RH = CH1= CH2 =

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

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 $E_y(x,t) = E_o\sin(kx-\omega t)$ is a solution of the one-dimensional wave equation for Electric Field in vacuum as long as $\omega/k = v = \sqrt{(1/\varepsilon_o\mu_o)}$:

f) [2] Show that $E_y(x,t) = E_o\sin(kx+\omega t)$ 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] __**$v = c = \sqrt{[1/(\varepsilon_o \mu_o)]}$**________. 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_o becomes ε (where $\varepsilon=K\varepsilon_o$, K is dielectric constant of material)**___________.

3. Given that a one-dimensional wave can be described as a sine wave of amplitude 9 cm, frequency of 220 Hz, with a phase velocity of 270 m/s moving in the +x direction: a) What is the wavelength of this wave?

[4] ______**1.23 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] ___**9 cm sin(5.12 rad/m x – 1,382 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 220 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 220 Hz is 5.0×10^{-3} W/m², what is the intensity in dB?

[4] _____**97 dB**______. b) Given that the intensity of a sound wave of frequency 550 Hz is 57 dB, what is the intensity in Watts/m² ?

[4] _**5.0×10^{-7} W/m²**_______.

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 (220 Hz and 550 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 220 Hz is 5.0×10^{-3} W/m² (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] __**8.0×10^{-2} W/m²**____ [1] ___**109 dB**. b) Given that the intensity of a sound wave of frequency 550 Hz is 57 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] ___**5.0×10^{-5} W/m²**_____ [1] ___**77 dB** . c) Given that the intensity of a sound wave of frequency 220 Hz is 5.0×10^{-3} W/m² (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] ______**3.13×10^{-4} W/m²**___ [1] _**85 dB**______.

7. a) What is the speed of sound in air in a freezer if the temperature of the freezer is -10°F ?

[3] ___**316.5 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] _**15.8 m**______ [2] _**1.58 cm**_____.

e) An FM radio station broadcasts its signal over an electromagnetic wave with a frequency of 98.9 MHz. What is the wavelength for this electromagnetic wave?

[2] _____**3.03 m**____________.

f) An AM radio station broadcasts its signal over an electromagnetic wave with a frequency of 710 kHz. Is the wavelength for this wave longer, the same, or shorter than for the FM radio station of part e?

[1] ___**larger**______.

8 Consider a speaker that produces a sound of frequency 4,000 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 away from the speaker at a speed of 30 m/s. What frequency will you measure for the sound?

[4] __**3,647 Hz**________.

b) Suppose that you are stationary and the speaker moves towards you at a speed of 20 m/s. What frequency will you now measure for the sound?

[4] ___**4,250 Hz**____.

c) Suppose that the speaker of frequency 4,000 Hz is mounted on a train that is leaving the station going West at 20 m/s, you are approaching the station and the front of the train going East at a speed of 30 m/s, and there is an East wind (blowing from the East towards the West) 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] ___**4,606 Hz**____.