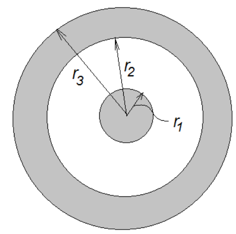
Physics C2802
Midterm Examination

Professor Christ
03/14/2013

Answer each of the following **three (3)** questions.

Please give a complete description of your method of solution since *partial credit* will be given.

1. A solid conducting sphere of radius r_1 is surrounded by a concentric conducting spherical shell of inner radius r_2 and outer radis r_3. The inner conducting sphere carries the charge Q while the conducting shell has no net charge.

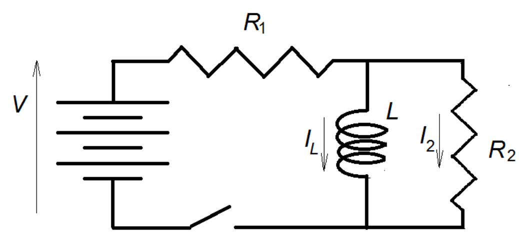


   (a) Find the electric field everywhere in space. [14 points]

   (b) Determine the charge distributions on the two conductors. [14 points]

   (c) Find the electrostatic potential of the inner conductor, assuming that the potential vanishes at infinity. [6 points]

2. Consider the circuit on the right composed of two resistors R_1 and R_2, an inductor L, a battery of voltage V with negligible internal resistance and a switch.

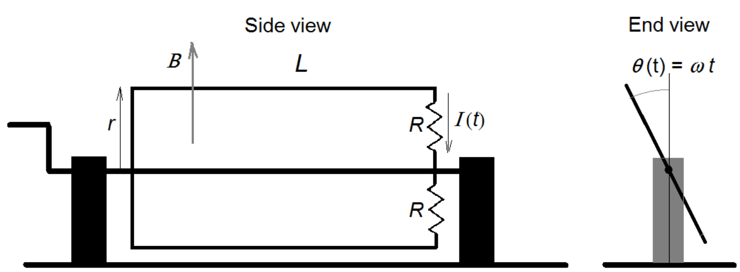


   (a) For $t < 0$ the switch is closed and the circuit is in a steady state. What are the currents I_L and I_2 flowing in the inductor and resistor? (Label these currents as positive if flowing in the direction of the arrows in the figure.) [5 points]

   (b) The switch is opened at $t = 0$ and remains open for all later time. Find the current $I_2(t)$ as a function of time. [23 points]

   (c) Sketch an approximate graph of your result for $I_2(t)$ versus t. [5 points]

3. A circuit formed from a conducting wire bent into a rectangle of side $2r$ and length l is fixed to an insulating rod with a crank at one end, free to rotate about its axis. The conducting rod is interrupted in two places by the insersion of a resistance R as shown in the figure.



There is a constant, uniform magnetic field $\vec{B}$ pointing in the vertical direction. The rectangular loop is turned at constant angular velocity ω starting at $t = 0$ in the vertical position.

   (a) Find the current $I(t)$ flowing through the loop. [12 points]

   (b) The moving charge (producing I) will experience a force from the magnetic field. Find the torque $\tau(t)$ that must be exerted on the crank to overcome this force and maintain the constant angular velocity ω. [12 points]

   (c) Find the instantaneous power $P(t)$ disappated in both resistors at the time t. [4 points]

   (d) Calculate the mechanical power that is must be provided to turn the crank. [3 points]

   (e) Is the power needed to turn the crank equal to that consumed in the resistors? [2 points]