Name ___KEY_____

Physics 161 Lab Time _______________

# Exam 1 – Sound and Waves

February 3, 2011

- This is a closed book examination.
- You may use a 3x5 index card that you have made with any information on it that you would like. You must have your name, lab section and the date on your index card.
- There is extra scratch paper available.
- Please fill out the Scantron sheet completely
    - Include your test code.
    - Include your Dragon ID
    - Include your name
- Mark your exam and include explanations where needed. This will help you learn from your exam as well as provide any verification of your scantron sheet.
- Please make sure to fill out each "Problem Solving Sheet" completely
    - Include your test code
    - Include your Dragon ID
    - Include your name
    - Include your lab time
- Your explanation/work for the worked problems is worth ¾ of the points. You must use a separate "Problem Solving Sheet" for each problem.

A general reminder about problem solving:

1. Visualize - draw a picture
2. Pick a coordinate frame
3. Create a simplified picture – if appropriate
    a. Schematic with vectors and free body diagrams
    b. Energy level diagrams
    c. Wave pictures with multiple time frames (cartoon panels)
4. Write down what you know – create separate columns for different directions
5. Write down what you don't know and/or what you want to know
6. List mathematical relationships
7. Combine mathematical formulas, Simplify and Solve
8. Check your answer – Is it reasonable? Are the units correct?

- Show all work!

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1. If the period of an oscillator is doubled (2x), the linear frequency
   A. is also doubled (2x).
   B. is unchanged (1x).
   C. is halved (½x) .
   D. is quartered (¼x).
   E. changes but depends on the speed.

$T=1/f$

2. Sound is a good example of a longitudinal wave. This means that the oscillation of the wave particles (molecules in this case) are
   A. circular around the propagation direction.
   B. perpendicular to the propagation direction.
   C. parallel to the propagation direction.
   D. random with a decreasing pressure gradient.

The next four problems refer to a simple pendulum that consists of a 0.35 kg mass suspended by a 120 cm string. Assume that the gravitational acceleration is 9.8 m/s$^2$.

3. What is the period of this pendulum?
   A. 0.045 s
   B. 0.45 s
   C. 2.2 s
   D. 22 s
   E. 12 s

$$T = 2\pi\sqrt{\frac{l}{g}}$$

4. If the mass of the pendulum is doubled to 0.70 kg, what happens to the period?
   A. The period does not change.
   B. The period increases by $\sqrt{2}$ .
   C. The period increases by 2.
   D. The period decreases by $\sqrt{2}$ .
   E. The period decreases by 2.

5. If the length of the pendulum is reduced in half to 60 cm, what happens to the period?
   A. The period does not change.
   B. The period increases by $\sqrt{2}$ .
   C. The period increases by 2.
   D. The period decreases by $\sqrt{2}$ .
   E. The period decreases by 2.

6. The pendulum is released at an angle of 25 degrees from the vertical so that it is raised 11 cm. What is the speed of the mass as it passes the lowest point?
   A. 0.05 m/s
   B. 0.67 m/s
   C. 1.47 m/s
   D. 5 m/s
   E. 14.7 m/s

$E_i=E_f$ so $PE_i=KE_f$ and since KE=½mv2 and PE=mgh,
$v = \sqrt{2gh}$

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7. The angular frequency of an oscillator is 165 rad/s. What is the period?
   A. 0.006 s
   B. 0.019 s
   C. 0.038 s
   D. 26.3 s
   E. 330 s

$$\boxed{T = \frac{1}{f} = \frac{2\pi}{\omega}}$$

8. What is the frequency of the second standing wave in a tube that is open on one end and closed on the other if the fundamental frequency is 20 kHz?
   A. 10 kHz
   B. 30 kHz
   C. 40 kHz
   D. 50 kHz
   E. 60 kHz

$$\boxed{f_n = (2n-1)\frac{v}{4L}}$$

9. Does increasing the tension on a guitar string cause the fundamental frequency of the string to change?
   A. The fundamental frequency does not change. The string just gets tighter.
   B. The fundamental frequency increases since the length increases.
   C. The fundamental frequency decreases since the length increases.
   D. The fundamental frequency increases since the wave speed increases.
   E. The fundamental frequency increases since the wave speed decreases.

$$\boxed{v = \lambda f \text{ and } v = \sqrt{\frac{T}{\mu}}}$$

The next two questions refer to an iron wire that is pulled tight between two end points that are separated by 1.8 meters.

10. What is the wavelength of the fundamental frequency?
    A. 0.90 meters
    B. 1.8 meters
    C. 2.7 meters
    D. 3.6 meters
    E. 7.2 meters

$$\boxed{\lambda_n = \frac{2L}{n}}$$

11. If the fundamental frequency is ~~1.9 kHz~~ 1.425 kHz, what is the wave speed?
    A. 5130 m/s
    B. 704 m/s
    C. 1.42 m/s
    D. 5 m/s
    E. 14 m/s

$$\boxed{v = \lambda f}$$

12. What is the wavelength of an 880 Hz sound wave in air? Assume $v_{sound} = 340\,{}^{m}\!/_{s}$
    A. 0.193 meters
    B. 0.386 meters
    C. 0.773 meters
    D. 1.29 meters
    E. 2.59 meters

$$\boxed{\lambda = \frac{v}{f}}$$

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13. Two guitar strings are wired to the same apparatus so that they have the same tension and length. If string one has a mass density 4x smaller than string two so that $\mu_2 = 4\mu_1$ then,

A. $f_2 = 4f_1$
B. $f_2 = 2f_1$
C. $f_2 = f_1$
D. $f_2 = \frac{1}{2}f_1$
E. $f_2 = \frac{1}{4}f_1$

$v = \lambda f$ and $v = \sqrt{\frac{T}{\mu}}$

The next two problems refer to a 3.5 kg mass suspended from a spring. Assume that the gravitational acceleration is 9.8 m/s$^2$.

14. If the mass is doubled to 7.0 kg, what happens to the period?

A. The period does not change.
B. The period increases by $\sqrt{2}$.
C. The period increases by 2.
D. The period decreases by $\sqrt{2}$.
E. The period decreases by 2.

$T = 2\pi\sqrt{\frac{m}{k}}$

15. If the spring constant is 40 N/m, what is the period when the 3.5 kg mass is set in oscillation?

A. 0.30 s
B. 1.86 s
C. 3.38 s
D. 10.6 s
E. 21.2 s

The next two questions refer to a lab experiment you and your partners conducted. You and your lab partners measured the position as a function of time for a mass attached to a spring which was set oscillating. You fit a sinusoidal curve to your data and obtained a fit of $0.08\sin(12.6t - 1.05) + 21.3$.

16. What is the oscillation period?

A. 0.499 s
B. 1.05 s
C. 2.01 s
D. 3.39 s
E. 5.98 s

12.6=ω so T=2π/12.6

17. Which two numbers have the same units?

A. None. All of the numbers in the fit above have different units.
B. 12.6 and 1.05 have the same units.
C. 0.08 and 21.3 have the same units.
D. 0.08 and 12.6 have the same units.
E. 1.05 and 21.3 have the same units.

You can only add numbers with the same units.

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18. Two different speakers that are placed in a room play the same 440 Hz frequency sound wave (assume $v_{sound} = 340 \, {}^{m}\!/_{s}$). You place a microphone so that it is 200 cm away from one speaker. At what distance should you place the second speaker from the microphone so total destructive interference occurs?
   A. 239 cm
   B. 123 cm
   C. 277 cm
   D. 219 cm
   E. You can not obtain total destructive interference if the speakers are playing the same frequency.

You need to have a path difference that is ½λ. λ=v/*f*=77cm so anything that is Δx=39cm + (n)77cm different (where n is an integer).

19. Two different speakers placed 100 cm apart play a 1.22 kHz wave and a 1.23 kHz wave. What is the beat frequency that you hear? Assume $v_{sound} = 340 \, {}^{m}\!/_{s}$
   A. There is no beat frequency since the speakers are too far apart.
   B. There is no beat frequency since the speakers are a full wavelength apart.
   C. You hear a 10 Hz beat frequency.
   D. You hear a 1.225 kHz beat frequency.
   E. You hear a 0.1 kHz beat frequency

$f_{beat}=|f_1-f_2|$

20. The external sound intensity is measured at $1.58 \times 10^{-3} \, \frac{W}{m^2}$ next to your lawn mower. You buy earplugs that are rated to reduce the sound level 32 decibels. What is the sound intensity level next to your lawn mower when you use these?
   A. $6.31 \times 10^{-4} \, \frac{W}{m^2}$
   B. $9.97 \times 10^{-7} \, \frac{W}{m^2}$
   C. $7.56 \times 10^{-4} \, \frac{W}{m^2}$
   D. $1.58 \times 10^{-9} \, \frac{W}{m^2}$
   E. $1.00 \times 10^{6} \, \frac{W}{m^2}$

$dB = 10\log\left(\frac{I}{I_0}\right)$ and so solving $-32dB = 10\log\left(\frac{I}{1.58 \times 10^{-3} \, {}^{W}\!/_{m^2}}\right)$ for the intensity you find $I = \left(1.58 \times 10^{-3} \, {}^{W}\!/_{m^2}\right)10^{-32/10}$

Do the next two problems using separate problem solving sheets. There are extra problems solving sheets available if you need one.

21. [10 PTS] A fish scale is just a large spring balance. You just caught a "giant" fish and want to record its weight and then release it. Unfortunately the markings on the scale are worn off so you cannot read them. However, you notice the fish is oscillating on the balance with a period of 2.1 seconds, which gives you an idea. You release your fish and when you get back to shore you hook a 5.0 lb bag of sugar to the scale and measure its period at 0.84 seconds. How much does your fish weigh? Convince your fellow fisher-folk that you are not telling a fish tale.

22. [10 PTS] Many marine mammals use sound for navigation. Suppose a dolphin is swimming in the ocean and it sends out a 15kHz sound while swimming at 8.94 m/s. What is the exact frequency of the returning sound wave the dolphin would hear if a large ship is directly in front of it? What is the beat frequency the dolphin would hear? The speed of sound in water is 1484 m/s (4.3x times faster than in air).