EXAM 2 (100 Points, Show All Work)

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Phy 7B
8-6-02

8 Points

1. The current in an electromagnet connected to a 240 V line is 14.5 A. At what rate must cooling water pass over the coils if the water temperature is to rise by no more than 6.5° C?

12 Points Each

2. A copper rod if length, r, rotates at constant angular frequency, ω, in a uniform magnetic field, $\vec{B}$, as shown in Figure 1. Derive the emf, $\mathcal{E}$, developed between the two ends of the rotating rod.

3. The capacitor shown in Figure 2 is initially uncharged. Find the current through the battery
   a) Immediately after the switch is closed.
   b) A long time after the switch is closed.

4. Determine the net resistance of the network shown in Figure 3 between points a and c. Assume that R' = R. Hint: Use symmetry.

5. Starting with the result below for the magnetic field along the axis of a single loop, derive the magnetic field inside a very long solenoid. Please don't use Ampere's law. $dB = \frac{\mu_0 n I}{2} dx \frac{R^2}{(R^2+x^2)^{3/2}}$ (radius R)

6. A smooth conducting sphere of radius r_o carries a charge Q. Half of the energy stored in its electric field is contained in a volume of what radius?

7. Find the direction of the following, as shown in Figure 4:
   a) What direction is the force on a long current carrying wire to right if $\vec{B}$ is out of page?
   b) What direction is the magnetic field if a negative charge is moving down and force to left?
   c) What direction is the magnetic field at a point to the right of the wire and in the plane of the page due to a long current carrying wire with a current direction up the page?

20 Points

8. A coaxial cable consists of a solid inner conductor of radius R_1, surrounded by a concentric cylindrical tube of inner radius R_2 and outer radius R_3. The conductors carry equal and opposite currents I_o, but the current density j varies linearly with distance from the center: $j_1 = c_1 r$ (inner conductor) and $j_2 = c_2 r$ (outer conductor). Determine the magnetic field for:
   a) $r < R_1$
   b) $R_1 < r < R_2$
   c) $R_2 < r < R_3$
   d) $r > R_3$

Figure 1

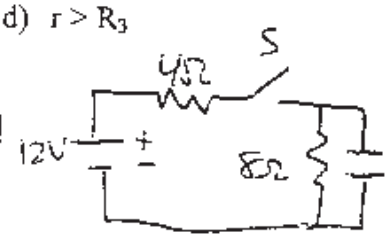


Figure 2

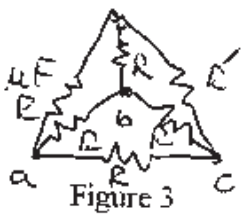
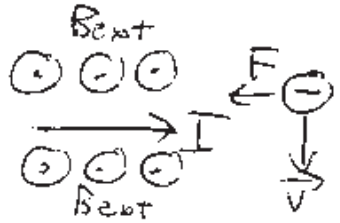
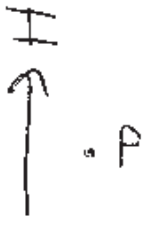


Figure 3



4a) 4b)



4c)

Figure 4

Possibly Useful Constants

$k = 9 \times 10^9\ Nm^2/C^2$ $\mu_o = 4\pi \times 10^{-7}\ Tm/A$ $\varepsilon_o = 8.85 \times 10^{-12}\ C^2/Nm^2$ $c_{water} = 4186\ J/Kg\text{-}$