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(2bii contd)

$$E = \sqrt{\Sigma f x^2 + \Sigma f y^2}$$

$$E = \sqrt{(-3.45)^2 + (10.6)^2}$$

$$E = \sqrt{11.9025 + 112.36}$$

$$E = 11.147 \text{ N/C}$$

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2b i) $q_1 = +8nc$
$q_2 = 12nc$
$x = 4m$
~~k = Q~~ $E = \frac{kQ}{r^2}$

$E = \frac{9\times10^{9}\times 8\times10^{-9}}{7^2}$

$= \cancel{14.7 N/c}$ $1.47 N/c$

Distance of the point 12nc is $7-4 = 3m$

$\therefore E = \frac{kQ}{r^2}$

$E = \frac{9\times10^{9}\times 12\times10^{-9}}{3^2}$

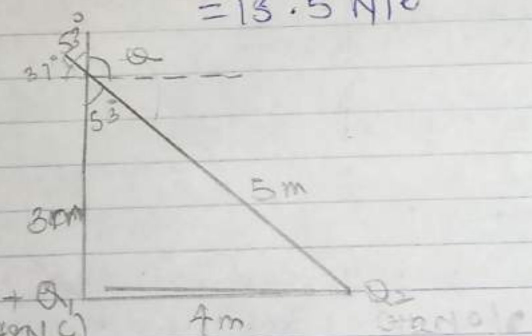
$= 12 N/c$

$\therefore E_{net} = \cancel{14.7N/c + 12N/c}$ $1.47 N/c + 12 N/c$

$= \cancel{13N/c}$ $13.47 N/C$

$= 13.5 N/c$

ii)



$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times 8\times10^{-9}}{3^2} = 8 N/C$

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

Vector	Angle	X-component	Y-component
$E_1 = 8N/C$	90°	8 cos 90 = 0	8 sin 90 = 8
$E_2 = 4.32N/C$	37°	4.32 cos 37° = −3.45	4.32 sin 90° = 2.6
		$\Sigma f_x = -3.45$	$\Sigma f_y = +10.6$

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5b continued

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

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

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

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

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

In a physical situation, we have axial symmetry about the y-axis. Thus, at all points circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{(magnitude of magnetic field)}$$

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3a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol ϕ. Mathematically, $\phi = B \cdot dA$

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

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

$B = 3.5 \times 10^{-1}$ weber/meter square

Cyclotron frequency = angular speed

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

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

$$\omega = 6.147 \times 10^{10} \text{ rad/s}$$

c) in the question, the parameters given were;

i) mass of the electron $= 9.11 \times 10^{-31}$ kg

ii) radius ~~=~~ 1.4×10^{-7} m

iii) magnetic field $= 3.5 \times 10^{-1}$ weber/metre square

and we were asked to find the cyclotron frequency which is the same as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

Recall, angular speed is ; $\omega = \frac{v}{r} = \frac{qB}{m}$.

by substituting;

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

$$= 6.147 \times 10^{10}$$

Therefore since cyclotron frequency and angular speed ~~are~~ are equal then cyclotron frequency is 6.147×10^{10} having a unit of ~~[illegible]~~ rad/s

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Vector	Angle	X – component	Y – component
$E_1 = 5.75\times10^4$	63.4	$5.75\times10^4 \cos 63.4$ $= -2.664\times10^4$	$5.75\times10^4 \sin 63.4$ $= 5.32\times10^4$
$E_2 = 5.75\times10^4$	63.4	$5.75\times10^4 \cos 63.4$ $= 2.664\times10^4$	$5.75\times10^4 \sin 63.4$ $= 5.32\times10^4$
$E_q = 9\times10^9 q$	90°	$9\times10^9 q \cos 90°$ $= 0$	$9\times10^9 q \sin 90$ $= 9\times10^9 q$
		$\Sigma f_x = 0$	$\Sigma f_y = 106404.3542 + 9\times10^9 q$

$$E_p = \sqrt{(0)^2 + (106404.3542 + 9\times10^9 q)^2}$$

$E_p = 106404.3542 + 9\times10^9 q$

Remember $E_p = 0$

$0 = 106404.3542 + 9\times10^9 q$

$9\times10^9 q = -106404.3542$

$$q = \frac{-106404.3542}{9\times10^9}$$

$q = -1.182\times10^{-5}$

$q = -11.8\times10^{-6}$

$q = -11.8\mu C$

2a Electric field is a region or space in which an electric charge will experience an electric force while.

Electric field intensity is the force per unit charge.

b)

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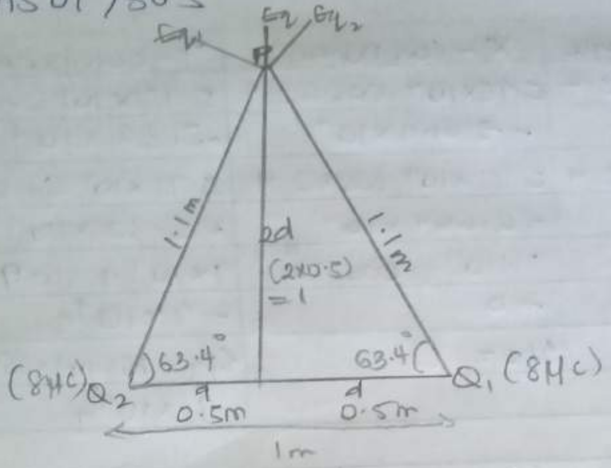
1c)



$x^2 = 0.5^2 + 1^2$

$x^2 = 0.25 + 1$

$x = \sqrt{0.25+1}$

$x = 1.1m$

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

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

$\theta = 63.4°$

$Eq_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 Nm^2/c^2 \times 8\times10^{-6}}{1.1^2}$

$Eq_1 = 59504.13$

$Eq_1 = 5.95\times10^4$

$Eq_2 = \frac{9\times10^9 \times 8\times10^{-6}}{1.1^2}$

$Eq_2 = 5.95\times10^4$

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

$Eq = 9\times10^9\times q$

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

$F = 1N$

$k = 9\times10^{9} Nm^2/C^2$

$d = 2m$

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

$1N = \frac{9\times10^9 Nm^2/C^2 \; q_1q_2}{2^2}$

$4 = 9\times10^9 q_1q_2$

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

$= 4.44\times10^{-10}$ ---(i)

remember,

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

$q_1 = 5\times10^{-5} - q_2$ ---(ii)

put eq(i) in equ(ii)

$(5\times10^{-5} - q_2)\times q_2 = 4.44\times10^{-10}C$

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

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

solve using quadratic equation;

$\frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$a = 1$

$b = 5\times10^{-5}$

$c = 4.44\times10^{-10}$.

$\frac{-(-5\times10^{-5}) \pm \sqrt{(-5\times10^{-5})^2 - 4(1)(4.44\times10^{-10})}}{2\times1}$

$\frac{5\times10^{-5} \pm \sqrt{2.5\times10^{-9} - 1.776\times10^{-9}}}{2}$

$\frac{5\times10^{-5} + 2.690\times10^{-5}}{2}$

$= 3.84\times10^{-5}C$

$\frac{5\times10^{-5} - 2.690\times10^{-5}}{2}$

$= 1.16\times10^{-5}C$.

$\therefore q_2 = 3.84\times10^{-5}C$ or $1.16\times10^{-5}C$,

remember,

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

$q_1 = 5\times10^{-5} - 3.84\times10^{-5}C$

$q_1 = 1.16\times10^{-5}C$

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

$q_1 = 5\times10^{-5} - 1.16\times10^{-5}$

$q_1 = 3.84\times10^{-5}C$

Therefore

$q_1 = 1.16\times10^{-5}C$,

$q_2 = 3.84\times10^{-5}C$ or vice verse

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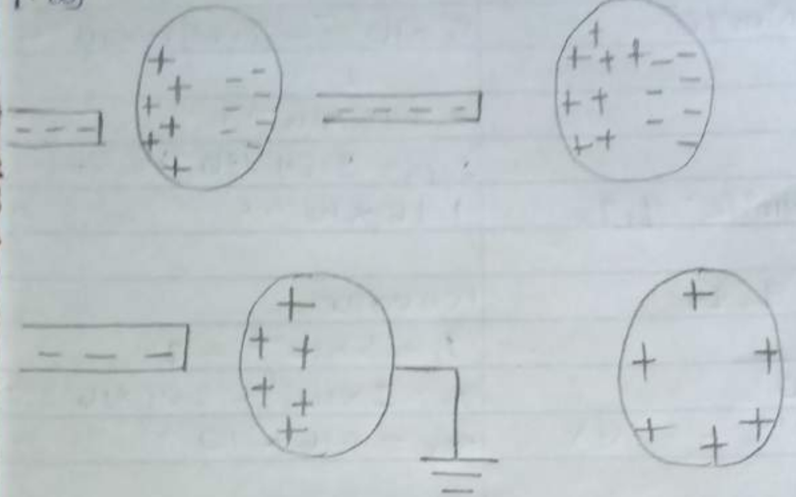
1. a)



Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown above. The repulsive force between the electrons in the rod and those in the sphere cause a repulsive redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod (fig 1.39). The region of the sphere nearest to the negatively charged rod has an excess of positive charge because of the migration of electrons away from its 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 in the underground ed sphere and becomes uniformly distributed over the surface of the sphere.

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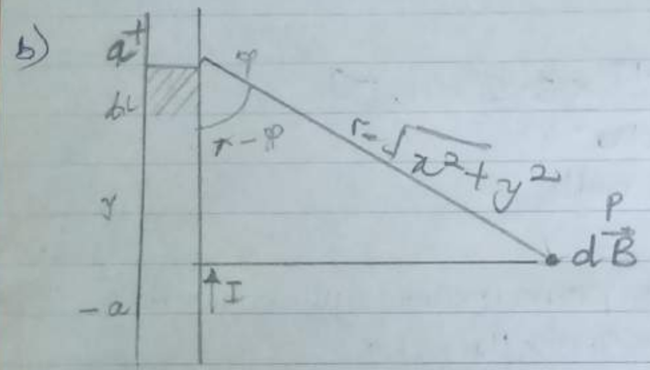
5a) Biot – Savart law

Biot-savart Law states that the magnetic field ~~intensity~~ is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2).

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

μ_0 is free space of permeability. The unit of $\vec{B}$ is weber/metre square.

b)



Applying the Biot-savart law, we find the magnitude of the fied $\vec{dB}$

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

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

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

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

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

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