Physics 31B 1st Midterm (200 pts Max.)
Fall 2004

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Show your works with diagrams, explanations, and clear writings. No credit will be given for answers without diagrams, explanations, and clear writings.

1. (a) Determine an expression for the instantaneous current density that exists when a time-varying current flowing along a gold rod, having a cross-sectional area of 2.00 mm^2, delivers charge according to the function $q = (4.00C/s^3)t^3 - (4.00C/s)t$. What is the current density, in amps per meter squared, at $t = 1.00$ s?

   (b) Consider a hollow spherical shell of resistive material having an inner radius of r_i, an outer radius of r_o, and a resistivity of ρ. Determine its resistance when a potential difference is applied between the inner and outer surfaces.

2. (a) A beam of electrons corresponding to a time-varying current $I(t) = (3.00A/s^2)t^2 - (2.00A/s)t+3.00$ A impacts on a detector. How much charge is delivered to the detector during the interval from t =1.00 s to t = 2.00 s?

   (b) A glass rod of length L lies along the positive x-axis with one end at $x = 0$. Given that it is charged positively in such a way that its linear charge density (i.e., charge per unit length) is $\lambda(x) = (30.0\mu C/m^3)x^2$, find the total charge on the rod.

3. (a) FiG. 1 depicts a narrow ring carrying a uniformly distributed net charge Q. Find the electric field it produces at a point P on the central axis an arbitrary distance x from the plane of the ring. Assume the medium is air.

   (b) Find the electric potential at P on the central axis of the ring-shaped charge distribution of net charge Q. See FiG. 1.

4. (a) A uniformly charged rod lies along the x-axis with one end at the origin and the other at $x = L$, as pictured in FiG. 2. It carries a total charge of $+Q$. Determine the electric potential at a point P on the y-axis at $y = h$.

   (b) What is the equivalent capacitance of the circult between the terminals A and B indicated in FiG. 3?

5. Use the Biot-Savart Law to determine the magnetic field at a point P anywhere on the central axis of a circular loop of wire of radius R carrying a counterclockwise current I.

6. (a) Find the values of R, V, and all the unknown branch currents in the network of FiG. 4. Given that $I_3 = 1.0$ A.

   (b) the R-C circuit in FiG. 5, which depicts a capacitor being charged, and derive an expression for $I(t)$. What is the initial value of the current, I_i, at $t = 0$?

7. (a) Given the circuit in FiG 6, calculate the current in each resistor. What power is delivered by the battery? What is the potential difference between A and C?

(b) FiG. 7 represents three light bulbs with resistances of 2.0 Ω, 4.0 Ω, and 8.0 Ω attached across a source with an emf of 6.0 V and an internal resistance of 1.0 Ω. Find the current through each bulb.

FiG. 1

FiG. 2

FiG. 3

FiG. 4

FiG. 5

FiG. 6

FiG. 7