(343 - V_s) = 343$

$343 - \frac{343}{1.1} = V_s = \boxed{31\,\frac{m}{s}}$

Questions 19–20: Two point sources produce sound waves in phase, as shown below. Points P, Q, R, and S are points in space around the sources. The wavelength $\lambda$ of each source is the same.




19. At all points along the $+y$ axis,

(a) total constructive interference occurs.
(b) total destructive interference occurs.
(c) neither total constructive nor total destructive interference occurs.

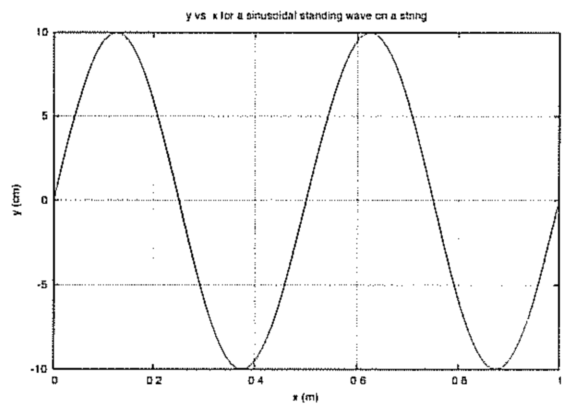
sources are $2\lambda$ apart so $|d_1 - d_2| = 2\lambda$ everywhere on $+y$ axis.

20. At point S, what is the path difference $|d_1 - d_2|$?

(a) $2.5\lambda$
(b) $2\lambda$
(c) $1.5\lambda$
(d) $1\lambda$
(e) zero

$d_1 = 2\lambda$
$d_2 = 3.5\lambda$
$|d_1 - d_2| = 1.5\lambda$

Questions 21–23: A standing wave on a 1 m long string fixed at each end is shown below at a certain instant of time. Because this is a standing wave, each piece of the string oscillates up and down in simple harmonic motion. Using video analysis, you determine that the frequency of the wave on the string for this harmonic is 20 Hz.




4 antinodes

21. Which harmonic is this?

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

22. What is the wavelength?

$L = 1\,m$

$\lambda = \frac{2L}{n} = \frac{2(1\,m)}{4} = 0.5\,m$

(a) 1.0 m
(b) 0.67 m
(c) 0.40 m
(d) 2.0 m
(e) 0.5 m

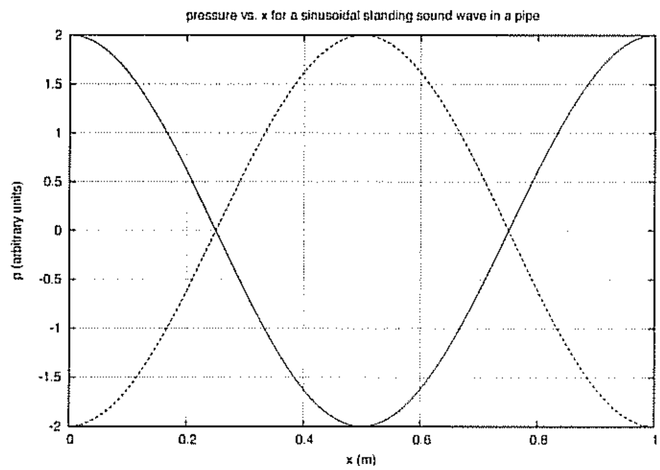
23. What frequency is required to produce a fundamental standing wave on the same string?

$f_n = n f_1$

$20\,Hz = 4 f_1$ so $f_1 = 5\,Hz$

(a) 20 Hz
(b) 80 Hz
(c) 4 Hz
(d) 10 Hz
(e) 5 Hz

Questions 24–25: The pressure as a function of location for a standing sound wave in air in a pipe is shown below.




Since the pressure at every point is oscillating, two plots are used to display when the pressure is at a maximum and at a minimum at every location.

24. The left end of the pipe is closed and the right end of the pipe is closed.

(a) closed; open
(b) closed; closed
(c) open; open
(d) open; closed

Pressure is a node at the end if it is open. Since pressure is an antinode at both ends, then both ends are closed

25. As you can see from the graph, the length of the pipe is 1 m. What is the *longest possible* wavelength standing wave that can be produced in this pipe?

This would be the fundamental,

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

(a) 4 m
(b) 3 m
(c) 2 m
(d) 1.5 m
(e) 1 m