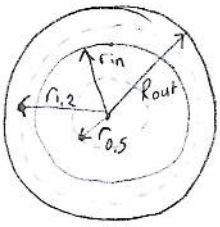
PHY 1304 Test #2 Oct. 16, 2008 Name: KEY

[Note: Please choose one of the two 12 pt problems, and three of the four 10 pt problems.]

1) A thick conducting cylinder has a uniform total current of 10 A, an inner radius of 1 cm and an outer radius of 1.5 cm. What is the magnetic field at a radius of 1.2 cm? What is it at 0.5 cm? Draw each Ampere's path and explain your answers. [12 pts]



$\oint B \cdot d\vec{s} = \mu_0 I_{in}$

a) $B \cdot 2\pi r_{1.2} = \mu_0 \cdot \frac{I}{\pi (R_{out}^2 - R_{in}^2)} \cdot \pi (r_{1.2}^2 - R_{in}^2) \Rightarrow B = \frac{\mu_0 I}{2\pi r_{1.2}} \cdot \left(\frac{r_{1.2}^2 - R_{in}^2}{R_{out}^2 - R_{in}^2} \right)$

$B = \frac{(4\pi \times 10^{-7}) \cdot 10}{2\pi (0.012)} \cdot \left(\frac{0.012^2 - 0.01^2}{0.015^2 - 0.01^2} \right) \Rightarrow \boxed{B = 5.87 \times 10^{-5}\ T}$

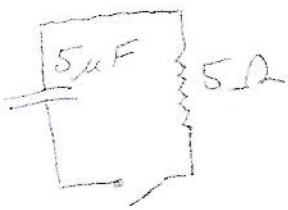
b) $I_{in} = 0 \Rightarrow \boxed{B = 0}$

2) An emf of 12 V is placed across a 5 ohm resistor. What is the power consumption of the resistor? What current flows thru the circuit? [10 pts]

$P = \frac{V^2}{R} = \frac{12^2}{5} \Rightarrow \boxed{P = 28.8\ W}$

$I = \frac{V}{R} = \frac{12}{5} \Rightarrow \boxed{I = 2.4\ A}$

3) A capacitor is fully charged to a capacitance of 5×10^{-6} F. This is placed in a series circuit with a 5 ohm resistor and a switch, as shown. The switch is closed at t=0s. At what time will the current in the circuit be 1% of its initial value? [10 pts]



$I(t) = I_0 e^{-t/RC}$

$0.01 I_0 = I_0 e^{-t/RC}$

$0.01 = e^{-t/RC}$

$t = -RC \ln(0.01) \Rightarrow t = -5 \cdot (5 \times 10^{-6}) \cdot \ln(0.01)$

$\boxed{t = 1.15 \times 10^{-4}\ s}$

4) A pair of conducting square plates are spaced 10 microns (10^{-6} m) apart to form a capacitor. If the plates are 200 microns long on a side, what is the resulting capacitor's capacitance? [10 pts]

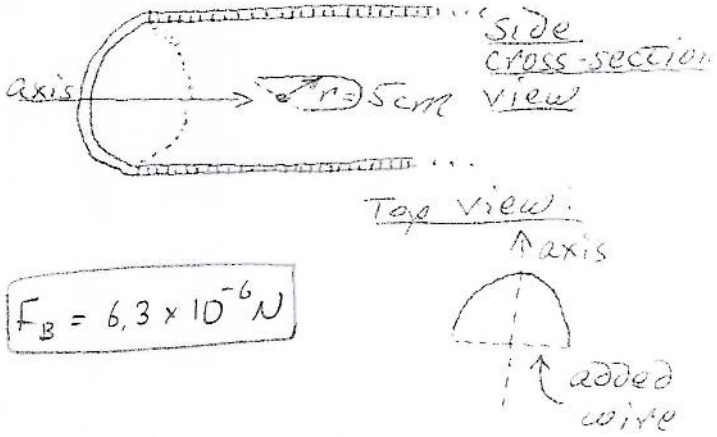
$$C = \frac{\varepsilon_0 A}{d} = \frac{(8.85\times10^{-12})\,(200\times10^{-6})^2}{10\times10^{-6}}$$

$$\boxed{C = 3.54\times10^{-14}\ F}$$

5) A solenoid has a current of 1 A. There are 10^4 turns over the solenoid's 1m length. What is the magnetic field inside the solenoid? A semicircular segment of wire is placed in the magnetic field so that it is aligned along the axis of the solenoid as shown. If there is a current of 5 mA in the wire and the semicircle's radius is 5 cm, what force is exerted on the wire? If a wire joins the ends of the semicircle, then what is the net force? [12 pts]

$$B = \mu_0 \frac{N}{L} I = (4\pi\times10^{-7})\cdot\frac{10^4}{1}\cdot 1$$

$$\boxed{B = 1.26\times10^{-2}\ T}$$

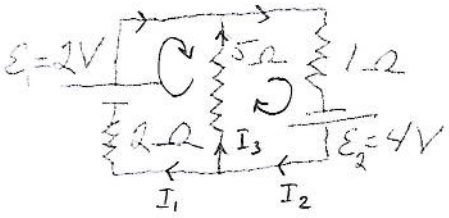


$$F_B = I L \times B = I L_\perp B = I\cdot 2R\cdot B$$
$$= (5\times10^{-3})\cdot(2\times0.05)\cdot(1.26\times10^{-2}) \Rightarrow \boxed{F_B = 6.3\times10^{-6}\ N}$$

If a wire joins the ends of semicircle:

$F_{B\,net} = 0$ since the wire becomes a closed loop.

6) The circuit below has two sources of emf and three resistors. What are the currents thru the 1 ohm, 2 ohm and 5 ohm resistors? [10 pts]



$$I_1 + I_3 = I_2$$
$$\varepsilon_1 + 5I_3 - 2I_1 = 0$$
$$\varepsilon_2 - 5I_3 - 1I_2 = 0$$

} 3 equations, 3 unknowns

When these three eqns are solved:

$$\boxed{I_1\,(\text{on } 2\Omega) = 1.88\ A\ ,\quad I_2\,(\text{on } 1\Omega) = 2.24\ A\ ,\quad I_3\,(\text{on } 5\Omega) = 0.35\ A}$$