PHYS 212E **Name _____**

Second Hour Exam **March 25, 2004**

Show all work for full credit! Answers must have correct units and appropriate number of significant digits. For all the problems (except for multiple choice questions), s tart with either (a) a generally applicable equation or statement; (b) a sentence explaining your approach; or (c) a sketch.

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

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

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

1. (12 points) Consider the function $y(x,t) = Ae^{kx}\cos(\omega t)$, where A, k, and ω are constants. Is this function a solution to the wave equation $\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$ for all values of x and t? **Show all your work!**

2. (16 points) A plane polarized electromagnetic wave is traveling ***in glass***. The wavelength of this wave is 200 nm, and the frequency of this wave is 1.0 x 10^{15} Hz. The following incomplete expressions describe the electric field and magnetic field part of the wave:

$$\vec{E}(\boxed{\text{(a)}},t) = (3\times10^{-3}\,\text{N/C})\sin(\boxed{\text{(b)}}\,t\ \boxed{\text{(c)}}\,\pi\times10^{7}\ \boxed{\text{(a)}})\hat{k}$$

$$\vec{B}(\boxed{\text{(a)}},t) = (\boxed{\text{(d)}}\,\text{T})\sin(\boxed{\text{(b)}}\,t\ \boxed{\text{(c)}}\,\pi\times10^{7}\ \boxed{\text{(a)}})\hat{j}$$

where time is in second and position is in meters. Box (a) represents the same quantity or number, box (b) represents the same quantity or number, etc.

a) Which of the following should be in box (a)? (Circle one.)

y ***z*** can't be determined

b) Determine the number that should go in box (b).

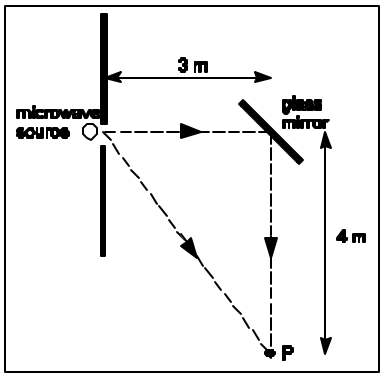
c) Which of the following should be in box (c)? (Circle one.)

+ – can't be determined

d) Determine the number that should go in box (d).

e) Determine the index of refraction of the glass.

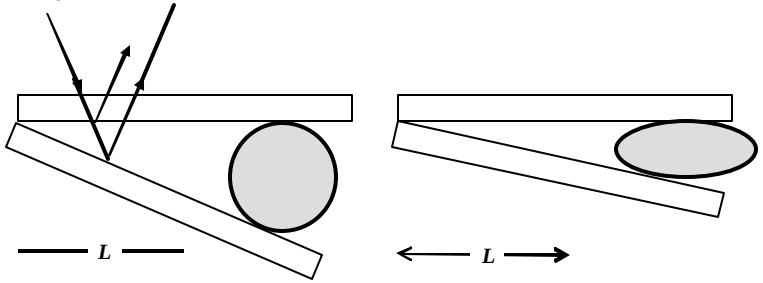
3. (20 points) Monochromatic microwaves of wavelength $\lambda = 3$ m are incident on a narrow slit. Consider waves coherent at the slit. One wave travels 3 meters, bounces off a mirror made of glass, and travels 4 meters more to pass through the point P, where it has amplitude *A* by itself. The second wave travels directly from the slit to the point P, where it also has amplitude *A* by itself.



a) Determine the phase difference between the two waves at the point P.

b) Determine the *combined* amplitude of the two waves at the point P. Express your answer in terms of *A*.

4. (13 points) Two optically flat pieces of glass are arranged with human hair between them, as shown on the left. Monochromatic light with normal incidence is shined on this arrangement. Consider reflections of the bottom of the top piece of glass, and off the top of the bottom piece of the glass, as shown. Remember that the light is incident and reflected straight up and down; the rays are drawn at angles for convenience.



You count the number of bright fringes in the length *L* in the reflection . Next, you apply pressure to the bottom piece of glass with the result that the hair is distorted, as shown on the right.

a) What happens to the number of bright fringes in the length *L*? (Circle one.)

increases decreases stays the same can't be determined

b) Justify your choice.

5. (12 points) Circle either **T**(rue) of **F**(alse) for the following statements about ***single-slit diffraction*** :

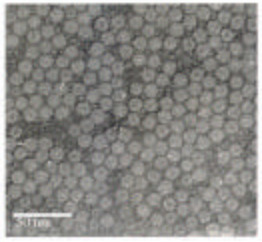
T **F** Decreasing the slit width increases the width of the central maximum

T **F** The bright spots to the side of the central maximum correspond to $\Delta\phi_{tb} = 2\pi, 4\pi, 6\pi, \ldots$

T **F** The width of the central maximum is independent of the wavelength.

T **F** The phasor diagram for the first minimum is a circle.

6. (15 points) The picture on the right shows a sample of magnetic particles made of iron. You want to observe these particles with a ***proton*** microscope; the wavelength of the protons should be 1 nm so that you can resolve features on the surface of the particles.



(This image was actually taken with an electron microscope; these particles were created by your instructor's research group.)

a) Determine the kinetic energy of these protons.

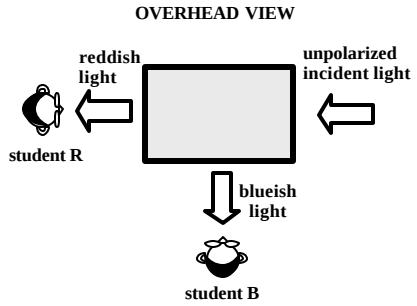
b) Consider a ***photon*** with the **same** wavelength as one of these protons. Which particle has the larger momentum? (Circle one.)

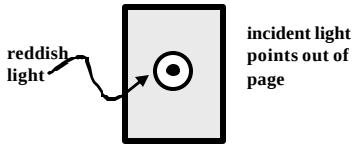
proton photon same momentum can't be determined

c) Again, consider a photon with the same wavelength as one of these protons. Which particle has the larger kinetic energy? (Circle one.)

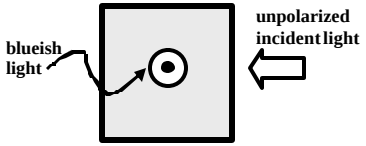
proton photon same kinetic energy can't be determined

7. (12 points) In a version of a demo shown in class, water in a tank has creamer dissolved in it. Unpolarized light passes through the tank, and is observed by two students. Student B, who is looking at the tank from the side (with respect to the incident light,) observes blueish light. Student R, who is looking at the tank along the direction of the incident light, observes reddish light.





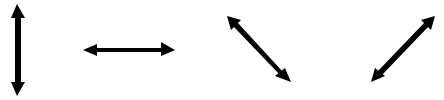
Student R's View



Student B's View

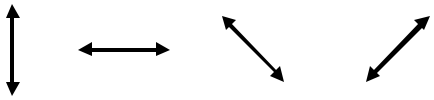
a) Use the results of this experiment to estimate the size of the creamer particles in the water. Briefly explain your reasoning.

b) Student B looks at the bluish light through a polarizing filter. What orientation of the ***transmission axis*** of the polarizer would result in the most noticeable **dimming** of the blue light? (Circle one.)



no noticeable dimming

c) Student R looks at the reddish light through a polarizing filter. What orientation of the ***transmission axis*** of the polarizer would result in the most noticeable **dimming** of the red light? (Circle one.)



no noticeable dimming