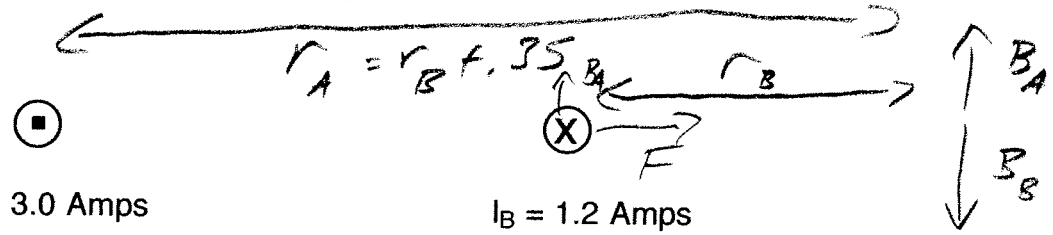
Physics 10164 - Exam #2A

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box. If you give more than one answer without indicating which is correct, you will definitely lose points, even if one answer is correct.

1. (40 pts) Two wires passing through the x-axis are shown below, separated by 35 cm. The magnitudes and directions of the currents in each wire are indicated in the diagram. Wire A passes through the origin.

a) At what x-coordinate is the net magnetic field due to these two wires equal to zero?

b) What is the magnitude and direction of the force per meter that wire B feels due to the magnetic field of wire A?



a) $|\vec{B}_A| = |\vec{B}_B|$

$$\frac{\mu_0 I_A}{2\pi(r_B + .35)} = \frac{\mu_0 I_B}{2\pi r_B} \Rightarrow \frac{3}{r_B + .35} = \frac{1.2}{r_B}$$

$$3r_B = 1.2r_B + .42$$

$$r_B = \frac{.42}{1.8} = 0.23$$

so $\boxed{x = .58}$

b) F on wire B points +x due to rt hand force rule

$$\frac{|F|}{l} = \frac{I_B \mu_0 I_A}{2\pi r} = \frac{(2\times 10^{-7})(3)(1.2)}{(.35)}$$

$$= \boxed{2.1 \times 10^{-6}\ N,\ +x}$$

2. (30 pts) An RC circuit contains a 12 Volt battery and a 7500 Ohm resistor. At t=0, a switch is closed to start current flowing. The capacitor is initially uncharged. After 0.25 seconds, the voltage drop across the resistor is 3.0 Volts.

a) What is the capacitance of the capacitor?

b) At this time, what is the charge on the capacitor, expressed as a percentage of the maximum charge? In other words $100*Q/Q_{max}$.

a) If $\Delta V_R = IR = 3.0$ Volts

and $\Delta V_{R,MAX} = I_{max} R = 12$ Volts,

then $I = 0.25\, I_{max}$

$$0.25\, I_{max} = I_{max} e^{-t/\tau}$$

$$0.25 = e^{-t/\tau}$$

$$-1.386 = -\frac{t}{\tau} \Rightarrow \tau = 0.18$$

$$C = \frac{0.18}{7500} = \boxed{2.4 \times 10^{-5}\ F}$$

b) If $\Delta V_R = 3.0$ Volts,

then $\Delta V_C = 9.0$ Volts

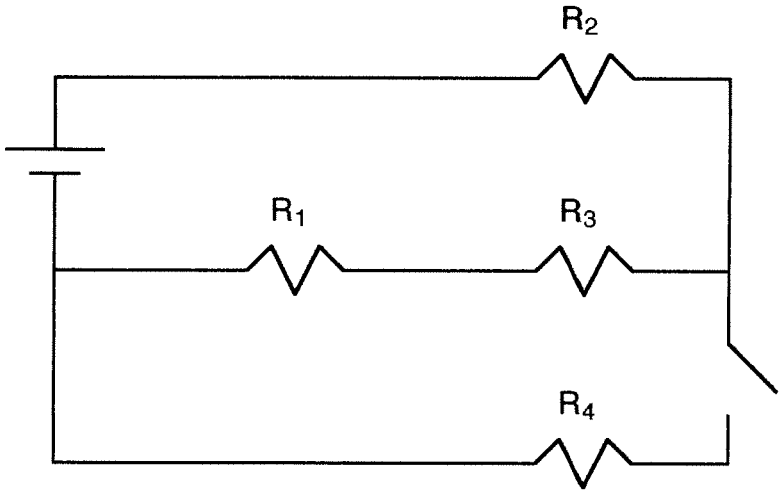
$$\frac{Q}{C} = 9.0 \text{ Volts and } \frac{Q_{max}}{C} = 12 \text{ Volts}$$

so $Q = 0.75\, Q_{max}$ or $\boxed{75\%}$

3. (30 pts) In the circuit below, the battery has a voltage of 12 V. R_1 = 1.0 Ohms, R_2 = 2.0 Ohms, R_3 = 3.0 Ohms, R_4 = 4.0 Ohms.

a) When the switch is closed, what is the power dissipated by the resistor R_2?

b) When the switch is opened, does the power dissipated by R_2 increase, decrease or stay the same? Justify your answer either mathematically or with an explanation.

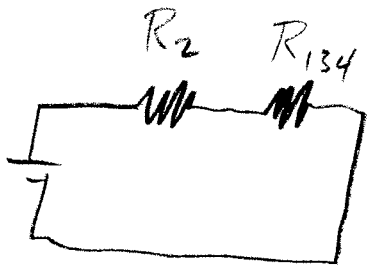


$R_1 + R_3 = 4.0\,\Omega$

If S closed

R_{13} is parallel to R_4

$$\frac{1}{R_{134}} = \frac{1}{4} + \frac{1}{4} = \frac{1}{2}$$



$R_{TOT} = R_2 + R_{134} = 4.0\,\Omega$

$I_{TOT} = \frac{12}{4} = 3.0\,A$

a) $I_2 = I_{TOT}$, so $P_2 = I_2^2 R_2 = (3)^2(2)$

$= \boxed{18\ W}$

b) If S opens R_{TOT} becomes $R_2 + R_3 + R_1 = 6.0\,\Omega$

so I_{TOT} decreases to 2.0 A

and $\boxed{P_2 \text{ decreases}}$ to 8 W