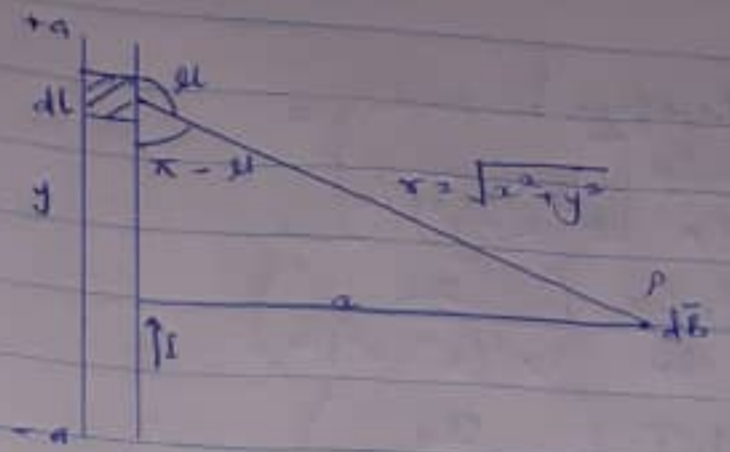
b.



A section of a straight current carrying conductor

Applying the Biot-Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

From diagram, $r^2 = x^2 + y^2$ (Pythagoras theorem)

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

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

Substituting (**) into (*), we have

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

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

Recall $dl = dy$

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

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

Using special integrals:

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

4a A magnetic flux is the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ

b $m = 9.11 \times 10^{-31} Kg$

$r = 1.4 \times 10^{-7} m$

$B = 3.5 \times 10^{-1} W/m^{3}$

$q = 1.6 \times 10^{-19} C$

$$V = \frac{qBr}{m}$$

$$V = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$V = 8.61 \times 10^{8} m/s$

Angular speed = cyclotron frequency

$$\omega = \frac{qB}{m} = \frac{v}{r}$$

$$= \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-3}}$$

$$= 6.15 \times 10^{10} \text{ rads}$$

c The charge particle circulates at the angular frequency or angular speed at 6.15×10^{10} rads in the type of accelerator called cyclotron, therefore, the angular speed is also seen as cyclotron frequency

5. The Biot-Savart law is an equation describing the magnetic field generated by a constant electric current

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

where μ_0 is a constant called permeability of free space

$$\mu_0 = 4\pi = 10^{-7} T \cdot m/A$$

Equation(. . .) 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 long. That is, when a is much larger than x,

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

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

At all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r}$$

$q_1 = 5.0 \times 10^{-5} - 1.4 \times 10^{-5}$

$= 3.86 \times 10^{-5} C$

$\therefore q_1 = 3.86 \times 10^{-5} C, \; q_2 = 1.14 \times 10^{-5}$

c $Q_1 = Q_2 = 8 \mu C$

$d = 0.5m$

$\tan\theta = \frac{opp}{adj}$

$\theta = \tan^{-1} \frac{1}{0.5}$

$\theta = 63.4$

$E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.22)^2} = 5732.79$

$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.28)^2} = 5739.29$

$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{(1)^2} = 9 \times 10^9 q$

Vector	Angle	x - comp	y - comp
5732·79	~~63·4~~ 63·4	25700·94	5132·26
5739·29	63·4	25700·74	5132·26
$9 \times 10^9 q$	90	0	$9 \times 10^9 q$
		0	$E_y = 10264 \cdot 2365 q$

Magnitude

$E_q = \sqrt{(0)^2 + (10264 \cdot 2365)^2}$

Since $E = 0$

$0 = 9 \times 10^9 q + 10264 \cdot 52568$

$q = 11 \mu C$

2a A ~~dect~~ electric f

will experience

field interact

lly, it is give

coulomb (N/C)

b $Q_1 = 8 \mu C$

i $x = 7m$

⊙

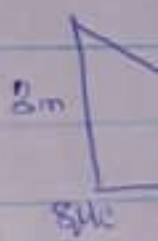
$8 \mu C$

$E_{1p} = \frac{kq}{}$

$E_{2p} = \frac{k}{}$

$E_{net} =$

ii



$E_{1q} =$

$E_2 q$

Vecto

$E_{1q} = 8$

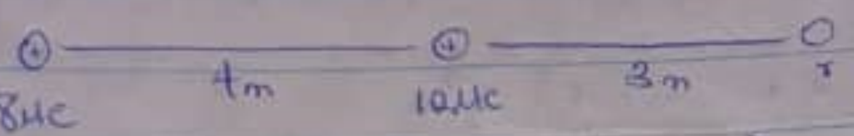
$E_{2q} = 4$

Σ

2a A ~~elect~~ electric field is a region of space in which an electric charge will experience an electric force, while the electric field strength or electric field intensity can be defined as the force per unit charge. Mathematically, it is given as $E = F(N) / q(C)$ which is measured in Newton per coulomb (N/C)

b $Q_1 = 8\mu C$, $Q_2 = 12\mu C$, $x = 4m$, $K = 9\times10^9$

i $x = 7m$

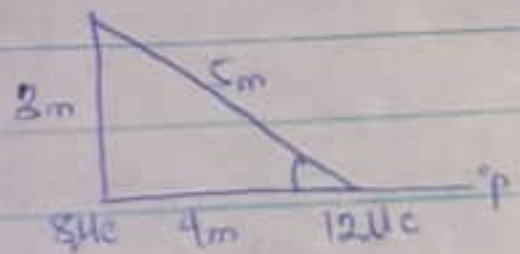


$$E_{1p} = \frac{kq_1p}{r^2} = \frac{9\times10^9 \times (8\times10^{-9})}{7^2} = 1.469\,N/C$$

$$E_{2p} = \frac{kq_2p}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{3^2} = 12N/C$$

$$E_{net} = 12 + 1.469$$
$$= 13.469N/C$$

ii



$\cos\theta = 4/5$

$\theta = 36.87°$

$$E_{1q} = \frac{kq_1}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{3^2} = 8N/C$$

$$E_2q = \frac{kq_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{5^2} = 4.32N/C$$

Vector	Angle	x-comp	y-comp
$E_{1q} = 8N/C$	90°	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_{2q} = 4.32N/C$	36.87°	$4.32\cos 36.87 = 3.46$	$4.32\sin 36.87$
		$\Sigma = 3.46\,N/C$	$\Sigma = 10.59N/C$

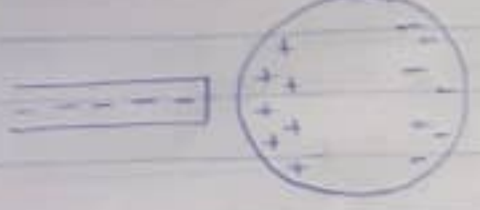
$$E_{net} = \sqrt{(3.46)^2 + (10.59)^2}$$

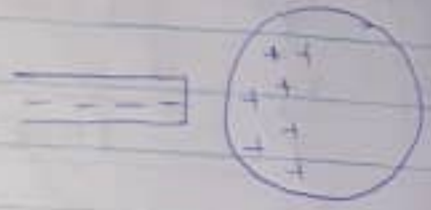
$$E_{net} = 11.14\mu C$$

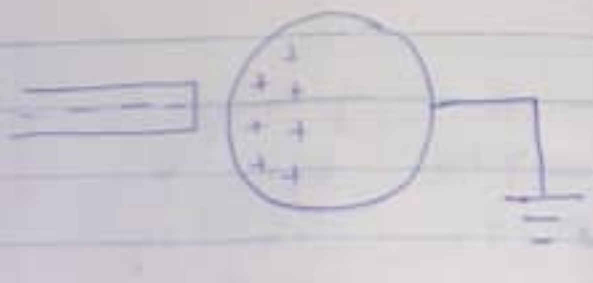
PHY 102

MADUEGWU KAMSILI EMMANUELLA 19/MTH/2040

1a Charging by induction. A negatively charged rubber rod is brought near a neutral conducting sphere that is insulated so that there is no conducting path to ground as shown below. 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 farthest away from the rod. A grounded conducting wire is connected to the sphere and some electrons leave the sphere and it is left with excess of induced positive charge. When the rubber rod is removed from the vicinity of the sphere, these induced positive charges remain in the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.







b $q_1 + q_2 = 5.0 \times 10^{-5} C$

$F = 1$

$r = 2$

$F = \frac{kq_1q_2}{r^2}$

$1 = \frac{9 \times 10^9 \times (q_2 - 5.0 \times 10^{-5}) \times q_2}{4}$

$4.44 \times 10^{-10} = (q_2 - 5.0 \times 10^{-5}) q_2$

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

$q_1 = 1.14 \times 10^{-5}$