**FINAL. PHYS 208. FALL 2003. 12/18/03**

**NAME:**

**1. Electric Potential and Electric Field (10 points).**

Consider a region in space where a uniform electric field $\vec{E} = -7500\text{N/C}\ \hat{x}$ points in the negative $x$ direction. (a) What is the orientation of the equipotential surfaces? Draw a picture. (b) If you move in the positive $x$ direction, does the electric potential increase or decrease? Explain. (c) What is the distance between +14-V and the +16-V equipotentials?

**1b. Electric field lines (4 points)**.

Make a qualitative sketch of the electric field lines produced by four charges $+q, -q, +q, -q$, arranged clockwise on the four corners of a square with sides of length $d$.

**2. Gauss's Law (20 points).** The figure shows a charge $+q$ arranged as a uniform sphere of radius $a$ and placed at the center of a spherical conducting shell of inner radius $b$ and outer radius $c$. The outer shell carries a charge $-q$. Find $E(r)$ for (a) $r < a$, (b) $a < r < b$, (c) inside the shell $b < r < c$, and (d) outside the shell ($r > c$). (e) What charges appear on the inner and outer surfaces of the shell?

**3. (16 points).** Two infinitely large sheets are shown in the figure. Sheet 1 contains a charge density $+\sigma$. Sheet 2 contains $-\sigma$. Between the two sheets is an infinitely large 0.25 mm thick conducting plate that contains zero net charge.

(a) What is the charge density induced on each side of the conducting plate. Explain.

(b) What is the value of the electric field at points A and B. Explain.

(c) Calculate the voltage between the two sheets. Explain.

**4.1 (10 points).** In the following circuit:

(a) Find the equivalent resistance of the circuit.

(b) Find the total current from the battery.

(c) Find the equivalent resistance between points A and B and the voltage $V_{AB}$ between the points A and B.

(d) Find the power dissipated by the $5\Omega$ resistor

**4.2 (5 points).** A battery, a resistor, and inductor, and a switch are connected in series. Obtain the current vs. time after the switch is closed. Sketch the shape of the current vs time.

**5. Ampere's Law (18 points)**. The figure shows a cross-section of an infinite conducting sheet with a current per unit length $\lambda$ emerging from the page at right angles (a) Using symmetry arguments and the right-hand rule explain why the magnetic field $\vec{B}$ is constant for all points P above the sheet and for all points P' below it and is directed as shown. (b) Use Ampere's law and the result of (a) to probe that $B = 1/2\mu_0\lambda$.

**6. Faraday's Law (17 points).**

A conducting rod is free to slide along a pair of conducting rails in a region of constant and uniform magnetic field as shown in the figure. The rod moves with velocity $v = 1$ m/s and B=1 Tesla, and L = 0.1m. (a) Compute the current in the rod. What is the value and direction of the force on the rod needed to ensure that the rod moves with constant velocity?

(b) Answer (a) but now with a second resistance added to the right.