Name: _____ Instructor:_____

Louisiana State University Physics 2102, Final Exam,

May 9, 2008.

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

• The test consists of 6 questions (conceptual), and 6 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).

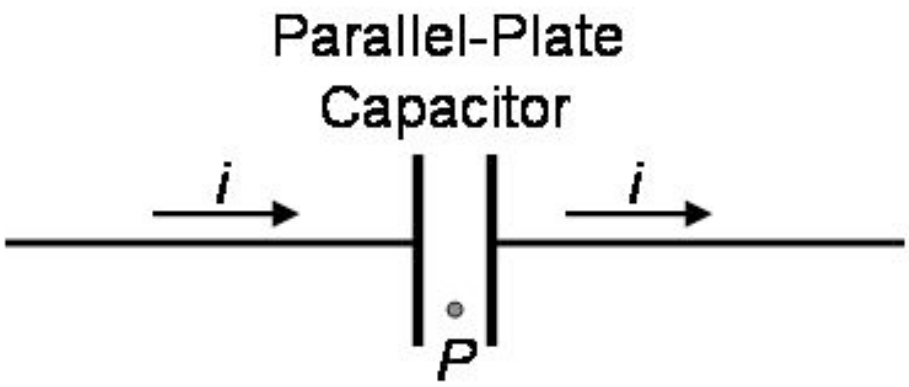
• You may use scientific or graphing calculators, but you must derive and explain your answer fully on paper so we can grade your work.

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

• **Good Luck!**

Question 1 [12 points]

The figure below shows a parallel-plate capacitor and the current in the connecting wires that is discharging the capacitor.



(i) What is the direction of the electric field between the plates?

(a) Toward the left
(b) Toward the right
(c) Upward
(d) Downward

(ii) What is the direction of the displacement current?

(a) Toward the left
(b) Toward the right
(c) Upward
(d) Downward

(iii) What is the direction of the magnetic field at point P?

(a) Upward
(b) Downward
(c) Into the page
(d) Out of the page

Problem 1 [22 points]

A plane electromagnetic wave propagates in the +y direction. The magnetic field associated with the wave oscillates in the x direction, and has a peak magnitude of 3.6 x 10^{-8} T? The frequency of the wave is 3.902 MHz.

(a) (3 pts) In which direction does the electric field oscillate?

(b) (3 pts) In which direction does the Poynting vector point?

(c) (3 pts) Calculate the peak magnitude of the electric field:

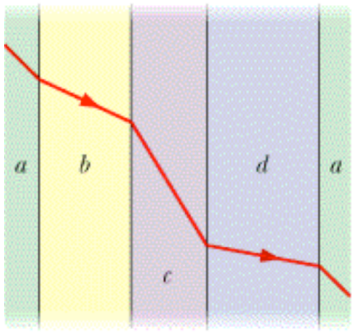
(d) (3 pts) Calculate the wavelength of the wave:

(e) (5 pts) Calculate the peak magnitude of the Poynting vector:

(f) (5 pts) Calculate the time averaged rate of flow of energy (in W/m^2):

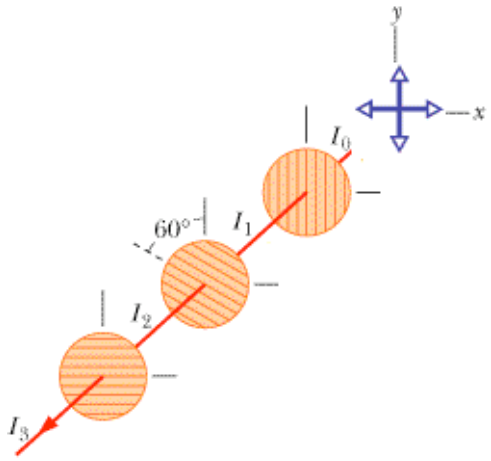
Question 2 [12 points]

In the figure below, light travels through 5 layers of material (the first and last are the same). Rank the four types of medium (a,b,c,d) according to the speed of light in the material, greatest first.



Problem 2 [16 points]

In the figure below, light is transmitted through three Polaroid sheets. The light is initially unpolarized and has an intensity of 3.2 W/m^2.



(a) (4 pts) What is intensity I_1 of the light after it passes through the first sheet?

(b) (2 pts) What is its polarization at this point?

(c) (4 pts) What is the intensity I_2 of the light after it passes through the second sheet?

(d) (4 pts) What is the intensity I_3 of the light after it passes through the third sheet?

(e) (2 pts) What is its polarization at this point?

Question 3 [8 points]

Imagine that you move from one bright fringe in a two-slit interference pattern to the next one farther out.

(i) (4 pts) What happens to the path length difference ΔL between the waves from the two slits

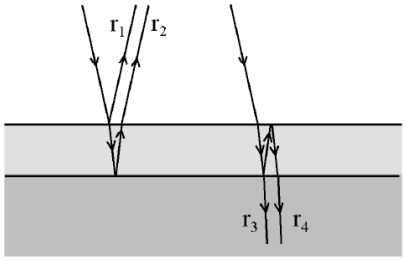
(a) Increases
(b) Decreases
(c) Stays the same

(ii) (4 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 [24 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.



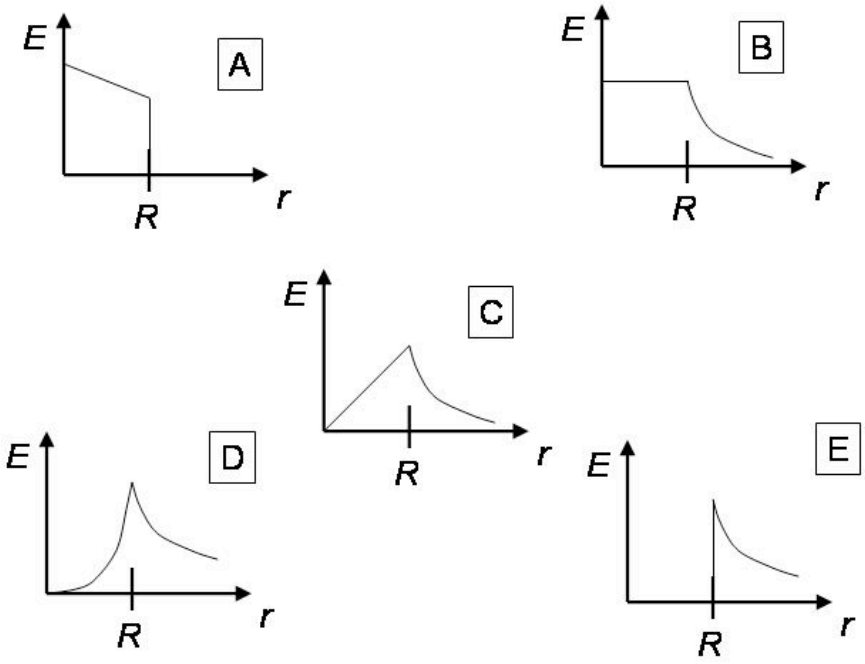
(i) (5 pts) What is the phase difference between the rays 1 and 2, due to their reflections on the surface of the kerosene film and the surface of the water (do not consider the difference in path length)?

(ii) (10 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) (9 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 [12 points]

Consider the following graphs which plot the magnitude of the electric field as a function of r, the distance from the center of a solid sphere of Radius R.

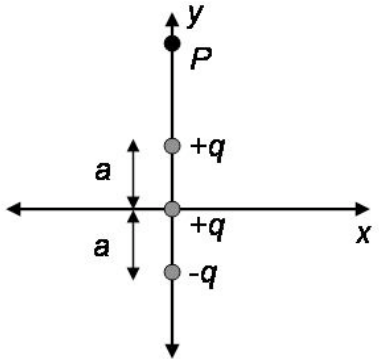


(i) (5 pts) Which graph represents E(r) for a solid conducting sphere with excess charge of +Q on it?

(ii) (7 pts) Which graph represents E(r) for an solid insulating sphere containing a uniform distribution of positive charge?

Problem 4 [24 points]

Consider the charge distribution shown below. Use q = 1.0 nC and a = 2.0 μm.



(a) (8 pts) Calculate the total electric potential energy of this three charge system.

(b) (8 pts) Calculate the electric potential at point P on the y axis, at a distance of 5.0 μm from the origin. (Note: there is no charge at point P).

(c) (8 pts) Calculate the magnitude of the total electrostatic force on the charge at the origin:

Question 5 [10 points]

Given a parallel plate capacitor of capacitance C, which of the following modifications would result in a circuit element with a new capacitance of 2C?

Circle all correct answers.

(i) Combine in series with another capacitor of capacitance C.

(ii) Combine in parallel with another capacitor of capacitance C.

(iii) Double the separation between the capacitor plates.

(iv) Halve the separation between the capacitor plates.

(v) Double the charge on the capacitor.

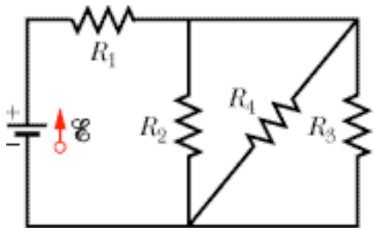
(vi) Halve the charge on the capacitor.

(vii) Double the area of the capacitor plates.

(viii) Halve the area of the capacitor plates.

Problem 5 [24 points]

In the circuit diagram below, $R_1 = 5\ \Omega$, $R_2 = 18\ \Omega$, $R_3 = 7\ \Omega$ and the ideal battery provides an EMF = 24 V.



Problem continues on next page:

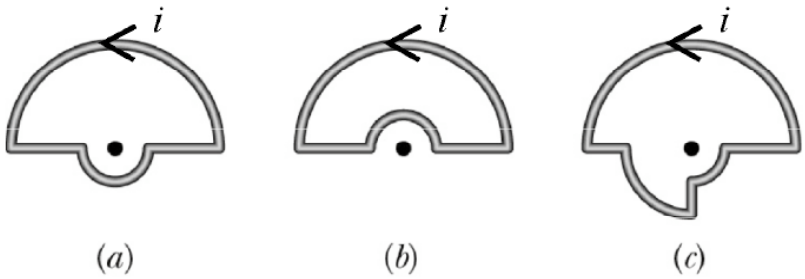
(a) (10 pts) For what value of R_4 will the rate at which the battery transfers energy to the resistors equal 60 W?

(b) (4 pts) For what value of R_4 will the rate at which the battery transfers energy to the resistors equal its maximum possible rate?

(c) (5 pts) What is the maximum possible power?

(d) (5 pts) For what value of R_4 will the rate at which the battery transfers energy to the resistors equal the minimum possible rate?

Question 6 [12 points]



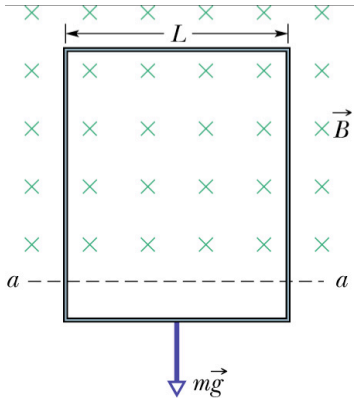
The figure shows three circuits consisting of concentric circular arcs (either half- or quarter-circles of radii r, $2r$, and $3r$) and radial lengths. The circuits carry the same current, indicated on the figure.

(i) (7 pts) Rank them according to the magnitude of the magnetic field produced at the center of curvature (the dot), greatest first.

(ii) (5 pts) What is the direction of the magnetic field at the center of curvature in (b)?

Problem 6 [24 points]

The figure shows a long rectangular loop, of width L = 15 cm, resistance R = 0.8 Ω and mass m = 0.1 kg. It is hung in a horizontal, uniform magnetic field B = 0.6 T that is directed into the page and that exists only above line aa. The loop is then dropped and starts to fall.



(a) (6 pts) Calculate the magnitude of the emf induced in the loop when it is falling with a speed v = 0.1 m/s.

(b) (5 pts) What is the direction of the current *i* induced in the loop when v = 0.1 m/s? Indicate on the figure.

(c) (6 pts) Calculate the magnetic force on the loop at this time.

(d) (7 pts) The loop initially accelerates until it reaches a certain terminal velocity v_t. Calculate v_t.