Carry over (CO)

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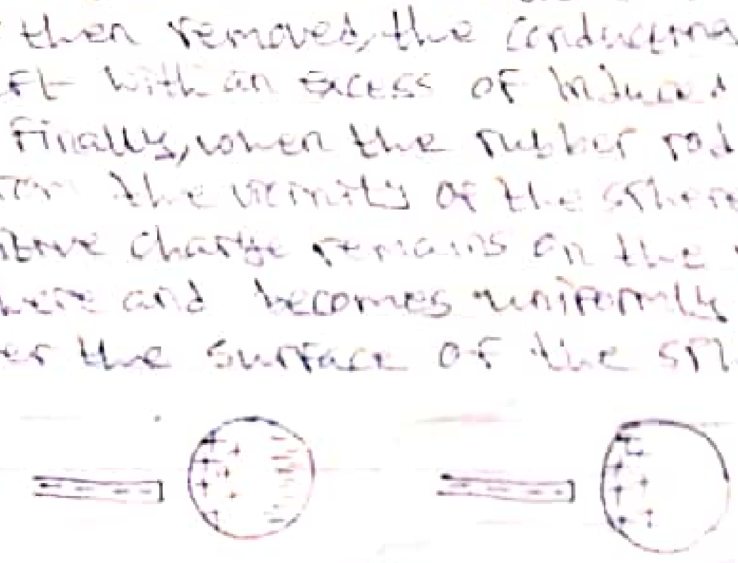
Matric No = 18/MHS02/015
Course code = PHY 102.
Department = Human nutrition and Dietetics

(1a)

Electric charge can be obtained on an object without touching it, by a process called electrostatic induction.

Consider a negatively charged rubber rod ~~[illegible]~~ brought near a negatively (uncharged) conducting sphere that is insulated so that there is no conducting path to ground. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere furthest away from the rod. The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed, the conducting sphere is left with an excess of induced positive charge.

Finally, when the rubber rod is removed from the vicinity of the sphere the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.



1B

$r = 1.0N,\ r = 2.0m \quad Q = 5.0\times10^{-5} \quad q_1 + q_2 = Q = 5.0\times10^{-5}$

$$F = \frac{kq_1q_2}{r}$$

$$1 = \frac{9\times10^9 \times q_1q_2}{2^2}$$

Cross multiply.

$$\frac{4}{9\times10^9} = \frac{\cancel{9\times10^9}\times q_1q_2}{\cancel{9\times10^9}}$$

$q_1q_2 = 4.44\times10^{-10}$ ---- eqn (1)

$q_1 + q_2 = 5.0\times10^{-5}$

$q_1 = 5.0\times10^{-5} - q^2$ ---- eqn (2)

Put eqn (2) in eqn (1)

$q_2 \times [5.0\times10^{-5} - q^2] = 4.44\times10^{-10}$

$5.0\times10^{-5}q_2 - q_2^2 = 4.44\times10^{-10}$

$-q_2^2 + 5.0\times10^{-5}q_2 - 4.44\times10^{-10} = 0$

$q_2 = 3.845\times10^{-5}C$ or $q_2 = 1.155\times10^{-5}C$

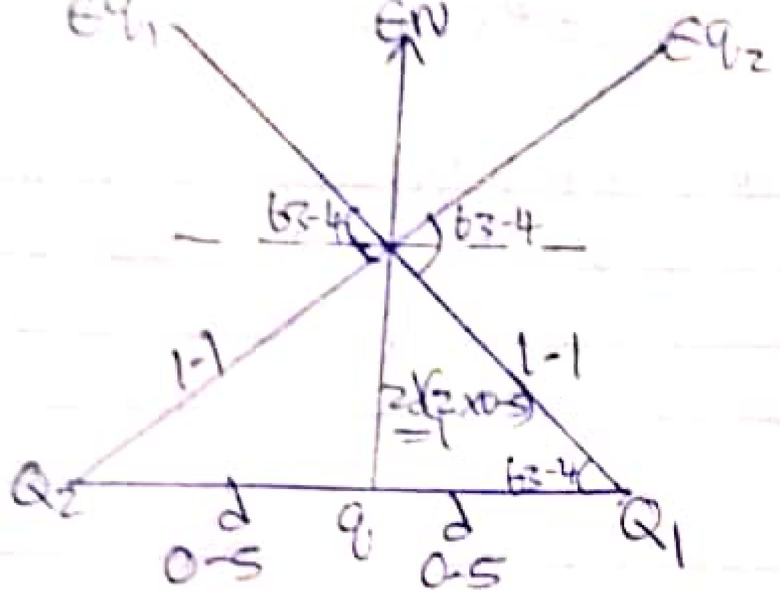
$q_1 = 5.0\times10^{-5} - 3.845\times10^{-5}$ or $q_1 = 5.0\times10^{-5} - 1.155\times10^{-5}$

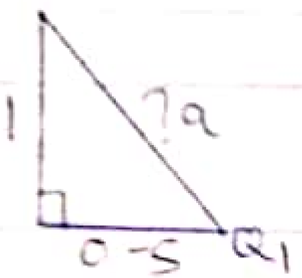
$= 1.155\times10^{-5}C$ or $= 3.845\times10^{-5}C$

$\therefore q_2 = 3.845\times10^{-5}C,\ q_1 = 1.155\times10^{-5}C.$

Scanned with CamScanner

1c





Using Pythagoras theorem

$$a^2 = 1^2 + 0.5^2$$
$$a^2 = 1 + 0.25$$
$$a^2 = 1.25$$
$$a = \sqrt{1.25}$$
$$a = 1.1$$

$$\tan\theta = \frac{1}{0.5}$$
$$\theta = 63.4$$

$$E_P = E_{Q_1} + E_{Q_2} + E_q$$

$$E_{Q_1} = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2} = 59504.1\,N/C$$

1C

$$Eq_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{1.1^2} = 59504.1 N/C$$

$$Eq = \frac{Kq}{r^2} = \frac{9\times10^9\times q}{1^2} = 9\times10^9 q\ N/C$$

Vector	Angle	X comp	Y comp
$Eq_1 = 59504.1$	63.4°	$-59504.1\cos63.4$ $= -26643$	$59504.1\sin63.4$ $= 53205$
$Eq_2 = 59504.1$	63.4°	$59504.1\cos63.4$ $= 26643$	$59504\sin63.4$ $= 53205$
$Eq = 9\times10^9 q$	90	$9\times10^9 q\cos90$ $= 0$	$9\times10^9 q\sin90$ $= 9\times10^9 q$
		$\Sigma F_x = 0$	$\Sigma F_y = 106410+9\times10^9 q$

$$EP = \sqrt{0^2+(106410+9\times10^9 q)^2}$$

$$EP = \sqrt{(106410+9\times10^9 q)^2}$$

$$EP = 106410+9\times10^9 q$$

at $EP = 0$

$$106410+9\times10^9 q = 0$$

$$\frac{9\times10^9 q}{9\times10^9} = \frac{-106410}{9\times10^9}$$

$$q = -1.18\times10^{-5}\ C$$

$$q \approx 12\,\mu C$$

i) Volume charge density is defined as the quantity of charge per unit volume. Its unit is Cm^{-3}

$$\rho = \frac{q}{V}$$

where, ρ = volume charge density
q = charge
V = volume.

ii Surface charge density is defined as the quantity of charge per unit Area. ~~Its unit is Cm~~ Its unit is Cm^{-2}

$$\sigma = \frac{q}{A}$$

where, σ = surface charge density.
q = charge
A = Area.

iii) Linear charge density - is defined as the quantity of charge per unit length - Its unit is Cm^{-1}

$$\lambda = \frac{q}{L}$$

where, λ = Linear charge density
q = charge
L = Length.

(3B)

The electric potential difference between two points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in volt (v) or Joules per coulomb (J/C). Electric potential difference is a scalar quantity.

Suppose a test charge q_0 is moved from point A to point B along an arbitary path inside an electric field E. The electric field E exerts a force $F = q_0 E$ on the charge. To move the test charge from A to B at constant velocity, an external force of $F = -q_0 E$ must act on the charge.

Therefore, the elemental work done dw is given as:

$$dw = F \cdot dL \text{ --- (1)}$$

But

$$F = -q_0 E \text{ —— (2)}$$

Substituting equation (2) in (1) yields:

$$dw = -q_0 E\, dL \text{ —— (3)}$$

Then total work done in moving the test charge from A to B is: $w(A \cap B)_{Ag} = -q_0 \int_A^B E\, dL$ — (4)

From the definition of electric potential difference, it follows that:

$$V_B - V_A = \frac{w(A \cap B)_{Ag}}{q_0} \text{ —— (5)}$$

Putting equation (4) in (5) yields

$$V_B - V_A = -\int_A^B E\, dL \text{ —— (6).}$$

$q_1 = 10\mu C$

$q_2 = -2\mu C$

$$V = \frac{kq_1}{r} + \frac{kq_2}{4-r}$$

FV = 0

$$\frac{kq_1}{r} = -\frac{kq_2}{4-r}$$

$$\frac{10\times10^{-6}C}{r} = \frac{-(-2\times10^{-6}C)}{4-r}$$

$$\frac{4-r}{r} = \frac{2\times\cancel{10^{-6}}C}{10\times\cancel{10^{-6}}C}$$

$$\frac{4}{r} - 1 = \frac{2}{10}$$

$$\frac{4}{r} = \frac{2}{10} + 1$$

$$\frac{4}{r} = \frac{2+10}{10} = \frac{12}{10}$$

$$\frac{4}{r} \times \frac{12}{10}$$

$$4\times10 = 12\times r$$

$$40 = 12r$$

$$r = \frac{40}{12}$$

$$r = 3.3m$$

(4a)

magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ.

(4B)

$M = 9.11\times10^{-31}kg, r = 1.4\times10^{-7}m, B = 3.5\times10^{-1}$ weber/m²

$\theta = 90°, w = ?$

$q = -1.60\times10^{-19}C$

$$w = \frac{qB}{me}$$

$$w = \frac{-1.60\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$$

$$w = -6.15\times10^{10}\ rad/sec$$

(4C)

Since our cyclotron frequency is negative -6.15×10^{10} rad/sec. It means that the charge particle electron circulates in a negative or opposite direction at the angular frequency.

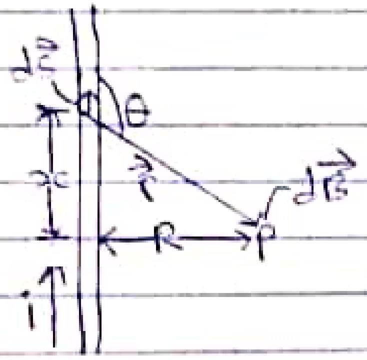
(5A)

Biot-Savart law is an equation that describe the magnetic field created by a current carrying wire and allows you to calculate its strength at various forms.

(5B)

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\,d\vec{l} \times \vec{r}}{r^3}$$

Compare with $d\vec{E} = \frac{dq}{4\pi\epsilon_0} \frac{\vec{r}}{r^3}$



$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\,d\vec{s} \times \vec{r}}{r^3}$$

$$dB = \frac{\mu_0}{4\pi} \frac{i\,ds(r\sin\theta)}{r^3}$$

$$B = \frac{\mu_0}{4\pi} \int_{-\infty}^{\infty} \frac{ds(r\sin\theta)}{r^3}$$

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i\,d\vec{s} \times \vec{r}}{r^3} \qquad dB = \frac{\mu_0}{4\pi} \frac{i\,ds(r\sin\theta)}{r^3}$$

$\sin\theta = R/r \qquad r = (s^2 + R^2)^{1/2}$

5B

$$B = \frac{\mu_0}{4\pi}\int_{-\infty}^{\infty} \frac{ds(r\sin\theta)}{r^3} = \frac{\mu_0 i}{4\pi}\int_{-\infty}^{\infty} \frac{R\,ds}{(s^2+R^2)^{3/2}}$$

$$= \frac{\mu_0 i}{2\pi}\int_{0}^{\infty} \frac{R\,ds}{(s^2+R^2)^{3/2}}$$

$$= \frac{\mu_0 i R}{2\pi}\left[\frac{s}{R^2(s^2+R^2)^{1/2}}\right]_0^{\infty}$$

$$= \frac{\mu_0 i}{2\pi R}$$