PHYS 212E **Name _____**
Second Hour Exam **March 24, 2005**

<u>Show all work for full credit</u>! Answers must have correct units and appropriate number of significant digits. For all the problems (except for multiple choice questions), start with either (a) a generally applicable equation or statement; (b) a sentence explaining your approach; or (c) a sketch. Solutions must proceed systematically from your starting point.

$m_{\text{electron}} = 9.11\times10^{-31}\,\text{kg} = 511\,\text{keV}/c^2$ $m_{\text{protom}} = 1.67\times10^{-27}\,\text{kg} = 938\,\text{MeV}/c^2$

$e = 1.6\times10^{-19}\,\text{C}$ $1\text{ eV} = 1.6\times10^{-19}\,\text{J}$ $hc = 1240\text{ eV}\cdot\text{nm}$

$c = 3.0\times10^{8}\,\text{m/s} = 3.0\times10^{17}\,\text{nm/s}$ $h = 6.626\times10^{-34}\,\text{J}\cdot\text{s}$ $4.136\times10^{-15}\,\text{eV}\cdot\text{s}$

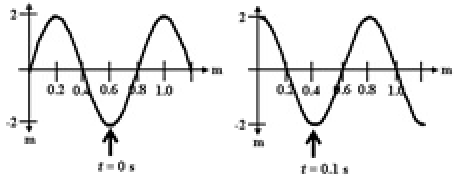
1. (9 points) You are designing a weather radar system to probe developing storms. (Basically, the device emits a wave and detects the portion of the wave reflected from the storm.) You want to resolve the smallest structures possible in the storms. For each of the following, circle the choice that gives the better resolution.

a) Frequency *f* of the radar wave: **larger** **smaller *f*** **no effect on resolution**

b) Intensity *I* of the radar wave: **larger *I*** **smaller *I*** **no effect on resolution**

c) Aperture *D* of the radar detector: **larger *D*** **smaller *D*** **no effect on resolution**

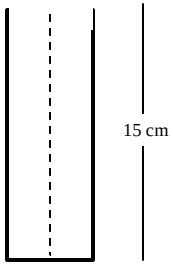
2. (12 points) The figures represent "snapshots" taken of a traveling wave on a string at time $t = 0$ and at time $t = 0.1$ s. The arrow represents the same peak of the traveling wave that you were able to observe moving. Note that both the horizontal and vertical axes are in meters; call the horizontal axis the *x*-direction.



a) Using information from the two "snapshots", write down the amplitude, velocity, wavelength and frequency of this wave.

b) Write down an equation that describes this traveling wave.

3. (12 points) You drink some soda out of a bottle. When there is approximately 15 cm of open space at the top of the bottle, you blow firmly across the top of the bottle and produce a beautiful note. You realize that you have excited the fundamental mode of the bottle, and decide to model this situation as a pipe with one end closed and the other end open.



a) In the figure provided on the right, sketch the standing wave corresponding to the fundamental mode for your model.

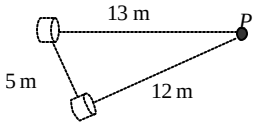
b) Use your sketch to determine the wavelength and frequency of the note you hear. Assume the speed of sound is 330 m/s.

c) Sean Astin stops by to talk about "Brotherhood and Community" but instead drinks half of your soda and leaves. You blow firmly across the top of the bottle again. What do you notice about the frequency of the note you produce compared to your previous note? (circle one).

Frequency increased **No change in frequency**

Frequency decreased **Not enough information to decide**

4. (16 points) Two speakers placed 5 m apart are driven by the same amplifier, each producing a bone shaking frequency of 110 Hz. You are standing at the point *P*, 12 m from one speaker and 13 m from the other, as shown in the diagram. The speaker closest to you produces sound of amplitude 2*A* when playing alone. The speaker further from you is old and only produces sound of amplitude *A* when playing alone.
Assume the speed of sound is 330 m/s.

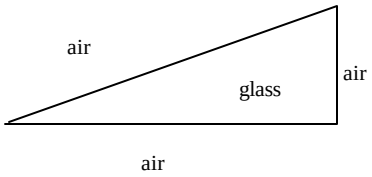


a) Compute the phase difference $\Delta\phi$ between the two waves arriving at point *P* from the speakers.

b) Draw a phasor diagram for the two waves arriving at point *P*. Recall that the amplitude from each speaker individually is not the same.

c) Determine the amplitude of the combined wave at your position, in terms of *A*.

5. (12 points) A triangular piece of glass (n = 1.40) is surrounded by air (n = 1.00) on all sides as shown in the figure.



a) What is the speed of light in the glass?

b) For reflected, monochromatic light viewed from above (with normal incidence), how many bright fringes will appear if the maximum thickness of the wedge is 8.0 times the wavelength of the light in air?

6. (9 points) Light of wavelength λ is incident on two narrow slits of width a separated by a distance d. Part of the intensity pattern of light on a screen a distance L away is sketched in the figure. Consider the following choices:

A. The distance between adjacent maxima increases.

B. The distance between adjacent maxima decreases.

C. The distance between adjacent maxima remains the same.

D. The pattern disappears.

? . The pattern does the hokey-pokey and turns itself around.

a) What happens to the pattern if you only decrease the distance between slits d? Enter best choice.

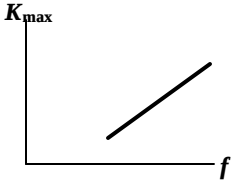
b) What happens to the pattern if you only decrease the wavelength λ? Enter best choice.

c) What happens to the pattern if you only decrease the slit width a? Enter best choice

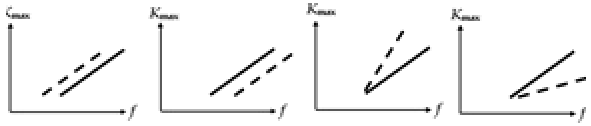
7. (10 points) In a photoelectric effect experiment, you shine light of different frequencies on a metal plate, and determine the maximum kinetic energy of electrons ejected from the metal surface. You obtain the following results:

f (Hz)	4.84×10^{14}	6.00×10^{14}	7.50×10^{14}
K_{max} (eV)	1.00	1.48	2.10

a) When you plot maximum kinetic energy vs. frequency, you obtain a straight line as sketched on the right. What is the minimum energy of light that will cause an electron to eject from the metal surface?



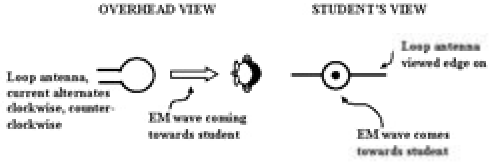
b) You repeat this experiment, this time using a metal with a higher binding energy (work function.) Which of the following best indicates the graph you would obtain when you plot maximum kinetic energy vs. frequency? The solid line is the previous data set, and the dashed line is the new data. (Circle one)



c) The abominable Dr. Phibes has proposed that Planck's constant might be influenced by gravity. You repeat the original experiment close to the surface of the earth and far from the surface of the earth. If Dr. Phibes's proposal is correct, what would be different in your two graphs?

8. (10 points) An alpha particle is composed of two protons and two neutrons and has total mass $m = 6.64 \times 10^{-27}$ kg $= 3.73 \times 10^{9}$ eV/c^2. The alpha particle is accelerated from rest through an electric potential difference of 10^6 V. Calculate the resulting de Broglie wavelength of the alpha particle.

9. (10 points) A student looks at an electromagnetic wave produced from a loop antenna. In the loop antenna, current alternates its direction of motion. The student holds a polarizing filter between his eye and the antenna.



a) Consider the student's point of view, where the incoming EM wave comes out of the page. What orientation of the transmission axis of the filter would let the **most** electromagnetic radiation through? (circle one)

b) Explain your reasoning for your choice above.