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PHY 102 Covid-19 Holiday Assignment.

1a) Electrostatic induction is the process by which electric charge can be obtained on an object without touching it.

How to charge a sphere negatively by induction.

Consider a positively charged rubber rod brought near a neutral sphere as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charge on the sphere so that some protons move to the side of the sphere farthest away from the rod has an excess of negative charge because of the migration of protons away from the location.

A granded conducting wire is then connected to the sphere some of the photons leave the sphere and travel to the earth. The wire is then removed, and the conducting sphere is then left with an excess of induced negative charge.

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

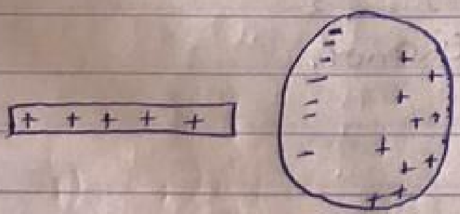


fig 1.1a

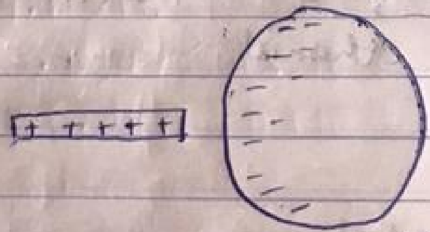


fig 1.1c

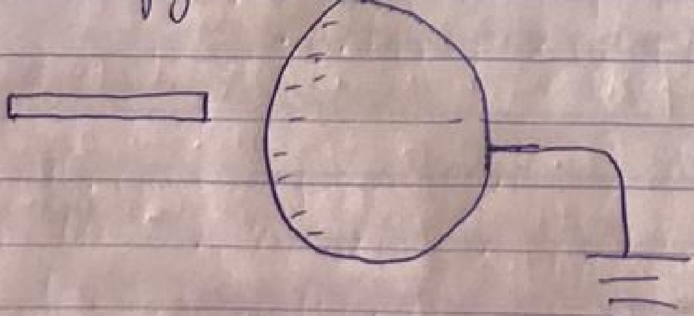


fig 1.1b

fig 1.1d

The magnitude of the resultant electric point Q is

$$E = \sqrt{\Sigma 6x^2 + \Sigma cy^2}$$

$$= \sqrt{(346)^2 + (10.592)^2}$$

$$= \sqrt{11.9716 + 112.1909}$$

$$= \sqrt{124.162064}$$

$$E_{net} = 11.14 N/C$$

2b)

2 n

Substituting (2) in (1) we have

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)^{3/2}}$$

we call $dl = dy$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}} dy$$

$$B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} dy \quad \text{——— (3)}$$

using special Integrals:

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} \frac{y}{(x^2+y^2)^{1/2}}$$

Equation (3) therefore becomes

$$B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$$

$$B = \frac{\mu_0 I x}{4\pi}\left(\frac{2a}{x^2(x^2+a^2)^{1/2}}\right)$$

$$B = \frac{\mu_0 I}{4\pi x}\left(\frac{2a}{(x^2+a^2)^{1/2}}\right)$$

when the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely. That is, when a is much larger than x,

$$(x^2+a^2)^{1/2} \simeq a \text{ as } a \to \infty$$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

In a physical situation, we have circle symmetry about y-axis thus, at all points in a circle of radius r around the conductor the magnitude of B is, $B = \frac{\mu_0 I}{2\pi r}$ ——— (4)

The equation defines the magnitude of the field of flux density B near a long straight current.

where Q = charge.
V = volume.
L = length.
A = area.

13. formulation of densities of charge.

a) volume charge density $\rho = \frac{dQ}{dV} = dQ = \rho dV$.

(ii) surface charge density $\sigma = {dQ}/{dA} = dQ = \sigma dA$.

(iii) linear charge density $\lambda = {dQ}/{dL} = dQ = \lambda dL$.

b) electric potential difference equation.

- due to a single point charge

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

where Q = point charge. V = electric potential.
r_B = distance of Q to point B.
r_A = distance of Q to point A.

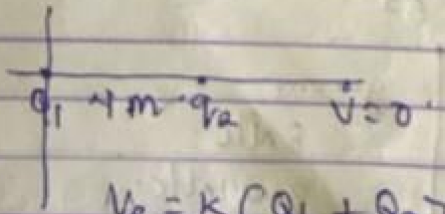
- due to several point charges

$$V_p = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right].$$

where V = electric potential.
Q = point charge.
r = distance of Q.

3c). Solution

Point charge $Q_1 = 10\mu C$ $Q_2 = -2\mu C$ along x-axis $x = 0$, $x = 4m$ resp
find the position along the x-axis where $V = 0$.



$$V_p = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right) \quad \text{recall } \frac{1}{4\pi\varepsilon_0} = 9\times10^9 = K.$$

$$V_p = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right].$$

$$V_p = 9\times10^9 \times\left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right].$$

$$0 = 9\times10^9 \times\left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right].$$

$$0 = \frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4+x} = \frac{2\times10^{-6}}{x}.$$

4) What is magnetic flux?

Magnetic flux (magnetic lines of force) is the imaginary line along which a free pole would tend to follow if placed in a magnetic field. It represents the direction and strength of the magnetic field at any point.

b. $m = 9.11 \times 10^{-31}$ kg, $B = 3.5 \times 10^{-1}$ weber/meter square

$r = 1.4 \times 10^{-9}$ m   cyclotron frequency = ?

Recall that angular speed, $\omega = \frac{v}{r} = \frac{qB}{m}$

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$= 0.6147091 \times 10^{11}$$

$$\omega = 6.1470911 \times 10^{10} \, T^{-1}$$

Note: cyclotron frequency = angular speed.

$\therefore$ The cyclotron frequency of the moving electron is $\omega = 6.1470911 \times 10^{10} T^{-1}$

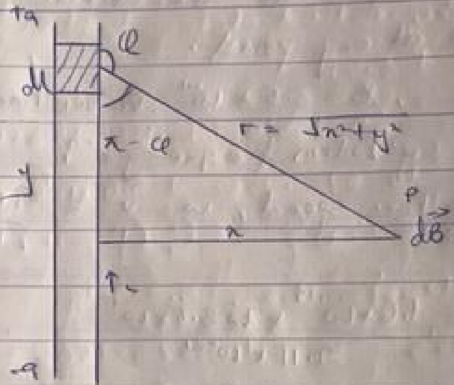
$\therefore$ The cyclotron frequency is equal to 6.1470911×10^{10} having a unit as 1/q which is equal to the limit of frequency dimensionally.

5. Biot Savart law states that the magnetic field dB at a particular point due to small element dl of a conductor carrying a current is directly proportional to the product of the permeability of free space (μ_0) the current (i), the change in length the radius and inversely proportional to the square of radius (r^2). It can be represented in mathematical form as.

$$dB = \frac{\mu_0}{4\pi} \frac{I \, d\vec{l} \times \hat{r}}{r^2}$$

where μ_0 is a constant called permeability of free space
$$\mu_0 = 4\pi \times 10^{-7} \ T\,m/A$$

6.



A diagram of a straight current carrying conductor

Applying the Biot-savart law, we find the magnitude of the field

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin\theta}{r^2}$$

$$\sin(\pi - \theta) = \sin\theta$$

$$\therefore \ B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \theta)}{r^2}$$

from diagram $r^2 = x^2 + y^2$ (Pythagoras as theorem)

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \theta)}{x^2 - y^2} \quad \text{——— (1)}$$

But $\sin(\pi - \theta) = \dfrac{x}{\sqrt{x^2+y^2}} = \dfrac{x}{(x^2+y^2)^{1/2}}$ ——— (2)

2) · electric field & electric field intensity

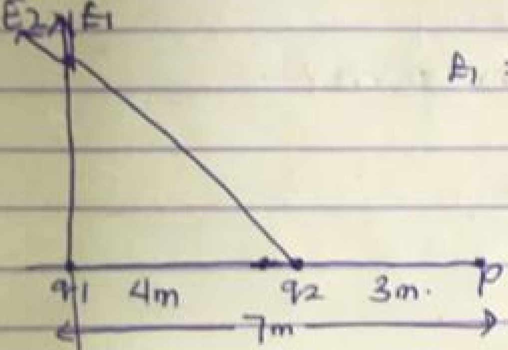
electric field	electric field intensity
· It's a region of space in which an electric charge will experience an electric force.	· It is the force per unit charge.

2b) · $q_1 = 8\,nC$ at origin, $q_2 = 12\,nC$ on x-axis at $x = 4m$.

(i) net electric field at point P on the x axis at $x = 7m$.

(ii) electric field at a point Q on the y axis at $y = 3m$ due to the charges.

(i) $E_2\ E_1$

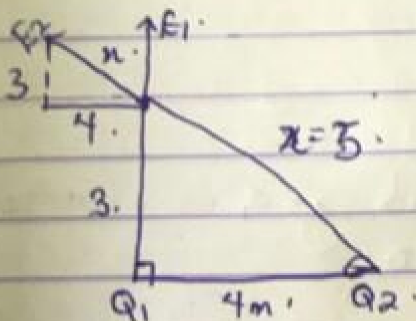


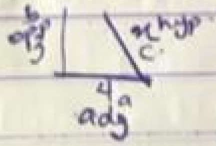
$$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = \underline{1.469\,N/C} \approx 1.5\,N/C$$

$$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7^2} = \underline{12\,N/C}$$

(ii) $E_{net} = \vec{E_1} + \vec{E_2} = (1.5 + 12)\,N/C = \underline{13.5\,N/C}$

(ii) · $\vec{E}$ at Point Q on the y axis at $y = 3m$ due to charge.





$c^2 = a^2 + b^2$

$c^2 = 4^2 + 3^2$

$c = 5$.

$$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2}\quad \vec{E_1} = 8\,N/C.$$

$$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32\,N/C.$$

vector	angle	x-comp	y-comp.
$E_1 = 8\,N/C$	$90°$	$0\,N/C$.	$8\,N/C$.
$E_2 = 4.32$	$36.87°$	$-3.45\,N/C$.	$2.59\,N/C$.
		$E_{fx} = -3.45\,N/C$	$E_{fy} = 10.59\,N/C$

$E_{net} = \sqrt{E_{fx}^2 + E_{fy}^2}$

$E_{net} = 11.12\,N/C$

Vector	Angle	x-Component	y-Component
$E_1 = 57397.95918$	63.43°	$E_{1x} = 57397.95918 \cos 63.43$ $= -25673.58$ N/C	$E_{1y} = 57397.95918 \sin 63.43$ $= 51336.0781$
$E_2 = 57397.95918$	63.43°	$E_{2x} = 57397.95918 \cos 63.43$ $= 25673.58$ N/C	$E_{2y} = 57397.95918 \sin 63.43$ $= 51336.0781.$
$E_q = 9 \times 10^{9} q$	90°	$E_{qx} = 9 \times 10^{9} \cos 90^\circ$ $= 0$ N/C	$E_{qy} = 9 \times 10^{9} \sin 90^\circ$ $= 9 \times 10^{9} q$
		$\Sigma E_x = 0$ N/C	$\Sigma E_y = (102672.1562 + 9 \times 10^{9} q)$ N/C

The magnitude of the resultant electric field. E_p at point P is

$$E_p = \sqrt{(\Sigma E_x)^2 + (\Sigma E_y)^2}$$

$$= \sqrt{0 + (102672.1562 + 9.0 \times 10^{9} q)^2}$$

$$= 102672.1562 + 9.0 \times 10^{9} q.$$

The charge at $P = 0$ $\quad (E_p = 0)$

$$0 = 102672.1562 + 9.0 \times 10^{9} q$$

$$\frac{9.0 \times 10^{9} q}{9.0 \times 10^{9}} = \frac{-102672.1562}{9 \times 10^{9}}$$

$$q = -1.14 \times 10^{-5} C$$

$$q = -1.1 \times 10^{-5} C$$

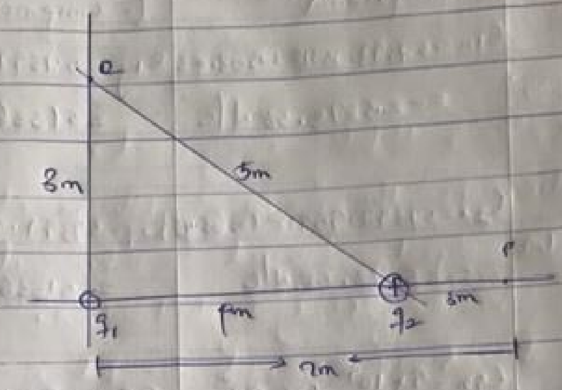
$$= -11 \times 10^{-6} C$$

$$\therefore q = -11 \mu C$$

$$\therefore q = -11$$

2. Electric field	Electric field intensity
It is a region or space where an electric charge experience an electric force	This is defined as the force per unit charge. its S.I unit is N/C

2.



$q_1 = +8nC$

$q_2 = +12nC$

$\sin\theta = 3/5$, $\theta = \sin^{-1}(3/5)$

$\theta = 36.87°$

i) $E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{(7)^2} = \frac{72}{49} = 1.469$ N/C $= 1.47$ N/C

$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{(3)^2} = 12$ N/C

The net Electric field at a point P on the x axis =

$= E_1 + E_2$

$= 12 + 1.47$

$= 13.47$ N/C

$E_{net} = 13.5$ N/C

ii) For point Q, $E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{3^2} = 8$ N/C

$r_2 = 5m$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32$ N/C

Vector	Angle	X- Component	Y- Components
$E_1 = 8$	90	$8\cos 90° = 0$ N/C	$8\sin 90° = 8$ N/C
$E_2 = 4.32$	36.87°	$4.32\cos 36.87° = 3.46$ N/C	$4.32\sin 36.87° = 2.592$ N/C
		$\Sigma E_x = 3.46$	$\Sigma E_y = 10.592$