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Course: Phy 102

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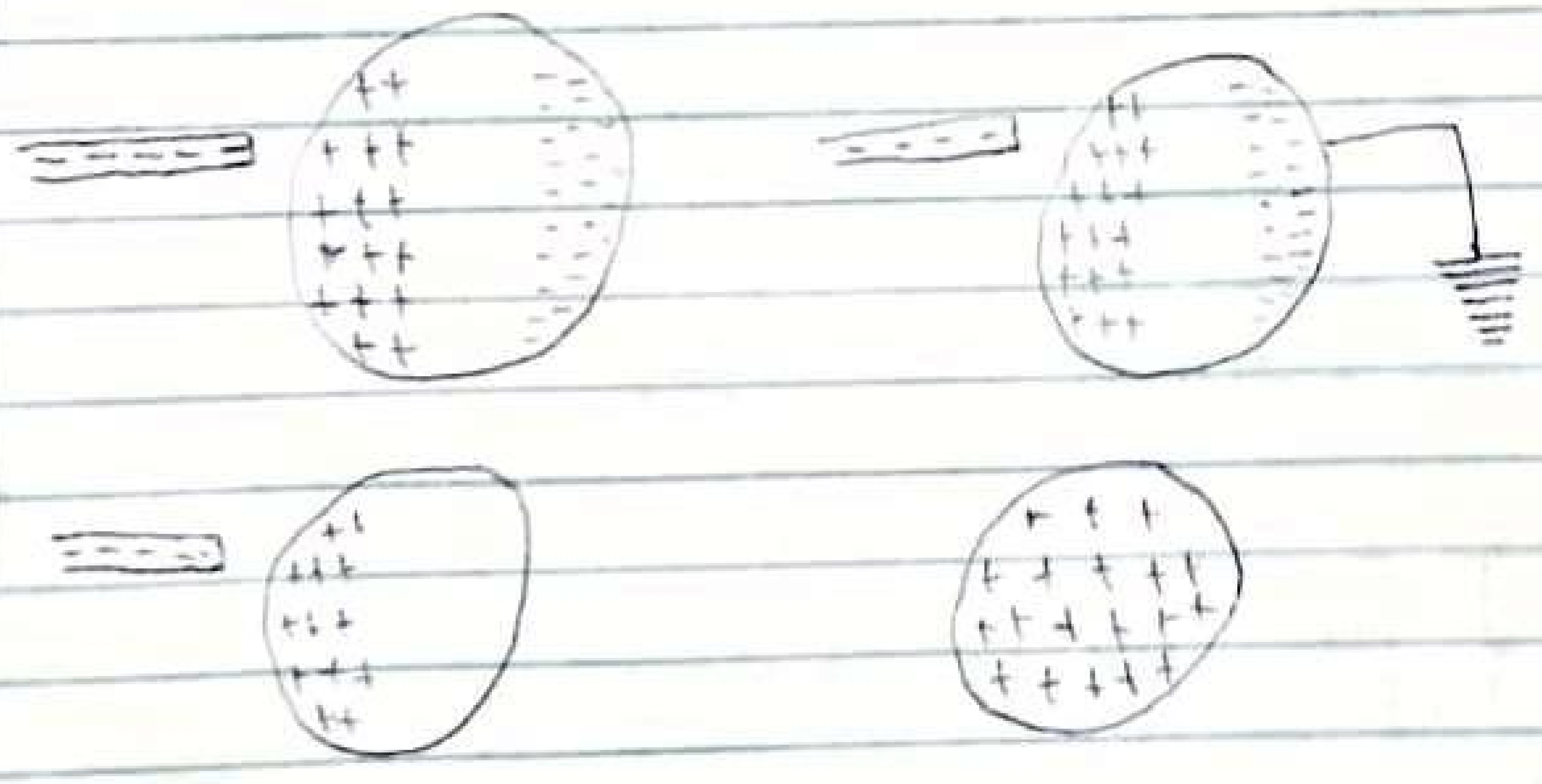
(i) Charging by induction:

When a negatively charged rubber rod is brought near a neutral conducting sphere as shown below. All the positively charges goes close to the rubber rod while the negative charges are ~~not~~ at the extreme end of the rubber rod. The neutral charged sphere is then connected to an insulator while the rod is still place close to it. The neutral sphere connected to an earth wire, all the negative charges passes through the earth wire and goes to the ground. The rubber rod is then removed and the sphere remains positively charged.



(i) $q_1 + q_2 = 5.0 \times 10^{-5} C$

$F = 1 \quad q_2 = q_2 - 5.0 \times 10^{-5} C$

$r = 2$

Recall that $F = \frac{K q_1 q_2}{r^2}$ $\quad (k = 9 \times 10^{9})$

5 continuation

Using special integrals

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

Equation (3) becomes

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

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

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

When the length 2a of the conductor is very great in comparison to its distance x from point p, we consider it indefinitely long. That is, when a is much larger than x,

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

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

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

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4a The magnetic flux =)

This is defined as the strength of a magnetic field represente by lines of force its usally represented by the symbol ϕ

4b $m_e = 9.11 \times 10^{-31}$ kg

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

$\theta = 90^\circ$

magnetic field $(w) = 3.5 \times 10^{-1}$

$q = 1.6 \times 10^{-4}$ C

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

$$V = \frac{(1.6 \times 10^{-9}) \times (3.5 \times 10^{-1}) \times (1.4 \times 10^{-9})}{9.11 \times 10^{-31}}$$

$V = 8.61 \times 10^{3}$ m/s.

Angular speed = Cyclotion frequency

$$W = \frac{qB}{m_e} = \frac{V}{r}$$

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

$= 6.15 \times 10^{10}$ rad/s

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

(1) continuation

$$1 = \frac{(9\times10^{9}) \times (q_2 \cdot 5.0\times10^{-5}\,C) \times q_2}{4}$$

$4.44\times10^{-10} = (q_2 - 5.0\times10^{-5}\,C)\,q_1$

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

$q_2 = 1.14\times10^{-5}$

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

$q_1 = 5.0\times10^{-5} - 1.14\times10^{-5}$

$q_1 = 3.86\times10^{-5}\,C$

1c $Q_1 = Q_2 = 8\mu C$

$d = 0.5\,m$

$\tan\theta = \text{opp}/\text{adj}$

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

$\theta = 65.4^\circ$

$$E_1 = \frac{kq_1}{r^2} = \frac{(9\times10^{9}) \times 8\times10^{-6}}{(1.22)^2}$$

$E_1 = 5732.79\,C$

$$E_2 = \frac{kq_2}{r^2} = \frac{(9\times10^{9}) \times (8\times10^{-6})}{(1.28)^2}$$

$E_2 = 5739.29\,C$

$$E_q = kq/r^2 = \frac{(9\times10^{9}) \times q}{(1)^2} = 9\times10^{9}q$$

Vector	Angle	X-comp	y-comp
5132.79	63.4	25700.74	5132.26
5739.29	63.4	25700.74	5132.26
$9\cdot10^{9}$	90	0	$9\times10^{9}q$
		0	$E_y = 10264 - 2365q$

magnitude

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

Since $E = 0$, $0 = 9\times10^{9}q + (10264) = 52568$

$q = \frac{52568}{9\times10^{9}} = 11\mu C$ $\quad q = 11\mu C$

(2)

2a An electric field:

This is the region of space in which an electric charge will experience an electric force while An Electric field strength or electric field intensity is the force per unit charge, mathematically, it is $E = F(N) / q(C)$, the unit is newton per coulombs (N/C)

bi $Q_1 = 8\mu C$, $Q_2 = 12\mu C$, $x = 4m$, $K = 9\times10^{9}q$

$$E_1P = \frac{kq_1P}{r^2} = \frac{(9\times10^{9}) \times (8\times10^{-9})}{7^2} = 1.469\,N/C$$

$$E_2P = \frac{kq_2P}{r^2} = (9\times10^{9}) \times (12\times10^{-9}) = 12\,N/C$$

$E_p = 1.469 + 12 = 13.469 \approx 13.5\,N/C$

ii $E_{net} = \vec{E_1} + \vec{E_2}$

$$E_1 = kQ_1/r^2 = \frac{9\times10^{9} \times 8\times10^{-9}}{3^2} = 8\,N/C$$

$$E_2 = k\frac{Q_2}{r^2} = \frac{9\times10^{9} \times 12\times10^{-9}}{5^2} = 4.32\,N/C$$

Vector	Angle	X-comp	y-comp
$E_1 = 8\,N/C$	90°	$8\cos 90 = 0$	$8\sin 90 = 8.00$
$E_2 = 4.32\,N/C$	36.9°	$4.32\times\cos 36.9 = -3.45$	$4.32\times\sin 36.9 = 2.59$
		$\Sigma E_x = -3.45$	$\Sigma E_y = 10.59$

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

$= \sqrt{(-3.45)^2 + (10.59)^2}$

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

(5)

5a The BIOT-SAVART LAW

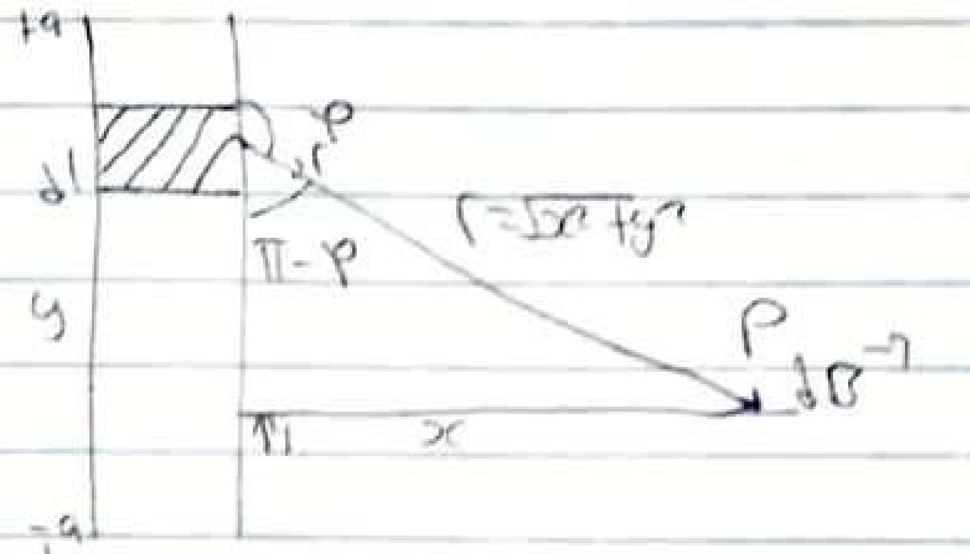
This is an equation that describes the magnetic field generated by a constant electric current

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

Where μ_0 is a constant called permeability of free space

~~$\mu_0 = 4\pi = 10^{9} \cdot m/A$~~

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



Applying the Biot-Savart law, we find the magnitude of the field dB

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

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

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

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

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

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

substituting (2) into (1)

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

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

Recall $dl = dy$

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

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