FINAL EXAM

Physics 9C-03 **NAME:**

March 21, 2001 **Social Sec. #:**

General Instructions: This examination is closed book. A separate formula sheet is provided. Only a calculator is allowed. Please show all your work and box your answers. Credit will only be given for *complete* solutions. Answers must have correct units. There are 12 problems on 6 pages. Note that not all the problems are worth the same number of points.

[15 points] 1. A point charge $Q_1 = +8\mu C$ is located at the origin $x = 0, y = 0$. Another point charge $Q_2 = -5\mu C$ is located at $x = 6, y = 6$.

a. Find the electric field at $x = 0, y = 6$.

b. Find the potential at $x = 0, y = 6$.

[15 points] 2. Three infinite planes of charge have charge densities $+\sigma$ $+2\sigma$, and $-\sigma$ as shown.

Find the electric field everywhere. Give both magnitude and direction.

Find the potential difference $V_b - V_a$.

Find the potential difference $V_c - V_a$.

Find the potential difference $V_e - V_d$.

[25 points] 3. A solid sphere of charge has radius a and uniform charge density ρ.

a. State Gauss' law and show how it can be used to get the electric field for $r < a$ and $r > a$, where r is the distance to the center of the sphere.

b. Compute the potential $V(r)$ for all r. Assume $V = 0$ when $r = \infty$.

[10 points] 4. A circuit contains a switch, a battery, an inductor and a resistor, as shown. The switch is closed at $t = 0$. Sketch the current as a function of time. Label your axes with appropriate numbers.

[15 points] 5. A particle with charge $q = -50\mu C$ moves in a region where the magnetic field is $3.0\hat{k}$ Teslas. Find the force on the particle when its velocity is, (a.) 3500 m/s $\hat{i}$; (b.) 20000 m/s $\hat{j}$; and (c.) 5000 m/s $(\hat{i} + \hat{k})$.

[15 points] 6. Suppose we set up a constant electric field $\vec{E} = 3\hat{i}$ and a constant magnetic field $\vec{B} = 4\hat{k}$ throughout space. Now put a loop C of radius R in the xy plane, centered on the z axis,

a. Calculate the integral of the electric field ($\oint \vec{E} \cdot d\vec{l}$ around the loop.

b. Suppose the magnetic field depends on time $\vec{B} = 5t\,\hat{k}$. What would the integral of the electric field around the loop be now?

[15 points] 7. At a certain instant of time a particle with charge $q = 10\,\mu C$ is located at $x = 0, y = 5$ meters. Its velocity at that time is $\vec{v} = 70\,m/s\,\hat{i}$. Find the magnetic field $\vec{B}$ at (a) $x = 0, y = 0$; (b) $x = 13, y = 5$ meters; and (c) $x = 5, y = 0$ meters.

[20 points] 8. Find the force and the torque on the rectangular loop of wire shown in the figure. Explain your reasoning clearly, especially in justifying why you set any contributions to zero.

[25 points] 9. You are given a long straight wire in the shape of a thick cylindrical shell of inner radius $a = 1.0$ cm and outer radius of $b = 2.0$ cm. That is, the wire is hollow for $r < a$ and filled with metal for $a < r < b$. (See picture.) The wire carries a current of 3 Amperes that is uniformly distributed over its cross sectional area.

a. State Ampere's law and show how it can be used to find the magnetic field B at a distance r from the axis of the wire.

b. Sketch $B(r)$.

[15 points] 10. Find the current in the four ohm resistor in the circuit shown. If point "A" is at potential $V = 0$ volts, find the potential at point "B".

[15 points] 11. In the circuit shown the capacitor is initially uncharged before the switch is thrown. What are the currents through the four and eight Ohm resistors right after the switch is thrown? What are the currents through the four and eight Ohm resistors after a long time has passed?

[15 points] 12. A 5 μF capacitor is charged to 100 Volts. The capacitor is then disconnected from the voltage source, and is connected to another, uncharged, capacitor. The final voltage is 40 Volts.

a. What is the capacitance of the other capacitor?

b. How much energy is lost when the connection is made?