Physics 172
Winter Quarter 1988
March 15, 1988
George Williams

1

FINAL EXAM

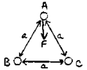
Name (print) Williams Name (signed) Av = 10.55 / 30

Discussion Instructor (circle one): Cady McAllister Molina Stone

Discussion Section #: ________

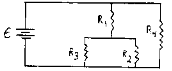
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.
Five points each. Circle your answer.

(a) In the drawing shown, three long, straight wires are perpendicular to the paper. If they each have a current of 5.00 A out of the paper and a is 2.00 cm, calculate the magnitude of the force per unit length on wire A.



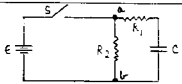
4.33×10^{-4} N/m vertically down

(b) If ϵ = 150 V, and all the resistors are 375 Ω, calculate the current through R_2.



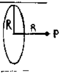
0.1333 A

(c) If the switch in the drawing is closed for 25.0 s and then opened, calculate the current in R_2 35.0 s after it is opened. R_1 = 150,000 Ω, R_2 = 250,000 Ω, C = 375 μF, ϵ = 200 V



1.421×10^{-4} A

(d) Calculate the magnitude of themagnetic field at point P due to a single loop of wire of radius R = 4.75 cm, carrying a current of 375 A. P is a distance R = 4.75 cm from the plane of the loop along a line perpendicular to the loop and through its center.

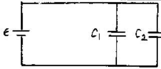


1.754×10^{-3} T

(e) An electron moving in a plane parallel to the earth's surface moves in a circle of radius 0.0736 m. If the earth's field is 4.00×10^{-5} T, at an angle of 90.0° from the horizontal at this point on the earth, calculate the velocity of the electron.

5.17×10^{5} m/s

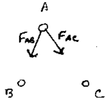
(f) The combination of C_1 and C_2 is charged to 125 volts with a battery. The battery is now removed, and dielectric of κ = 4.30 is inserted in C_2. Calculate the new potential difference. C_1 = 4.75 pF, C_2 = 1.25 pF



74.1 V

1.

(a) Most of the class forgot that force is a vector. Many did not know the direction of the force between wires. The force is along the line between the wires.



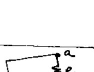
$\vec{F}$ on A due to B = $F_{AB} = \frac{\mu_0 I^2}{2\pi a}$

$\vec{F}$ on A due to C = $F_{AC} = \frac{\mu_0 I_2}{2\pi a}$

x components cancel.

$$F_y = 2\left(\frac{\mu_0 I^2}{2\pi a}\right)\cos 30^\circ = 4.33\times 10^{-4} N/m$$

(b) R_4 does not enter the solution at all, because its presence does not affect the potential between a and b.



Total current between a and b is $\mathcal{E}$

$$I_{ab} = \frac{\mathcal{E}}{R_1 + R_{23\parallel}} \qquad \frac{1}{R_{23\parallel}} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$= \frac{150}{375 + \frac{1}{2}(375)} = 0.2667\ A$$

Since $R_2 = R_3$, the current divides equally.

$$I_2 = \tfrac{1}{2}(0.2667) = 0.1333\ A$$

(c.) Note that with the switch closed R_2 is in parallel with $R_1 - C$. The battery is directly across the $R_1 - C$ branch, so the charging time constant is $R_1C = (1.5\times10^5)(375\times10^{-6}) = 56.25s$

$$V(\text{on } C) = V_\infty\left(1 - e^{-t/\tau}\right)$$
$$= 200\left(1 - e^{-25.0/56.25}\right) = 71.76V$$

When the switch is open the discharge time constant is $(R_1+R_2)C = 150s$

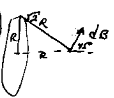
The cap behaves like a battery.

$$I = \frac{V_c}{R_1+R_2}e^{-35/150} = \frac{71.76}{4.00\times10^5}(0.7919) = 1.421\times10^{-4} A$$

This is not zero, since we are not at more than 5 time constants.

(d) If you did not have a formula on your card, you needed to use Biot-Savart to calculate it.

$$dB = \frac{\mu_0 I}{4\pi}\frac{ds}{(\sqrt{2}R)^2}\sin 90^\circ$$ (The line from ds to the measurement point is $\perp$ to the loop.)



Only the x component does not go to zero.

$$B_x = \frac{\mu_0 I}{4\pi}\frac{\cos 45^\circ}{2R^2}\int ds \quad \text{but} \quad \int ds = 2\pi R$$

$$= \frac{\mu_0 I}{4\pi}\frac{1}{\sqrt{2}}\frac{1}{2R^2}2\pi R = \frac{\mu_0 I}{R}\cdot\frac{1}{2}\cdot\frac{1}{\sqrt{2}}\cdot\frac{1}{2}$$

$$= \frac{(4\pi\times10^{-7})(375)}{(4.75\times10^{-2}\,m)}\cdot\frac{1}{4\sqrt{2}}$$

$$\boxed{B_x = 1.754\times10^{-3}\,T}$$

(e)

$$\frac{evB}{m} = \frac{v^2}{R} \qquad v = \frac{eBR}{m}$$

$$= \frac{(1.6\times10^{-19}\,C)(4.00\times10^{-5}\,T)(0.0736)}{9.11\times10^{-31}\,kg}$$

$$\boxed{|v| = 5.17\times10^{5}\,m/s}$$

(f) Original charge $Q_0 = \mathcal{E}(C_1 + C_2)$

Same charge, new effective capacitance (since $C = \frac{Q}{V}$ ALWAYS)

$$Q_0 = V_{New}(C_1 + \kappa C_2)$$

$$V_{New} = \frac{\mathcal{E}(C_1 + C_2)}{C_1 + \kappa C_2} = 125\,\frac{(4.75 + 1.25)\times10^{-12}}{(4.75 + 4.30(1.25))\times10^{-12}}$$

$$= 125\,V\,\frac{6.00}{10.125}$$

$$\boxed{V_{New} = 74.1\,V}$$