Physics 211 Final Exam

January 31, 2005

Your name:

ID number:

Time given: 120 minutes

Please provide your reasoning for each step of your solution (providing an answer without a solution is not enough)

Problem 1

A conducting sphere of radius R carries total positive electric charge Q and is concentric with insulating uniformly charged shell with the internal and external radii equal to $2R$ and $3R$, as shown on the Figure 1. The total electric charge carried by the shell is equal to $2Q$. 1) Find the electric field as a function of the distance from the origin O in the regions 1,2,3 and 4 (see the Figure 1).

2) Find the electric potential at the point P, located on the inner surface of the shell.

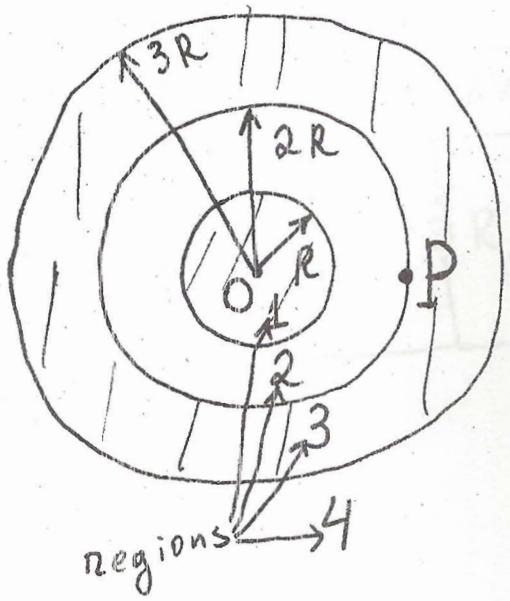


Figure 1

Problem 2

An electric circuit consistc of the 3 batteries with the voltages $\Delta V_1 = 2V, \Delta V_2 = 4V$ and $\Delta V_3 = 8V$ and 3 resistors $R_1 = 1\Omega$, $R_2 = 2\Omega$ and $R_3 = 8\Omega$, as shown on the Figure 2. Find the electric currents in each of the resistors.

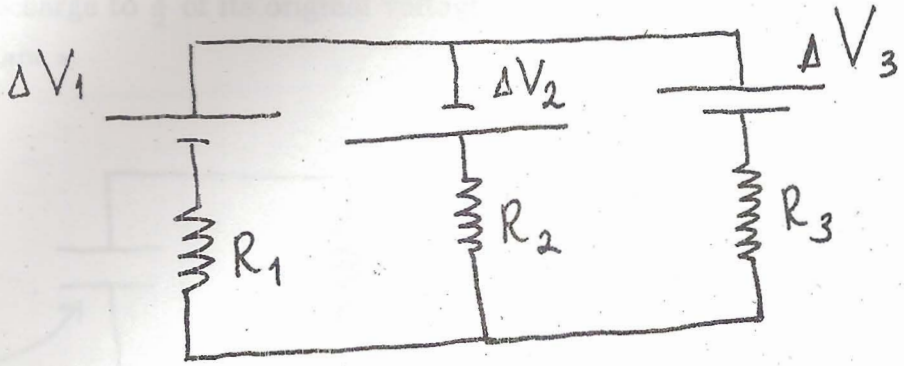


Figure 2.

Problem 3

The RC-circuit consists of the parallel plate capacitor C and the resistor R. (originally, the space between the plates is empty). Initially the capacitor has the voltage ΔV. Once the switch is on, it takes the time T for the capacitor to discharge to $\frac{1}{10}$ of its original voltage. The space between the plates of the capacitor is then fully filled with a dielectric with unknown constant κ and the capacitor is charged again to the same initial voltage ΔV. With the dielectric is introduced, it then takes the same time T for the capacitor to discharge to $\frac{1}{2}$ of its original voltage after the switch is turned on. Find the dielectric constant κ.

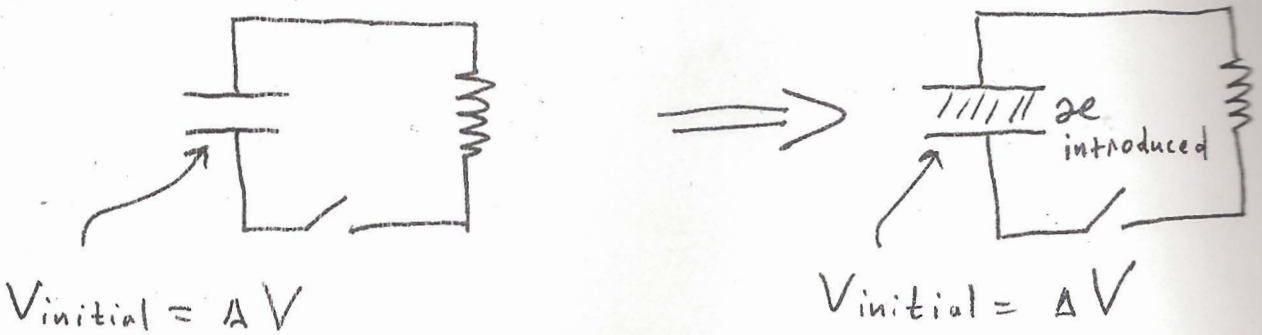


Figure 3

Problem 4

A part of an infinite straight conductor carrying the current I is deformed into a circular loop of the radius R, as shown on the Figure 4. Find the magnitude and the direction of the magnetic field at the center of the loop.

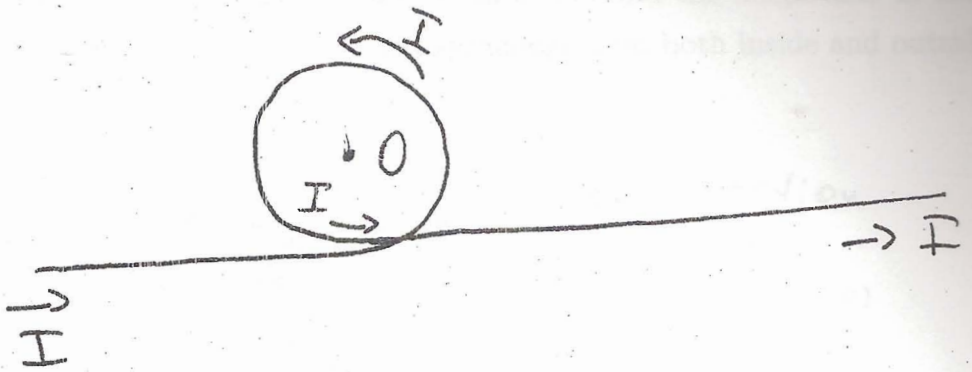


Figure 4

Problem 5

An infinite cylindrical conductor with the radius R carries a non-uniform, but cylindrically symmetric current density given by $j(r) = \alpha r^2$ where α is some given constant ant r is the distance to the symmetry axis of the conductor (note: j depends only on r but not on any angles) Find the direction and the magnitude of the magnetic field as a function of the distance to the symmetry axis, both inside and outside the conductor.

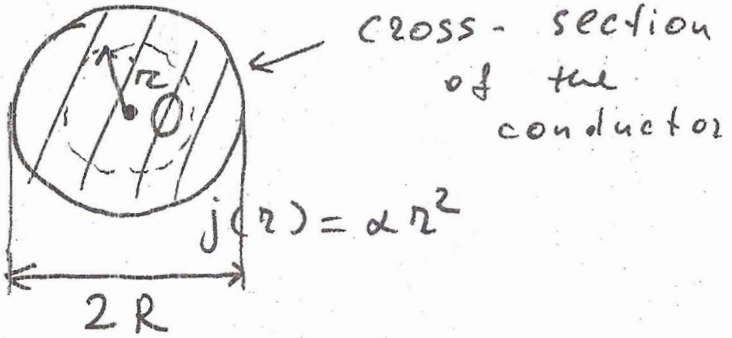


Figure 5

Problem 6

A rectangular frame of the with the sides a and b is moving with constant velocity v away from the infinite straight conductor with the current I, as shown on the Figure 6. The sides AB and CD are always parallel to the conductor.The total resistance of the frame is equal to R. Find the magnitude and direction of the induced current in the frame as the function of the distance r between the conductor and the side AB of the frame.

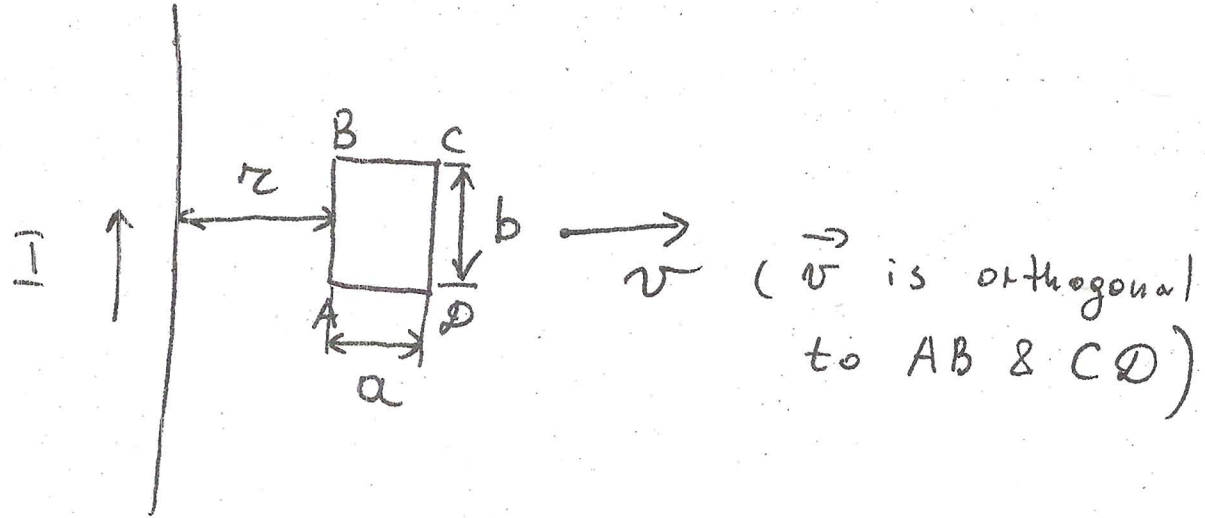
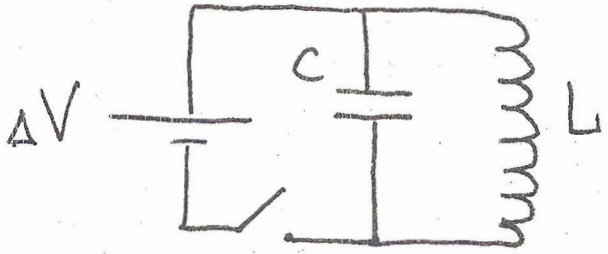


Figure 6

Problem 7

An inductor L and a capacitor C are connected through the switch S to the battery with the constant voltage ΔV, as shown on the Figure 7. switch is turned on at the moment $t = 0$ and is then turned off at the moment of time $t = t_0$ (t_0 is given). 1) Find the current in the inductor and the charge on the plates of the capacitor at $t = t_0$. 2)After the switch is disconnected ($t > t_0$) find the period of oscillations in the resulting LC-contour, the maximum value of the current in the coil and the maximum charge on the plates of the capacitor.

Figure 7



Problem 8

The alternating current source is connected in series to the resistor R, the inductor L and the capacitor C. The current leads the voltage by 60 degrees, the maximum value of the voltage is $10V$ and the power delivered to the circuit is equal to 50W. Find the values of the resistor R and of the difference $X_L - X_C$.

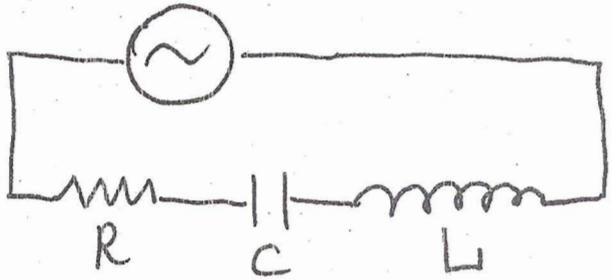


Figure 8