University of Bahrain
College of Science
Dept. of Physics

PHYCS 102
FINAL EXAM

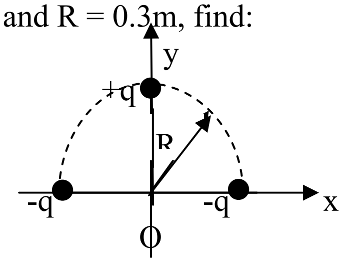
Date: 15/1/2001 **Time:Two Hours**

Name:--ID#--------------------- Section:----------------

Q1. For the set of three charges shown below, q = 10μC and R = 0.3m, find:

a) The electric field at the center (O).

b) The electric potential at the center (O).



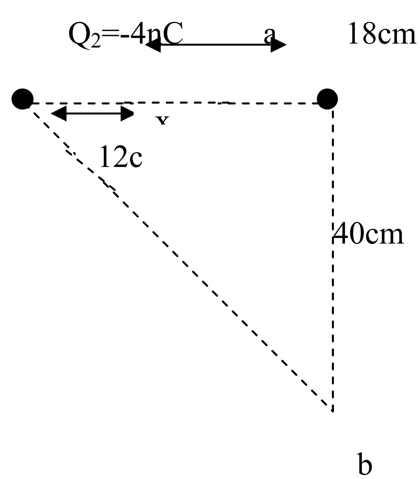
a. $E_x = 0, \quad E_y = (-)K\dfrac{q}{R^2} = -10^6\, N/C$

b. $V = -K\dfrac{q}{R} - K\dfrac{q}{R} + K\dfrac{q}{R} = -K\dfrac{q}{R} = -3 \text{ x } 10^5\ \text{V}$

Q2. In the figure shown below, two point charges, Q_1 = +6.0 nC and Q_2 = -4.0 nC, are separated by 30.0 cm.

a) What is the potential energy of the pair?
Q_1=+6nC

b) What is the electric potential difference V_{ab}?



a. $U = K\dfrac{Q_1Q_2}{0.3} = -7.2 \text{ x } 10^{-7}\ J$

b. $V_a = K\left\{\dfrac{6 \text{ x } 10^{-9}}{0.18} - \dfrac{4 \text{ x } 10^{-9}}{0.12}\right\} = 0$

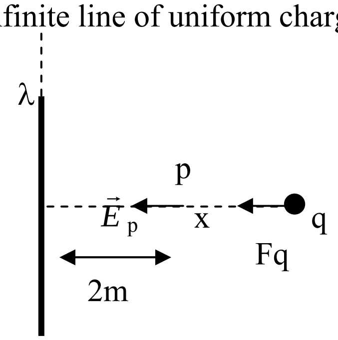
$V_b = K\left\{\dfrac{6 \text{ x } 10^{-9}}{0.4} - \dfrac{4 \text{ x } 10^{-9}}{0.5}\right\} = +63\text{V}$

$V_a - V_b = -63\text{V}.$

Q3. A point charge q = +9 μC is located 4m from an infinite line of uniform charge per unit length λ = -7 μC/m. Find:

a) The electric field at point "p".

b) The electric force on charge q.



a. $E_p = \dfrac{\lambda}{2\pi\varepsilon_o(2)} + K\dfrac{q}{2^2}$

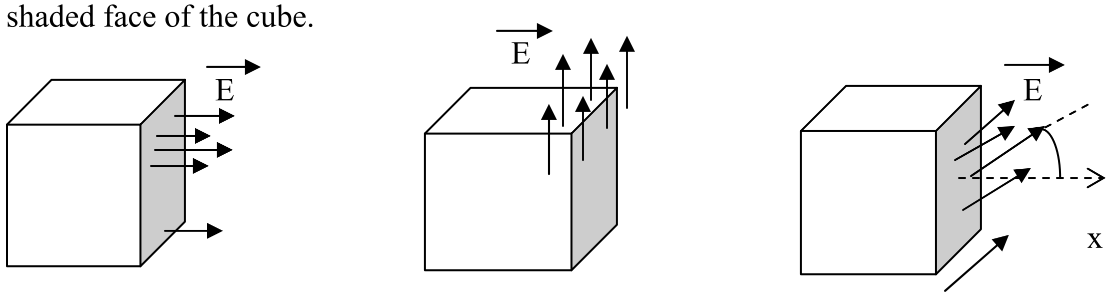
$= 83.2 \text{ x } 10^3$ N/C (⟵)

b. $F_q = Eq = \dfrac{\lambda}{2\pi\varepsilon_o(4)} \cdot q$

$= 0.28$ N (attraction ⟵)

Q4. In the figure shown below, if the magnitude of $\vec{E}$ is $2 \text{ x } 10^4$ N/C and the cube has a side of a = 0.1m, in each of the following cases determine the electric flux through the shaded face of the cube.

37^o



(1) ($\vec{E}$ is to the right) (2) ($\vec{E}$ is upwards) (3) ($\vec{E}$ at an angle of 37^o)

i. $\Phi = EA$

$= 200 \dfrac{N.m^2}{C}$

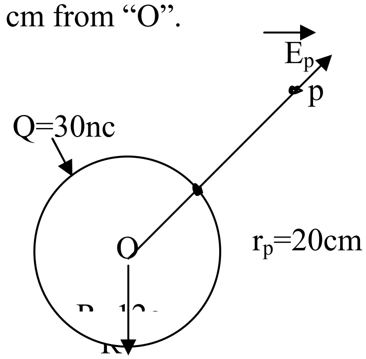
ii. $\Phi = 0$

$\theta = \dfrac{\pi}{2}$

iii. $\Phi = EA\cos 37^o$

$= 159.72 \dfrac{N.m^2}{C}$

Q5. A spherical conductor has a radius of 12cm and charge of 30nC.
Calculate :
a) The electric field at center "O" and at point "p" 20 cm from "O".
b) The potential difference V_{op}.



a. $E_o = 0$, $E_p = k\dfrac{30 \text{ x } 10^{-9}}{(0.2)^2} = 6.75 \text{ x } 10^3 \dfrac{N}{C}$

b. $V_{op} - V_{bp} = K\dfrac{Q}{R} - K\dfrac{Q}{r_p}$

$= 900$ V

Q6. An air-filled capacitor consists of two parallel plates, each with an area of 7.5 cm^2, separated by a distance of 1.6 mm. The capacitor is charged to a potential difference of 100 volt, then is removed from the source.

a) Calculate the electric field between the plates.

b) If the plates were pulled apart such that their separation becomes 3.2 mm, what would be the voltage across the plates?

c) The space between the plates of capacitor (in part a) is filled with a dielectric substance of dielectric constant K = 2.5. What is the voltage across the plates?

a.

$$E = \frac{V}{d} = \frac{100}{1.6 \text{ x } 10^{-3}} = 62.5K \text{ V}/m$$

b.

$$Q_i = Q_f ,\ C_i V_i = C_f V_f ,\ \frac{\varepsilon_o A}{d_i} V_i = \frac{\varepsilon_o A}{d_f} V_f$$

$$V_f = \frac{d_f}{d_i} V_i = 2V_i = 200\text{V}$$

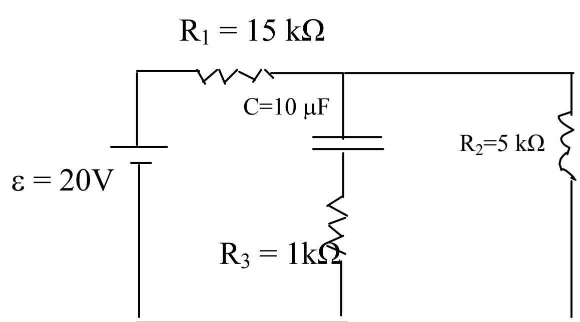
c.

$$Q_i = Q_f ,\ \frac{\varepsilon_o A}{d} V_i = \frac{\varepsilon_o AK}{d} V_f ,\ V_f = \frac{V_i}{K} = 40\text{V}$$

Q7. In the circuit shown, find:

a) The currents in R_1, R_2 and R_3.

b) The charge on capacitor C.



a.

$$I = \frac{20}{20 \text{ x } 10^3} = 1\ mA$$

$$I_{R_1} = I_{R_2} = 1\ mA,\ I_{R_3} = 0$$

b.

$$V_c = V_{R_2} = IR_2 = 5\text{V},\ Q = CV_c = 50\ \mu C$$

Q8. A copper wire of 2m in length has a cross section area 2.5 $(mm)^2$ carries a current of 5A. The density of free electrons is $2.8 \times 10^{29}\ m^{-3}$. Compute:

a) The drift velocity of the electrons.

b) The potential drop along the wire. Use $\rho = 1.72 \times 10^{-8}\ \Omega.m$.

a. $$v = \frac{J}{ne} = \frac{5/2.5 \times 10^{-6}}{2.8 \times 10^{29} \times 1.6 \times 10^{-19}} = 4.46 \times 10^{-5} m/s$$

b. $$R = \frac{\rho L}{A} = 1.376 \times 10^{-2}\Omega,\ \text{V} = IR = 6.88 \times 10^{-2}\ \text{V}$$

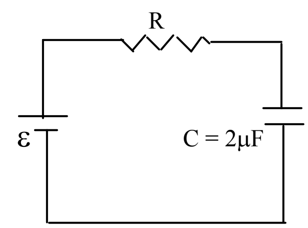
or

$$\text{V} = EL = \rho J\ L = 1.72 \times 10^{-8} \times \frac{5}{2.5 \times 10^{-6}} \times 2 = 6.88 \times 10^{-2}\ \text{V}$$

Q9. In the circuit shown, the current was found to vary according to the following relation where I is in μA: $I(t) = 20\ e^{-t/10}$ (μA).
If C = 2μF, find:

a) The values of ε and R

b) The charges that passes through the circuit during 20s.

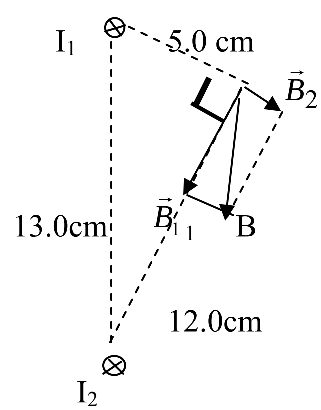


a. $$I = \frac{\varepsilon}{R}\ e^{-t/RC}$$

RC = 10S ∴ R = 5MΩ

b. $$Q = \int_{O}^{20S} Idt = 20 \times 10^{-6} \int_{o}^{20S} e^{-t/10}dt = 200 \times 10^{-6} \left[e^{-t/10}\right]_{20}^{0} = 172.93\ \mu C$$

Q10. Two long, parallel wires carry currents I_1 = 3.0A and I_2 = 3.0A, both directed into the figure given below. Determine the magnitude of the resultant magnetic field at point "p".



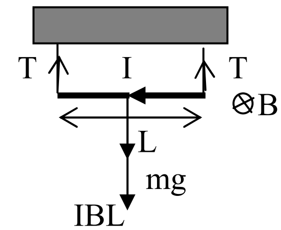
$$B_1 = \frac{\mu_o I_1}{2\pi(0.05)} = 120 \times 10^{-7}\ T$$

$$B_2 = \frac{\mu_o I_2}{2\pi(0.12)} = 50 \times 10^{-7}\ T$$

$$B = \sqrt{B_1^2 + B_2^2} = 130 \times 10^{-7}\ T$$

Q11. A wire (mass = 50g, length = 40 cm) is suspended horizontally by two vertical wires which conduct a current I =8A as shown in the figure below. The magnetic field in the region is into the paper and has a magnitude of 60 mT. What is the tension (in N) in both wires?

2T = mg + IBL
T = 0.346 N



Q12. An electron with kinetic energy 1.92 x 10^{-16}j circles in a plane perpendicular to a uniform magnetic field. The orbit radius is 25 cm. Find:

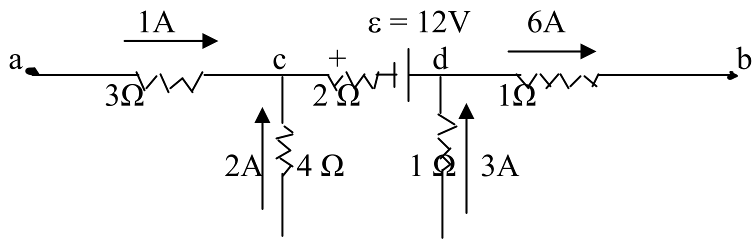
a) The magnetic field B.
b) The frequency of circling.

a. $K = \frac{1}{2} m v^2$, $v = \sqrt{2K/m} = 2.05 \text{ x } 10^7 \ m/s$

$$B = \frac{mv}{qr} = 4.67 \ x\, 10^{-4} \ T$$

b. $\omega = 2\pi f = \frac{v}{r}$, $f = \frac{v}{2\pi r} = 1.31 \text{ x } 10^7 \ HZ$

Q13. A portion of a complete electric circuit is shown in this diagram. The current in some resistors are given, current in others must be found. What is the potential difference between points (a) and (b).



$V_{ac} = 3\text{V}$, $V_{db} = 1 \text{ x } 6 = 6\text{V}$, $V_{cd} = 3 \text{x} 2 - (12) = -6\text{V}$

$\therefore V_{ab} = V_{ac} + V_{cd} + V_{db} = 3\text{V}$

Q14. A solenoid 3.55 cm in diameter and 1.23m in length has 850 turns and carries a current of 4.6A. Find:

a) The magnetic field at its center.

b) The average magnetic flux through its cross section.

a. $B = \mu_o nI = 4\pi \text{ x } 10^{-7} \dfrac{850}{1.23} 4.6 = 4mT$

b. $\Phi = BA = (4 \text{x} 10^{-3}) \left[\pi(3.55/2)^2 \text{ x } 10^{-4}\right] = 39.6 \text{x} 10^{-7} Wb$

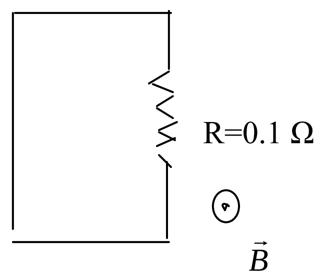
Q15. A rectangular conduction loop of area A = 0.02 m^2 and resistance R = 0.1 Ω. A time varying magnetic field in a direction perpendicular to the plane of the loop is given by the equation:

$$B(t) = 0.2 \cos(100\pi t) \qquad (T)$$

Find:

a) The induced emf in the loop as a function of time.

b) The maximum value and direction of induced current in the loop.



a. $\Phi = BA = 0.004 \cos(100\pi t)$

$\varepsilon_i = -\dfrac{d\Phi}{dt} = (0.004)\ (100\pi)\ Sin\ (100\pi t)$

$= 1.25 \sin(100\pi t)$ V

b. $I_i = \dfrac{\varepsilon_i}{R} = 12.5 \sin(100\pi t)\ A$

$I_{max} = 12.5A$

Induced current is alternative (A.C)

Use the following terms:

$K = 9\text{x}10^9\ N.m^2/C^2$	$\varepsilon_o = 8.854 \text{ x } 10^{-12} C^2/N.m^2$,	$m_e = 9.1 \text{ x } 10^{-31} Kg$
$m_p = 1.67 \text{ x } 10^{-27}$ Kg	$e = 1.602 \text{ x } 10^{-19} C$	$g = 10\ m/s^2$
$N_A = 6.022 \text{ x } 10^{23}\ mol^{-1}$	$\mu_o = 4\pi\ 10^{-7}$ T.m/A	