# FINAL EXAM

**Physics 9C-03** **NAME:**

**March 23, 1999** **Social Sec. #:**

**General Instructions:** This examination is closed book. Only a calculator and one 8.5x11 sheet of notes are 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 13 problems on 6 pages. Note that not all the problems are worth the same number of points.

**[20 points] 1.** A point charge $Q_1 = +4\mu C$ is located at $x = 4, y = 0$. Another point charge $Q_2 = -10\mu C$ is located at $x = 0, y = 6$.

a. Find the electric field at $x = 0, y = -3$.

b. Find the potential at $x = 0, y = -3$.

**[10 points] 2.** If there is a vacuum between the plates of a parallel plate capacitor, the electric field is $E = 4\pi k\sigma$, where $\sigma = Q/A$ is the charge density on the plates. What happens to $E$ when you stick some nonconducting material, like glass or oil between the plates? Why?

**[30 points] 3.** A thick, nonconducting spherical shell has inner radius $a$ and outer radius $b$, and uniform charge density $\rho$.

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

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

**[5 points] 4.** About how fast are the electric and magnetic fields oscillating in visible light?

once per hour. once per sec. $10^5$ times per sec. $10^{15}$ times per sec.

**[5 points] 5.** About how long is the wavelength of visible light?

100 meters 1 meter $10^{-2}$ meters $10^{-7}$ meters.

**[25 points] 6.** Find the current in the 10 Volt battery in the circuit shown. Find the potentials at the points **b**, **c**, and **d** given that the potential at **a** is $V_{\mathbf{a}} = 0$.

**[15 points] 7.** In a certain region of space the electric field $E$ is in the positive $x$ direction and the magnetic field is in the positive $z$ direction.

a. In what direction is the electric force on a positive charge moving with zero velocity?

b. In what direction is the magnetic force on a positive charge moving with zero velocity?

c. In what direction is the electric force on a positive charge moving with velocity $v$ in the positive $y$ direction?

d. In what direction is the magnetic force on a positive charge moving with velocity $v$ in the positive $y$ direction?

e. In what direction is the electric force on a positive charge moving with velocity $v$ in the positive $z$ direction?

f. In what direction is the magnetic force on a positive charge moving with velocity $v$ in the positive $z$ direction?

**[10 points] 8.** A wire carrying a current $I$ in the $z$ direction (out of the paper) is located at $x = y = 0$. Draw vectors indicating the direction of the magnetic field at the 10 points indicated by dark circles. Make the length of your vectors proportional to the strength of the field.

**[20 points] 9.** At a certain instant of time a particle with charge $q = 50\,\mu C$ is located at $x = 3, y = 0$ meters. Its velocity at that time is $\vec{v} = 50\,m/s\ \hat{j}$. Find the magnetic field $\vec{B}$ at (a) $x = 0, y = 0$; (b) $x = 3, y = 10$ meters; and (c) $x = 0, y = 3$ meters.

Hint: The formula for the field due to a point charge $q$ moving with velocity $\vec{v}$ is $\vec{B} = (\mu_0\ q\ \vec{v} \times \hat{r})/(\ 4\pi r^2\ )$, where $\mu_0 = 4\pi \times 10^{-7}\ T\,m/\,A$.

**[20 points] 10.** A wire of radius 2.0 cm carries a current of 40 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 1.0 cm from the center of the wire.

b. Do the same to obtain $B$ at a distance 4.0 cm from the center of the wire.

**[10 points] 11.**

a. An initially uncharged capacitor is in a circuit with a battery, as shown in the figure at the left. The switch $S$ is closed suddenly at time $t = 4$ seconds. Sketch the charge on the capacitor as a function of time. Indicate the final charge on the capacitor on the graph, and about how long it takes for the capacitor to charge up.

b. An inductor is in a circuit with a battery, as shown in the figure at the right. The switch $S$ is closed suddenly at time $t = -2$ seconds. Sketch the current in the circuit as a function of time. Indicate the final current on the graph, and about how long it takes for the current to ramp up.

**[15 points] 12.** For the circuit shown, find the currents $I_1, I_2$, and $I_3$

a. immediately after the switch is closed. (The capacitor is initially uncharged).

b. a long time after the switch is closed.

c. immediately after the switch is opened again.

d. a long time after the switch is opened again.

In each case, state your reasoning.

**[15 points] 13.** A loop of wire of area 0.6 $m^2$ lies in the $xy$ plane, as shown. It has resistance 10 Ohms. The magnetic field depends on time and is given by $\vec{B}(t) = [0.4 - 0.1t^2](\hat{x} + 2\hat{y} + 3\hat{z})$ Tesla.

a. State Faraday's law and compute the magnitude of the current.

b. Explain how Lenz's law determines the direction of the current.