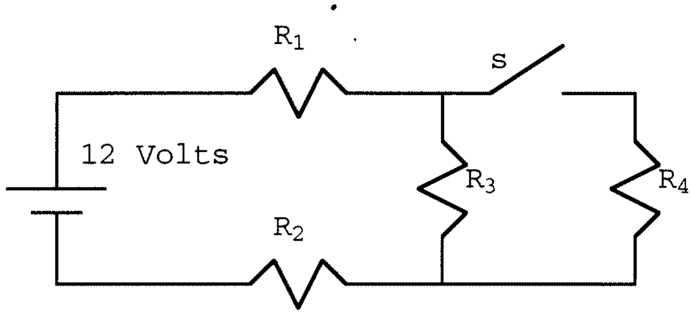
Physics 10164 - Exam 2

Each problem is worth 25 points. 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 of a box and remember to include correct units and significant figures.

1. In the circuit below, R_1 = 1.0 Ohms, R_2 = 2.0 Ohms, R_3 = 3.0 Ohms, R_4 = 4.0 Ohms.

a) Find the power dissipated by R_3 when the switch S is closed.

b) When the switch S is opened, does the power dissipated by R_3 increase, decrease or remain the same? Justify your answer either with a discussion or mathematical support.



$$\frac{1}{R_{34}} = \frac{1}{3} + \frac{1}{4}$$

$$R_{34} = \frac{12}{7} = 1.71\,\Omega$$

$$R_{1234} = 1.0 + 1.71 + 2.0 = 4.71\,\Omega$$

$$I_{1234} = \frac{12}{4.71} = 2.55\,A$$

Thus, $I_{34} = 2.55\,A$

and $\Delta V_{34} = (2.55)(1.71) = 4.35\,V$

Thus, $I_3 = \frac{\Delta V_3}{R_3} = \frac{4.35\,V}{3} = 1.45\,A$

$$P_3 = (1.45)^2(3) = \boxed{6.3\,W}$$

S open: $R_{TOT} = 6\,\Omega$, $I_{TOT} = \frac{12}{6} = 2\,A$

$P = (2)^2(3) = \boxed{12\,W}$ increases

2. A circuit contains a 12 Volt battery, a 350 Ohm resistor and a 68 μF capacitor, initially uncharged. The circuit is closed at time t = 0.

a) What is the voltage drop across the capacitor at a time 1.5 time constants after the circuit is closed?

b) After how much time (in seconds) is the charge on the capacitor equal to 95% of its maximum value?

a) $\Delta V_c = \frac{Q}{C} = \mathcal{E}(1 - e^{-1.5})$

$= 12(1 - 0.223)$

$= \boxed{9.3\ V}$

b) $0.95 = (1 - e^{-t/\tau})$

$-0.05 = -e^{-t/\tau}$

$2.995 = t/\tau$

$t = 2.995\tau$

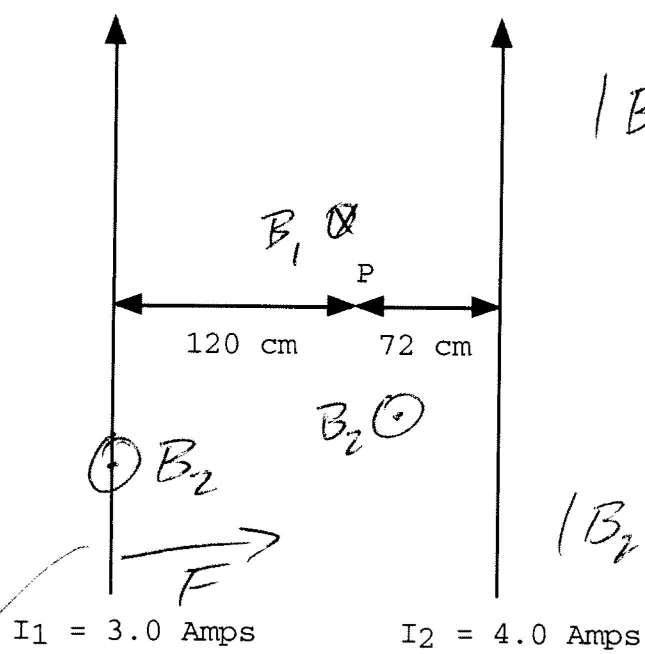
$\tau = RC = (350)(68 \times 10^{-6}) = .0238$

$\boxed{t = 0.071\ s}$

3. Two wires carry currents as shown below.

a) What is the magnitude and direction of the magnetic field at point P?

b) What is the force per unit length felt by wire 1 as a result of the magnetic field of wire 2? Give magnitude and direction.



$$|B_1| = \frac{\mu_0 I_1}{2\pi r_1}$$

$$= \frac{(2\times10^{-7})(3)}{1.2}$$

$$= 5\times10^{-7} \otimes$$

$$|B_2| = \frac{(2\times10^{-7})(4)}{.72}$$

$$= 11.1\times10^{-7} \odot$$

$$B_{net} = 11.1\times10^{-7} - 5.0\times10^{-7}$$

$$= \boxed{6.1\times10^{-7} \odot}$$

$$\frac{F}{l} = \frac{\mu_0 I_1 I_2}{2\pi(1.92)} = \frac{(2\times10^{-7})(3)(4)}{1.92}$$

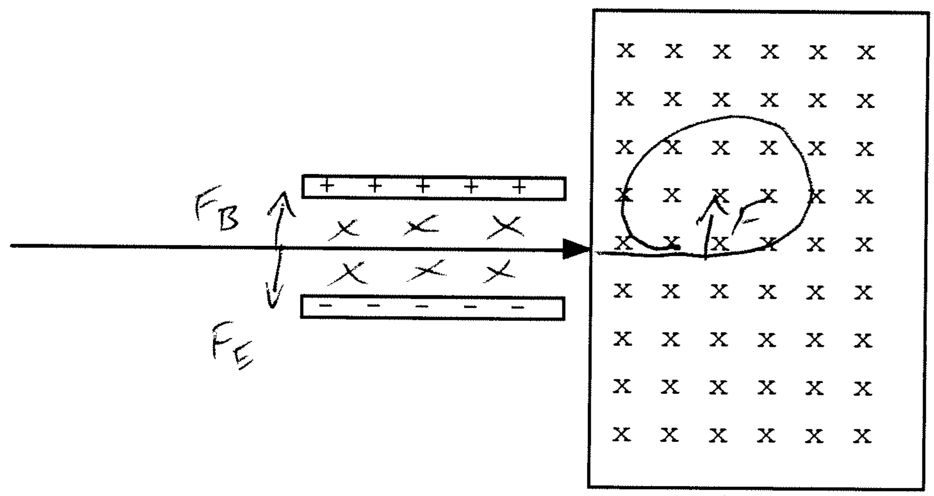
$$= \boxed{12.5\times10^{-7} \quad +x \text{ dir}}$$

RHR

4. A proton starts from rest and is accelerated through a potential of 120 Volts. After this, it moves at a constant velocity and passes through two metal plates of equal and opposite charge density with an electric field between them of 670 Volts/meter pointing down.

a) What is the magnitude and direction of the magnetic field required to keep the proton flying in a straight path once it enters the region between the plates?

b) After it exits the plates, the electric field is gone, but it enters a device with a uniform magnetic field of 0.78 Tesla pointing into the page. Sketch the direction of travel of the proton and determine the radius of its circular path.



a) $q\Delta V = \frac{1}{2}mv^2$ $\quad v = \sqrt{\frac{2q\Delta V}{m}}$

$= \sqrt{\frac{2(1.60\times10^{-19})(120)}{1.67\times10^{-27}}}$

$= 1.5\times10^5$

F_B must be ↑ since F_E ↓, so

$\vec{B}$ must point ⊗

$v = \frac{E}{B}$ $\quad B = \frac{E}{v} = \frac{670}{1.5\times10^5} = 4.5\times10^{-3}\,T$

b) $r = \frac{mv}{qB} = \frac{(1.67\times10^{-27})(1.5\times10^5)}{(1.60\times10^{-19})(0.78)} = 2.0\times10^{-3}\,m$

2.0 mm