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CH1=

CH2 =

PHYS 251 TEST #5 12/07/18 Dr. Holmes NAME Key

DO ALL EIGHT PROBLEMS. THE WORTH OF EACH PROBLEM IS MARKED BESIDE THE PROBLEM. SHOW YOUR WORK FOR PARTIAL CREDIT.

1. a) [3] Write down the one-dimensional wave equation for a string:

b) [2] Where did this equation come from (that is, is it basic, or is it derived from more basic principles - and if so, what is that basic principle or principles)?

c) [3] Write down the one-dimensional wave equation for an electric field wave in vacuum:

d) [2] Where did this equation come from (that is, is it basic, or is it derived from more basic principles - and if so, what is that basic principle or principles)?

e) [2] Show that $E_y(x,t) = E_0 \sin(kx - \omega t)$ is a solution of the one-dimensional wave equation for Electric Field in vacuum as long as $\omega/k = v = \sqrt{1/\epsilon_0 \mu_0}$:

f) [2] Show that $E_y(x,t) = E_0 \sin(kx + \omega t)$ is a wave that moves in the negative x direction.

2. a) What is the predicted speed for an electromagnetic wave in vacuum? [3] 3×10^8 m/s

b) Where does this value come from? (That is, what parameters of the vacuum does it depend on?

[3] $v = c = \sqrt{1/(\epsilon_0 \mu_0)}$. c) If the electromagnetic wave were to travel in a transparent material different than vacuum, such as glass, would the wave travel slower, the same speed, or faster?

[2] slower. d) What would change in part b that would lead to your answer in part c?

[3] ϵ_0 becomes ϵ (where $\epsilon = K\epsilon_0$, K is dielectric constant of material).

3. Given that a one-dimensional wave can be described as a sine wave of amplitude 7 cm, frequency of 550 Hz, with a phase velocity of 170 m/s moving in the +x direction: a) What is the wavelength of this wave?

[4] 0.309 m. b) Write a function, $y(x,t)$, for this wave:

(be sure to have only x and t show up as variables; all other quantities should have values with units included)

$y(x,t) =$

[4] 7 cm sin(20.33 rad/m x - 3,456 rad/s t).

c) If the frequency and amplitude did NOT change but the physical medium did change, would the following quantities change? Answer each with one of the following: [Yes: would change; No: would not change:] wavelength phase velocity: power:

[2] Yes [2] Yes [2] Yes.

4. a) DESIGN a string (choose it's length, mass density, and tension) that when plucked will have a fundamental frequency of 550 HZ: [6]

Length:

Mass density:

tension:

b) Based on your design, what is the phase velocity of waves on your string?

[4] _____.

5. a) Given that the intensity of a sound wave of frequency 550 Hz is $7.0 \times 10^{-5} \text{ W/m}^2$, what is the intensity in dB?

[4] 78.45 dB. b) Given that the intensity of a sound wave of

frequency 750 Hz is 87 dB, what is the intensity in Watts/m² ?

[4] $5 \times 10^{-4} \text{ W/m}^2$.

c) Does the frequency enter into calculations for part a only, for part b only, for both, or for neither?

[2] neither.

d) If two waves with the two frequencies above (550 Hz and 750 Hz) had the same power, would the smaller frequency have a larger, the same, or smaller amplitude?

[2] larger.

6. a) Given that the intensity of a sound wave of frequency 550 Hz is $7.0 \times 10^{-5} \text{ W/m}^2$ (same as in 5a above), what will its intensity be if the amplitude of the sound wave is increased by a factor of 4: (in Watts/m²)? (in dB)?

[3] $1.12 \times 10^{-3} \text{ W/m}^2$ [1] 90.5 dB.

b) Given that the intensity of a sound wave of frequency 750 Hz is 87 dB (same as in 5b above), what will its intensity be if the amplitude stays the same but the frequency is increased by a factor of 10:

(in Watts/m²)? (in dB)?

[3] $5 \times 10^{-2} \text{ W/m}^2$ [1] 107 dB.

c) Given that the intensity of a sound wave of frequency 550 Hz is $7.0 \times 10^{-5} \text{ W/m}^2$ (same as in 5a above) at a distance of 3 meters from the speaker, what will its intensity be at a distance of 12 meters from the speaker:

(in W/m²)? (in dB)?

[3] $4.38 \times 10^{-6} \text{ W/m}^2$ [1] 66.4 dB.

7. a) What is the speed of sound in air in a freezer if the temperature of the freezer is -50°F ?

[3] 302 m/s. b) What are the nominal lower and upper limits on the frequency of SOUND that are audible to the human ear at room temperature?

lower: upper:

[2] 20 Hz [2] 20,000 Hz.

c) Does temperature affect the frequencies that the human ear can hear? (yes/no):

[1] No.

d) What is the wavelength of the SOUND in the above freezer:

for the lower frequency ? for the upper frequency?

[2] 15.1 m [2] 1.51 cm.

e) An FM radio station broadcasts its signal over an electromagnetic wave with a frequency of 103.1 MHz. What is the wavelength for this electromagnetic wave?

[2] 2.91 m.

f) An AM radio station broadcasts its signal over an electromagnetic wave with a frequency of 600 kHz. Is the wavelength for this wave longer, the same, or shorter than for the FM radio station of part e?

[1] longer.

8 Consider a speaker that produces a sound of frequency 5,000 Hz. (In parts a and b, consider the air to be still - no wind, and consider the speed of sound in the air to be 340 m/s.)

All answers for a, b, and c should be to the nearest Hz.

a) Suppose that the speaker is held stationary, and you head towards the speaker at a speed of 30 m/s. What frequency will you measure for the sound?

[4] 5,441 Hz.

b) Suppose that you are stationary and the speaker moves away from you at a speed of 30 m/s. What frequency will you now measure for the sound?

[4] 4,595 Hz.

c) Suppose that the speaker of frequency 5,000 Hz is mounted on a train that is leaving the station going North at 20 m/s, you are approaching the station and the back of the train going North at a speed of 30 m/s, and there is a South wind (blowing from the South towards the North) at a speed of 10 m/s (relative to the station). What will you measure for the frequency of the sound [you must be precise: answer to the closest Hz]?

[4] 5,143 Hz.