PHYSICS 208 Final Exam

Fall, 2018

Do not fill out the information below until instructed to do so!

Name:_______________________

Signature:___________________

E-mail:______________________

Section Number: ____________

- No calculators are allowed in the test.
- Be sure to put a box around your final answers and clearly indicate your work to your grader.
- **All work must be shown to get credit for the answer marked. If the answer marked does not obviously follow from the shown work, even if the answer is correct, you will not get credit for the answer.**
- Clearly erase any unwanted marks. No credit will be given if we can't figure out which answer you are choosing, or which answer you want us to consider.
- Partial credit can be given only if your work is clearly explained and labeled. Partial credit will be given if you explain which law you use for solving the problem.

Put your initials here after reading the above instructions:

For grader use only:

Problem 1 (5) ____________

Problem 2 (20) ____________

Problem 3 (15) ____________

Problem 4 (18)____________

Problem 5 (20) ____________

Problem 6 (20)____________

Problem 7 (7)____________

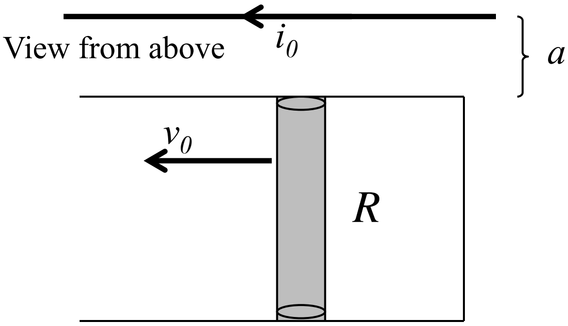
Total (105) ____________

Problem 1: (5 points)

Write Maxwell's equations in the integral form.

Problem 2: (20 points)

A rod of length l is forced to move at constant speed v_0 along horizontal rails connected by wire at the right. The rod has resistance R; the rest of the loop has negligible resistance. A wire, carrying a constant current i_0, is parallel to the tracks, in the same plane at distance a from the loop.



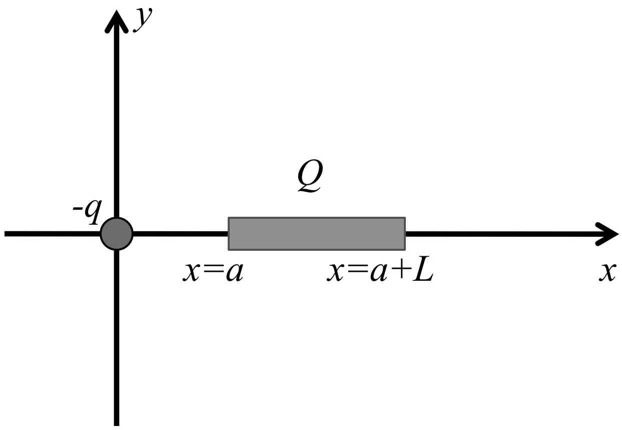
a) Find the direction of the current in the loop. Explain your answer within this box:

b) Find the current through the rod. Ignore self-inductance.

c) What is the magnitude and direction of the force that must be applied to the rod to make it move at constant speed?

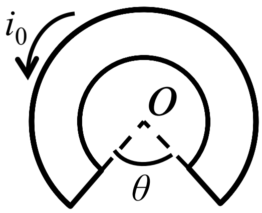
Problem 3: (15 points)

A charge $-q$ is at the origin and an amount of charge Q is uniformly distributed along x-axis from $x = a$ to $x = a + L$. Find the force on the charge at the origin.

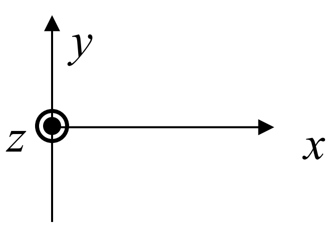


Problem 4: (18 points)

a) A closed loop carries current i_0. The loop consists of two radial straight wires and two concentric circular arcs of radii R_1 and R_2, $R_1 > R_2$. The angle θ is given. Find the magnitude and direction of magnetic field created by this current at point O. (see the figure below).



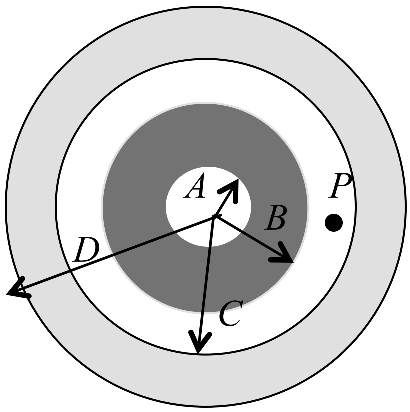
b) A particle with a **positive** charge q is moving in the positive x direction with velocity of magnitude v_0. If there were an electric field in the positive y direction with magnitude E_0, and the velocity of the particle is unchanged, find the magnitude and direction of magnetic field.



c) A particle with a **negative** charge q is moving in the positive x direction with velocity of magnitude v_0. If there were an electric field in the positive y direction with magnitude E_0, and the velocity of the particle is unchanged, find the magnitude and direction of magnetic field.

Problem 5: (20 points)

A spherical conducting shell, inner radius A and outer radius B, is charged with charge Q. It is surrounded by an insulating spherical shell of inner radius C and outer radius D. The insulating shell has a uniform charge density ρ.



a) Find the charge per unit area at $r = A$ and $r = B$.

b) Find the electric field at

i) $r < A$

ii) $A < r < B$

iii) $B < r < C$

iv) $C < r < D$

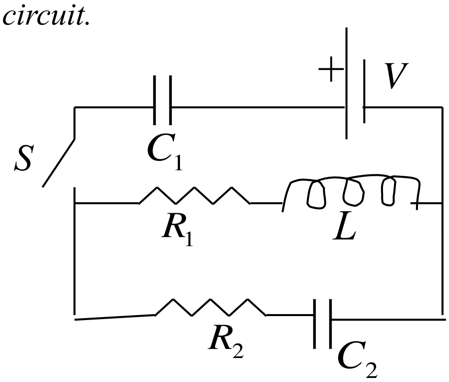
v) $r > D$

c) Find the difference in electric potential between the center and point $r = P$, $V(\mathrm{P})-V(0)$.

d) If the conducting shell has $Q = 0$ and the insulating shell, inner radius C and outer radius D, has a nonuniform volume charge density $\rho = cr^2$ where c is a known positive constant, find the electric field at $C < r < D$.

Problem 6: (20 points)

a) In a circuit below, R_1, R_2, C_1, C_2, L, and V are given. The switch S was closed for a long time so that the steady state was reached. Find the current in each resistor and the charge on the capacitor. *The problem will not be graded without a direction of current and charges on the capacitor indicated on the circuit.*



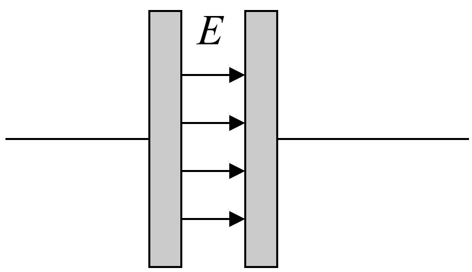
b) At $t = 0$ the switch is open. Assume that the charge on the capacitor 2 is Q_0. Starting from some famous law, derive the equation that describes charge Q on the capacitor as a function of time. *The problem will not be graded without a direction of current and charges on the capacitor indicated on the circuit.*

c) Neglect L. Solve for the charge on the capacitor as a function of time.

d) In part b), neglect R_1 and R_2. Solve for the charge on the capacitor as a function of time.

Problem 7: (7 points)

a) Find the displacement current if the electric field between parallel plate capacitor is $E=E_0\sin(\omega t+\gamma)$. The area of the plates is A.



b) Which of the following equations is the wave equation?

$$\frac{\partial E_y}{\partial x} = C\frac{\partial E_y}{\partial y} \qquad \frac{\partial^2 E_y}{\partial x^2} = \mu_0\varepsilon_0\frac{\partial^2 E_y}{\partial t^2} \qquad \frac{\partial E_y}{\partial x} = -\frac{\partial B_z}{\partial t}$$

$$i = \frac{dQ}{dt}$$

$$R = \frac{V}{i}$$

$$R = \rho \frac{l}{A}$$

$$\vec{E} = \rho \vec{j}$$

$$i = \int_S \vec{j} \cdot d\vec{S}$$

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i(d\vec{s} \times \vec{r})}{r^3}$$

$$d\vec{F} = i d\vec{s} \times \vec{B}$$

$$\Phi_B = \int \vec{B} \cdot d\vec{S}$$

$$\Phi_B = \pm Li$$

$$C = \frac{Q}{\Delta V}$$

$$\left|\vec{F}_E\right| = \frac{1}{4\pi\varepsilon_0} \frac{|q_1 q_2|}{x^2}$$

$$V(\vec{r}_2) - V(\vec{r}_1) = -\int_{\vec{r}_1}^{\vec{r}_2} \vec{E} \cdot d\vec{r}$$

$$i_D = \varepsilon_0 \frac{d}{dt} \int \vec{E} \cdot d\vec{S}$$

$$Q = \int \rho \, dV$$

$$Q = \int \sigma \, dS$$

$$Q = \int \lambda \, dx$$