Name: ______________________ Instructor:_________________

Louisiana State University Physics 2102, Final Exam,

May 10, 2007.

• Please be sure to write your name and class instructor above.

• The test consists of 7 questions (multiple choice, no partial credit), and 7 problems (numerical).

• For the problems: Show your reasoning and your work. Note that in many of the problems, you can do parts (b) and (c) even if you get stuck on (a) or (b).

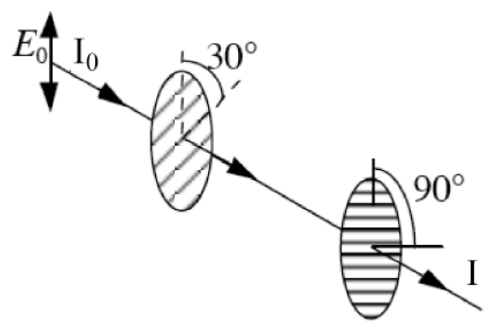
• You may use scientific or graphing calculators, but you must derive and explain your answer fully on paper so we can grade your work.

• Feel free to detach, use, and keep the formula sheet pages. No other reference material is allowed during the exam.

• **Good Luck!**

Question 1 [10 points]

The figure shows a linearly polarized electromagnetic wave which is sent through two polarizers. The first polarizer, **A**, is oriented so that its transmission axis makes an angle of 30° with respect to the incident electric field of the wave. The second polarizer, **B**, is oriented so that its transmission axis makes an angle of 90° with the incident electric field of the wave. The incident beam has an electric field of peak magnitude E_0 and average intensity I_0.



(i) (5 pts) What is the peak value of the electric field amplitude after it goes through polarizer **A**? (Circle the correct answer)

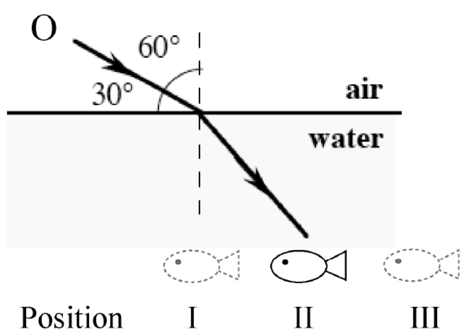
Zero $\qquad$ 0.30 E_0 $\qquad$ 0.60 E_0 $\qquad$ 0.75 E_0 $\qquad$ 0.87 E_0

(ii) (5 pts) Suppose that **A** and **B** are interchanged so that the wave is first incident upon polarizer **B**. What is the average wave intensity after passing through both polarizing sheets?

Zero $\qquad$ 0.34 I_0 $\qquad$ 0.43 I_0 $\qquad$ 0.50 I_0 $\qquad$ 0.19 I_0

Problem 1 [18 points]

The figure shows the path of a ray of light as it travels through air and crosses a boundary into water. The index of refraction of water for this light is 1.33.



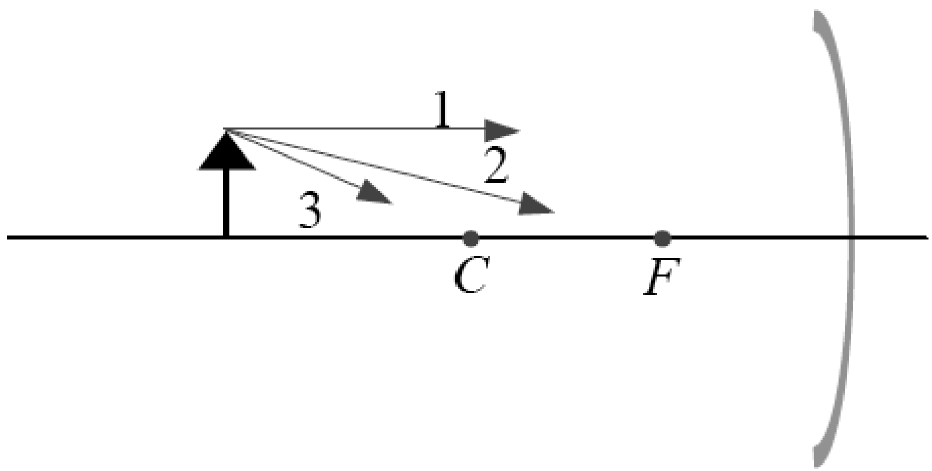
(a) (5 pts) Calculate the speed of this light as it travels through the water:

(b) (6 pts) Calculate the angle of refraction for this light:

(c) (7 pts) Imagine that you are an observer standing at point O. You see a fish under the water which is located at position II. Where do you as the observer *perceive* the fish to be? Answer position I, II, or III (2 pts) and explain (5 pts).

Question 2 [10 points]

An object is placed in front of a concave spherical mirror as shown below. The three rays **1**, **2**, and **3**, leave the top of the object and, after reflection, converge at a point on the top of the image. Ray **1** is parallel to the principal axis, ray **2** passes through *F*, and ray **3** passes through *C*.



(i) (3 pts) Which ray(s) will pass through *F* after reflection?

(a) **1** only
(b) **2** only
(c) **3** only
(d) both **1** and **2**
(e) **1**, **2**, and **3**

(ii) (3 pts) Which ray(s) will reflect back on itself (themselves)?

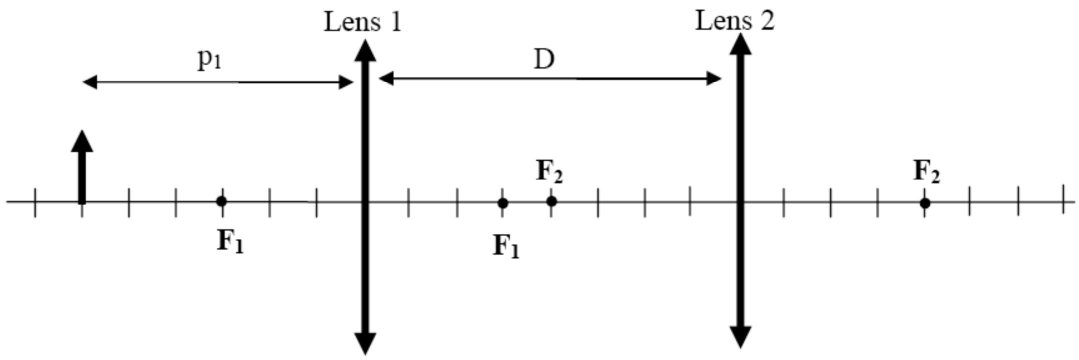
(a) **1** only
(b) **2** only
(c) **3** only
(d) both **1** and **2**
(e) **1**, **2**, and **3**

(iii) (4 pts) Which one of the following groups of terms best describes the image?

(a) real, upright, enlarged
(b) real, inverted, reduced
(c) virtual, upright, enlarged
(d) real, inverted, enlarged
(e) virtual, inverted, reduced

Problem 2 [19 points]

Two thin converging lenses of focal lengths f_1 and f_2 are located along a common axis a distance D apart. An object is placed a distance p_1 to the left of lens #1 as is illustrated in the figure. The points labeled F_1 and F_2 are the focal points of lenses 1 and 2.



(a) (8 pts) *Draw* the final image of the object formed by the two lenses, by using the principles of ray tracing to draw rays from the object to the image formed by each lens.

(b) (2 pts) Is the orientation of the final image the same or inverted relative to the object? Is the final image larger or smaller than the object?

(c) (4 pts) *Calculate* the **position** and **magnification** of the image of the object formed by the first lens, if f_1 = 3 cm and p_1 = 6 cm.

(d) (5 pts) *Calculate* the **position** and **magnification** of the final image of the object formed by the second lens, if f_2 = 4 cm and D= 8 cm. (*Hint*: are your answers to parts (a), (b), and (d) consistent?)

Question 3 [10 points]

If you move from one bright fringe in a two-slit interference pattern to the next one farther out, what happens to (circle the right answers):

(i) (5 pts) The path length difference ΔL between the waves from the two slits

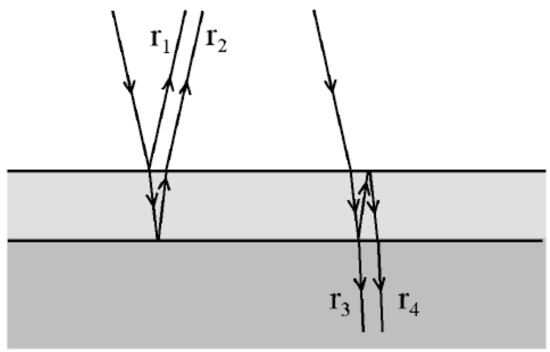
(a) Increases
(b) Decreases
(c) Stays the same

(ii) (5 pts) By how much does the path length difference change:

(a) 0
(b) $\lambda/2$
(c) λ
(d) $3\lambda/2$
(e) 2λ

Problem 3 [19 points]

A disabled tanker leaks kerosene (n = 1.20) into the Persian Gulf, creating a large thin film on top of the water (n = 1.30) of thickness 460 nm.



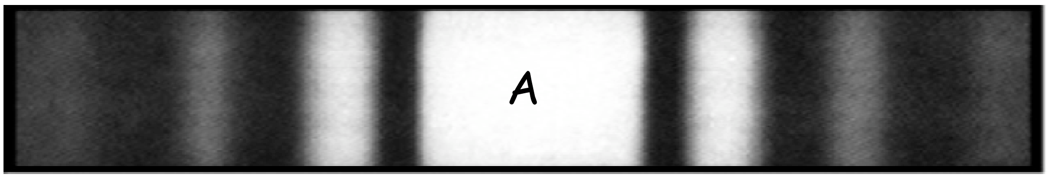
(i) (5 pts) What is the total phase difference between the rays 1 and 2, due to their reflections on the surface of the kerosene film and the surface of the water (do not consider the difference in path length)? Express your answer is radians.

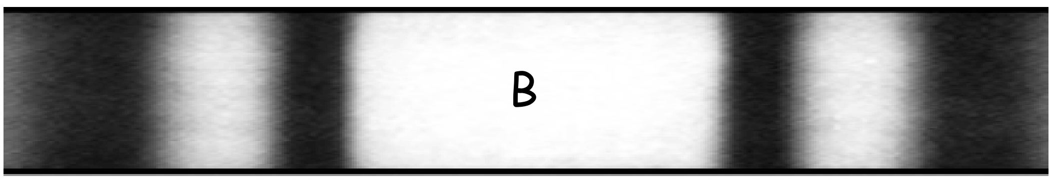
(ii) (8 pts) If you are looking straight down at the kerosene, for which wavelength(s) of visible light do you get bright reflections because of constructive interference? (Visible light has wavelengths between 400 and 700 nm)

(iii) (6 pts) If you are looking straight up from under water, for which wavelength(s) of the visible light is the transmitted intensity strongest? (Hint: consider rays 3 and 4)

Question 4 [10 points]

Two single slit diffraction patterns are shown. The distance from the slit to the screen is the same in both cases.





(i) (5 pts) Circle the correct statement among the following:

(a) The slit width *a* is the same for both, and $\lambda_A > \lambda_B$.
(b) The slit width *a* is the same for both, and $\lambda_A = \lambda_B$.
(c) The slit widths are related as $a_A > a_B$, and $\lambda_A = \lambda_B$.

(ii) (5 pts) What is the orientation of the slit? (Circle ***one.***)

(a) Vertical (↕)?
(b) Horizontal (↔)?
(c) Out of the page (•)?

Problem 4 [16 points]

You are driving your car at night when you see a headlight from an oncoming vehicle.

(i) [8 points]

At what distance can you tell if the oncoming vehicle is a motorcycle (one headlight) or another car (two headlights)? (Assume a wavelength in the mid-visible range of 550 nm, that that the pupil of your eye has a diameter of 1.5 mm, that the headlights on a car are circular and two meters apart, and use the small angle approximation.)

Solution: $\theta_R =$€$1.22\lambda/d = 4.47*10^{-4}$ rad

$D*\theta_R = \Delta x_R$ => $D = \Delta x_R/\theta_R = (2\text{ m})/(4.47*10^{-4}\text{ rad}) = 4470\text{ m} = 4.47\text{km}$

(ii) [8 points]

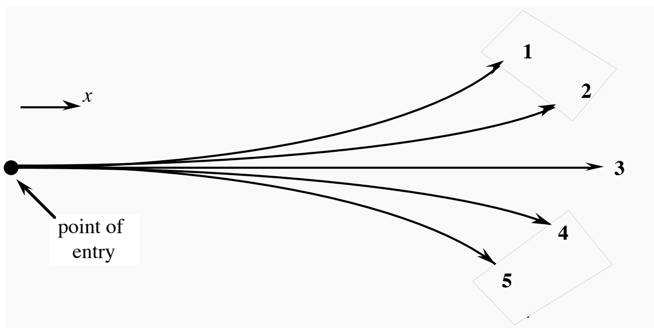
If your passenger is looking at the oncoming vehicle through a telescope, and she can tell that the oncoming vehicle is a car and not a motorcycle at a distance of 100 km, what it the minimum diameter possible for the aperture of her telescope?

Solution: $\theta_R =$€$1.22\lambda/d$ & $D*\theta_R = \Delta x_R$ => $\theta_R = \Delta x_R/D = 2.00*10^{-5}$ rad

=> $d = 1.22\lambda/\theta_R$€$= 3.36*10^{-2}\text{m} = 3.36\text{ cm}$

Question 5 [10 points]

Five particles are shot from the left into a region that contains a uniform electric field. The numbered lines show the paths taken by the five particles.   A negatively charged particle with a charge –3Q follows path **2** while it moves through this field. Do not consider any effects due to gravity.



(i) (4 pts) In which direction does the electric field point?

(a) toward the top of the page
(b) toward the bottom of the page
(c) toward the left of the page
(d) out of the page
(e) toward the right of the page

(ii) (3 pts) Which path would be followed by a helium atom (an electrically neutral particle)?

(a) path **1**
(b) path **5**
(c) path **2**
(d) path **3**
(e) path **4**

(iii) (3 pts) Which path would be followed by a charge +6Q?

(a) path **1**
(b) path **3**
(c) path **5**
(d) path **2**
(e) path **4**

Problem 5 [19 points]

Two point charges are held at the corners of a rectangle as shown in the figure. The lengths of sides of the rectangle are 0.050 m and 0.150 m. Assume that the electric potential is defined to be zero at infinity.

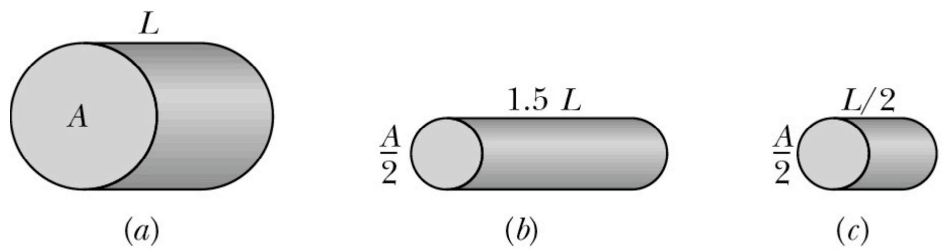
(i) (6 pts) Calculate the electric potential at corner **A**

(ii) (7 pts) Calculate the potential difference, $V_B - V_A$, between corners **A** and **B**:

(iii) (6 pts) Calculate the electric potential energy of a +3.0 μC charge placed at corner **A**:

Question 6 [10 points]

The figure shows three cylindrical copper conductors along with their face areas and lengths. The same potential difference V is placed across their lengths.



(i) (5 pts) Rank the conductors according to the current through them, greatest first

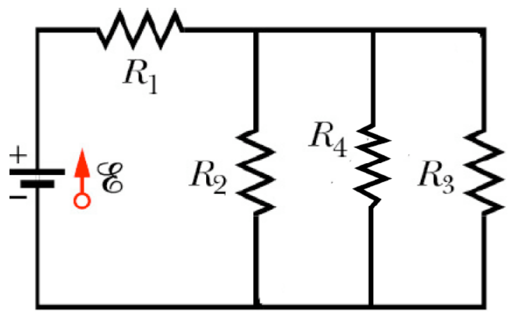
(a) $I_a > I_b > I_c$
(b) $I_c > I_a > I_b$
(c) $I_a > I_b = I_c$
(d) $I_a = I_c > I_b$
(e) All tie

(ii) (5 pts) Rank the conductors according to the current density in them, greatest first

(a) $J_a > J_b > J_c$
(b) $J_c > J_a > J_b$
(c) $J_a > J_b = J_c$
(d) $J_a = J_c > J_b$
(e) All tie

Problem 6 [19 points]

The figure shows a circuit with an ideal battery with an emf of 6.0 V, and four resistors with resistances $R_1 = 100\ \Omega$, $R_2 = R_3 = 50\ \Omega$, and $R_4 = 75\ \Omega$.



(i) (5 pts) Calculate the equivalent resistance of the four-resistor combination:

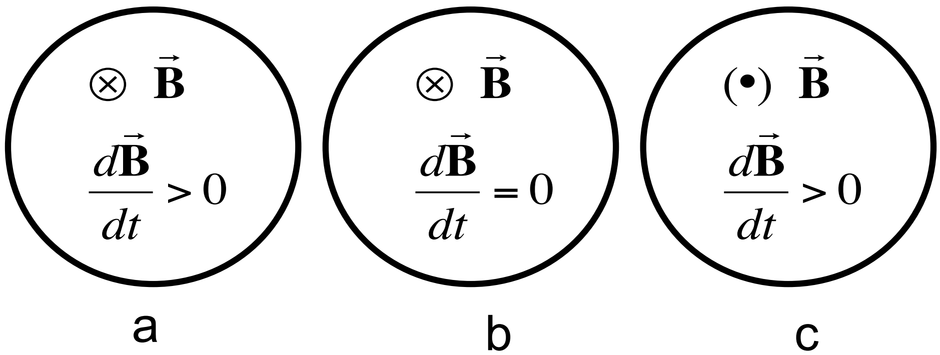
(ii) (4 pts) Calculate the potential difference over R_1:

(iii) (5 pts) Calculate the current through R_2:

(iv) (5 pts) Calculate the total power dissipated by the battery:

Question 7 [10 points]

The figure shows three loops of conducting wire. Through each wire is a changing magnetic field.



I each case, which way is the induced current around the wire clockwise (CW) or counterclockwise (CCW) or no current induced (NONE). Circle the right answers:

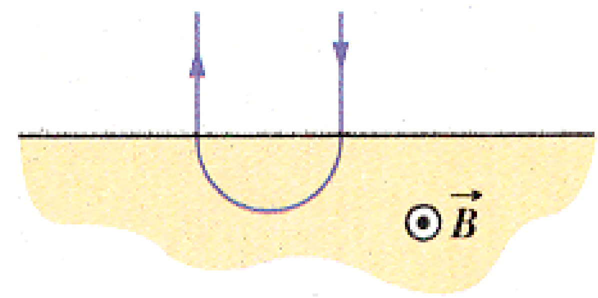
(a) (4 pts) **CW** **CCW** **NONE**

(b) (3 pts) **CW** **CCW** **NONE**

(c) (3 pts) **CW** **CCW** **NONE**

Problem 7 [19 points]

In the figure below, a charged particle travels downwards into a region of uniform magnetic field, goes through half a circle, and then exits that region. The particle is either a proton or an electron (you must decide which). It spends 105 ns in the region.



(i) (6 pts) Is the particle a proton or an electron (justify your answer)?

Solution: RHR => + Charge = proton

(ii) (7 pts) Calculate the magnitude of $\vec{\mathbf{B}}$:

Solution:
B = (2π m_p/(|e|*2*t) = 2*Pi*1.67*10^-27/(1.60*10^-19*(105*2*10^-9)) = 0.312 Tesla

(iii) (6 pts) If the particle had been sent downwards into the magnetic field region with 5.00 times its previous kinetic energy, how much time would it have spent in the magnetic field region during this trip?

Solution: Period is independent of v and hence of 1/2Mv^2 and so same T/2=105ns