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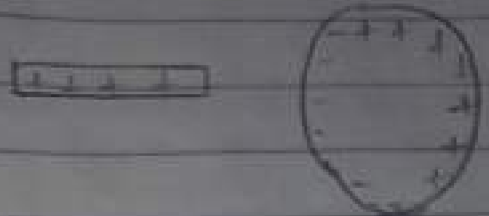
18/ENG07/001 PHY102

PETROLEUM-ENGINEERING.

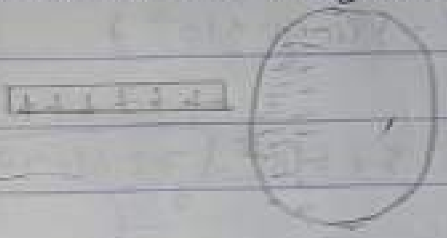
1a. Producing a negatively charged on a sphere by induction



A Positively charged rod is brought near a neutral conductor sphere. The Protons are forced to move from the left side of the sphere to the right side.

ii. 

The "ground" is brought close to right side of the sphere. The unbalance of charge is neutralized as the Protons leave the sphere and Pass through the "ground".

iii. 

The right side of the sphere has now been neutralized by the departure of Protons. There remains an unbalance of charge on the left side of the sphere

As the rod is Pulled away, there is a movement of the remaining electrons within the Conducting sphere which results in a uniform distribution of the negative charges throughout the sphere's surface.

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1b $q_1 + q_2 = 5.0 \times 10^{-9} C$

$$F = \frac{k q_1 q_2}{r^2}$$

$$10 = \frac{9 \times 10^9 \times q_1 q_2}{4}$$

recall $q_1 q_2 = 4.44 \times 10^{-10} C^2 \ldots$ (i)

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

sub equ(1) into eq(2)

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

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

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

Using the quadratic formula.

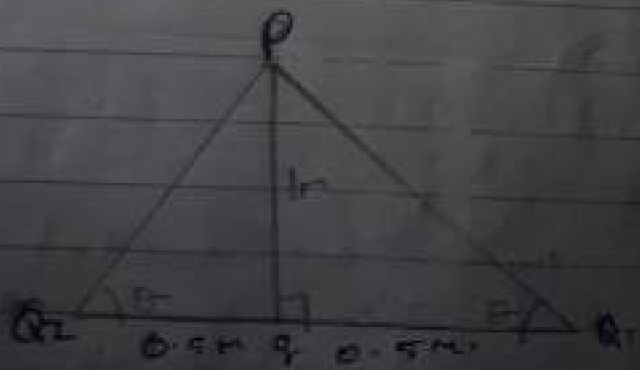
$$q = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{-(5.0 \times 10^{-5}) \pm \sqrt{(-5.0 \times 10^{-5})^2 - 4(4.44 \times 10^{-10})}}{2(1)}$$

$$= \frac{5.0 \times 10^{-5} + \sqrt{7.2 \times 10^{-10}}}{2} \text{ or } \frac{5.0 \times 10^{-5} - \sqrt{7.2 \times 10^{-10}}}{2}$$

$q = 3.85 \times 10^{-5} C$ or $q = 1.5 \times 10^{-5} C$

C1




$Q_1 = Q_2 = 8 \times 10^{-6} C$

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

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

$\theta = 63.43°$

Using Pythagoras theorem

$|PQ|^2 = |PQ|^2 + |OQ|^2$

$|PQ| = \sqrt{(1)^2 + (0.5)^2}$

$\therefore |PQ| = 1.12$

$|PQ_1| = |PQ_2| = 1.12$

$F_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 Nm^2/C^2 \times 8\times10^{-6}C}{(1.12m)^2} = 5.74\times10^{-4} N/C$

$F_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 Nm^2/C^2 \times 8\times10^{-6}C}{(1.12m)^2} = 5.74\times10^{-4} N/C$

$F_3 = \frac{kQ_3}{r^2} = \frac{9\times10^9 Nm^2/C^2 \times q}{(1m)^2} = 9\times10^9 q$

| E | θ | Fx | Fy |
|---|---|---|---|
| $5.74\times10^{-4}$ | $63.45°$ | $5.74\times10^{-4}\cos 63.43$ | $5.74\times10^{-4}\sin 63.43$ |
| $5.74\times10^{-4}$ | $63.43°$ | $5.74\times10^{-4}\cos 63.43°$ | $5.74\times10^{-4}\sin 63.43$ |
| $9\times10^9 q$ | $90°$ | 0 | $9\times10^9 q \sin 90°$ |

$|R| = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$

$0 = \sqrt{(0)^2 + (1.03\times10^{-3} + 9\times10^9 q)^2}$

$0 = \sqrt{(1.03\times10^{-3} + 9\times10^9 q}$

$0 = 1.03\times10^{-3} + 9\times10^9 q.$

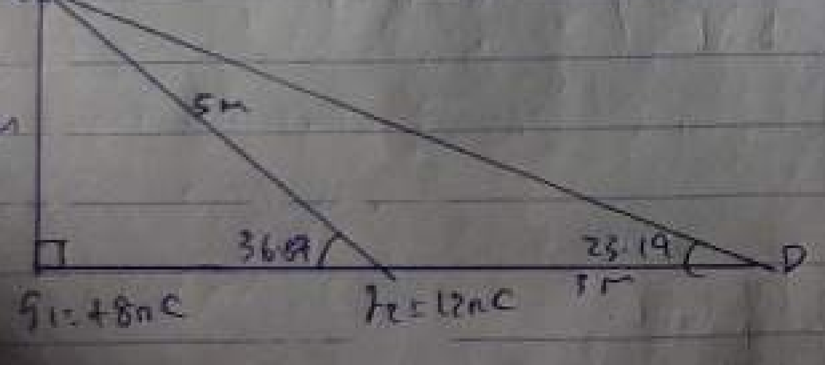
$\frac{-1.03\times10^{-3}}{9\times10^9} \therefore q = -11\times10^{-6} C = -11\mu C$

(2c) Electric field is a region of space in which an electric charge in experience an electric

Electric field intensity: it can be defined as the force per unit charge.

$$E = \frac{F(N)}{q(C)}$$

Measured in Newton per Coulomb (N/C).



(i) $E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47$

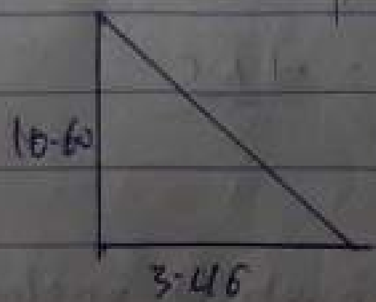
$= 1.47 + 12 = 13.47\ N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 12$

(ii) $E_1 = \frac{9\times10^9 \times 8\times10^{-9}}{9} = 8$

$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32$

| x | y |
|---|---|
| $8\times\cos(90)$ | $8\times\sin 90$ |
| $=0$ | $=8$ |
| $4.32\times\cos(36.87)$ | $4.32\times\sin(36.87)$ |
| $=3.46$ | $2.60$ |
| $3.46$ | $10.60$ |




$x = \sqrt{10.6^2 + 3.46^2} = 11.15\ N/C$

4a). Magnetic flux is defined as the strength of the magnetic field which can be represented line of forces. It is represented by the Symbol mathematically give as $\Phi = \int B \cdot dA$.

b) $m = 9.11 \times 10^{-31}kg$, $r = 1.4 \times 10^{-7}m$ $B = 3.5 \times 10^{-1}$ weber/metre square

Cyclotron Frequency = angular speed

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

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

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

we were given parameters such as

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

ii) A radius of $1.4 \times 10^{-7}M$

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

and we were asked to find the cyclotron frequency which equal or the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron. For all that angular speed is given as $\omega$ = substituting we.

5) Biot Savart law is an equation that describes the magnetic field by a Current Carrying wire, and allows you to calculate it's strength at various Points... And we replace the electric field dE with a magnetic field element dB because a moving charge Produces magnetic field not an electric field.

Permeability of free space

$$B = \frac{\mu_0 I}{4\pi} \int \frac{d\vec{s} \times A}{r^2}$$ A - Radical direction, $r^2$ - Distance ; $\mu_0 = 4.7 \times 10^{-7}$ ...

$\mu_0 I$ - Permeability of free space.

A - Radical direction

r - distance.

Magnetic field of a straight Current Carrying Conductor.

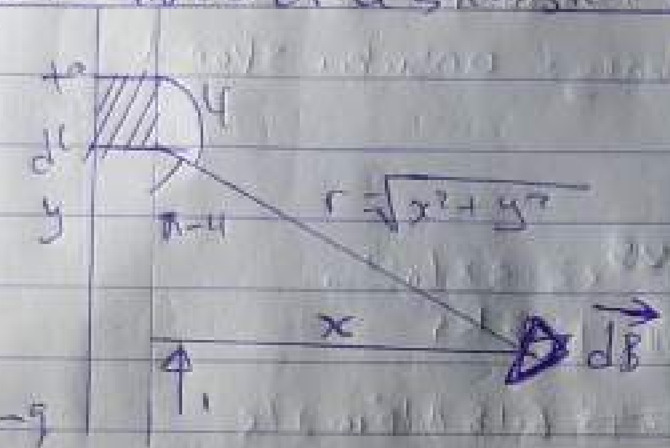



Fig 1 A section of a straight Current Carrying Conductor

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

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

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

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

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

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

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

Substituting eq (ii) into (i)

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

Recall $dl = dy$ when $x=1$

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

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

Using special integrals "

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

Equ (iii) therefore becomes

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

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

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

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

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

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

This defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor