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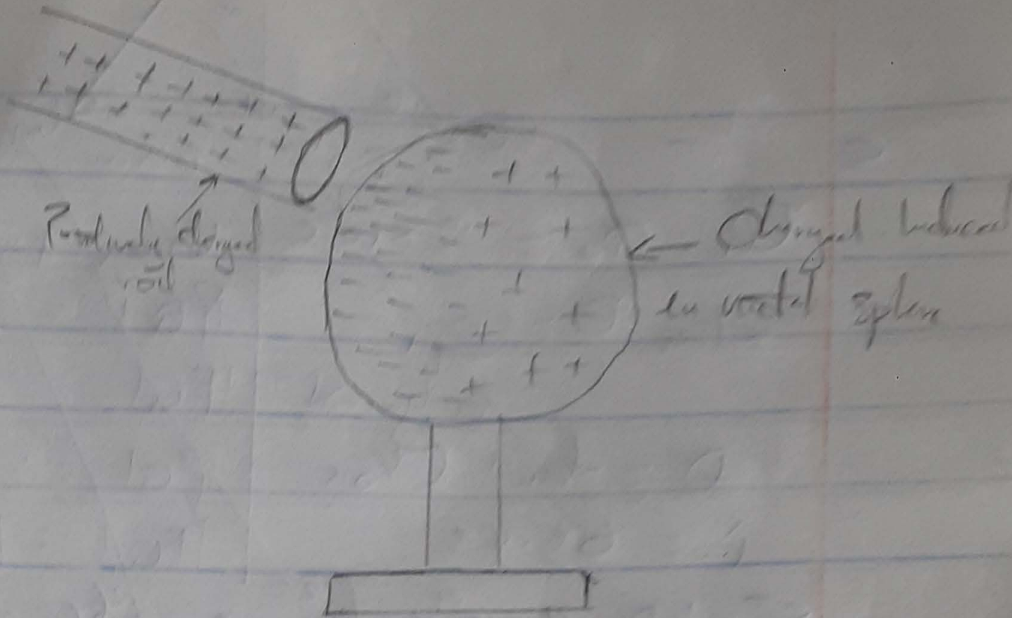
Elect / Elect

H/ENG/04/17

1 ~~In charging a metal sphere negatively by induction, by bringing a positively charged rod near it. In this case the electrons will flow from the ~~sphere~~ ground to the sphere when the sphere is connected to the ground with a wire~~

1 When we charge a ~~negatively~~ metal sphere negatively by bringing a positively charged rod near its left surface, the electrons get attracted towards the left side and positive charges on right side. Also, when the sphere is earthed the electrons from earth flow to the sphere. ~~is earthed the electrons from earth~~ to neutralise the positive charge collected on the right side. Also when the positively charged rod is removed the negative charges get distributed over the metal surface and the sphere gets negatively charge.



b $F = 0.1$, $k = 9\times10^{9}$ $\cancel{q_1 + q_2}$ $r = 0.02$

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

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

$0.1 = \frac{(9\times10^{9}) q_1 q_2}{0.02^2}$ $q_1 = 5.0\times10^{-5} - q_2$

$0.1 = 2.25\times10^{13} q_1 q_2$

$0.1 = 2.25\times10^{13}(5.0\times10^{-5} - q_2) q_2$

$0.1 = 1.1\times10^{9} q_2 - 2.25\times10^{13} q_2^2$

$2.25\times10^{13} q_2^2 \cancel{-1.1\times1} - 1.1\times10^{9} + 0.1 = 0$

$q_2 = 4.8\times10$ or 7.0×10^{-11}

$q_2 = 4.8\times10^{-5}$

$q_1 = 5.0\times10^{-5} - 4.8\times10^{-5}$

$q_1 = 2\times10^{-6}$

$\therefore q_1 = 2\times10^{-6}$

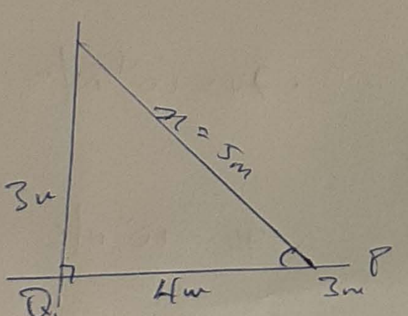
19/ENG04/017

2, Electric field is a region or space in which an electric charge experience an electric force.
Electric field intensity (strength) E can be defined as the force per unit charge mathematically, its magnitude can be represented by

$$E = \frac{F(N)}{q_0(C)}$$

Measured in Newton per Coulomb (N/C)

b



$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 Nm^2/C^2 \times 8 \times 10^{-9} C}{(7)^2} = 1.47 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 Nm^2/C^2 \times (12 \times 10^{-9} C)}{(5)^2} = 4.52 N/C$

E	θ	F_x	F_y
8 N/C	90°	0	8 sin 90°
4.52 N/C	36.87°	4.52 cos 36.87	4.52 sin
		$\Sigma F_x = 3.46$	$\Sigma F_y = 10.59$

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

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

$|R| = 11.14$ N/C

$E_{net} = 11.14$ N/C

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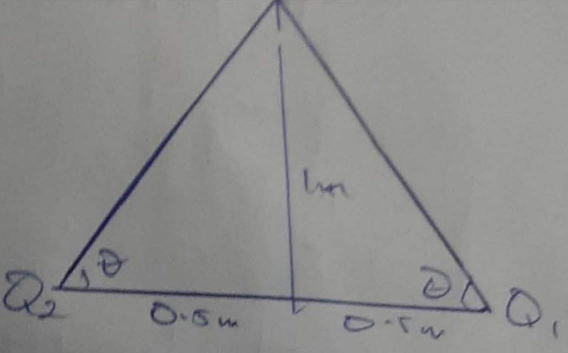


$Q_1 = Q_2 = 8\times10^{-6}C$, $\tan\theta = \frac{opp}{adjacent}$

Using Pythagoras theorem

$|PQ|^2 + |OQ|^2$ $\quad\quad \theta = \tan(1/0.5)$, $\theta = 63.43$

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

$|PQ| = 1.12$

$|PQ| = |PQ_2| = 1.12$

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 Nm^2 \times 8\times10^{-6}C}{(1.12m)^2} = 5.74\times10^4 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 Nm^2 \times 8\times10^{-6}C}{(1.12m)^2} = 5.74\times10^4 N/C$

$E_3 = \frac{kQ_3}{r^2} = \frac{9\times10^9 Nm/C^2 \times Q}{(1m)^2} = 9\times10^9 q$

E	θ	fx	fy
5.74×10^4	63.43°	$5.74\times10^{-4}\cos 63.43^\circ$	$5.74\times10^{-4}\sin 63.43^\circ$
5.74×10^4	63.43	$5.74\times10^{-4}\cos 63.43^\circ$	$5.74\times10^{-4}\sin 63.43^\circ$
$9\times10^9 q$	90°	0	$9\times10^9 q \sin 90^\circ$

$\Sigma fx = 0$ $\quad\quad 1.03\times10^3 + 9\times10^9 q$

$|R| = \sqrt{\Sigma fx^2 + \Sigma fy^2}$

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

$0 = \sqrt{1.03\times10^{-1} + 9\times10^{-9} q}$

$0 = 1.03\times10^3 + 9\times10^9 q$

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

(a) Magnetic flux (often denoted ϕ or ϕ_B) through a surface [is] the surface integral of the normal component of the magnetic field flux density B passing through the surface. The SI unit of magnetic field is weber (Wb), in derived units: volt-seconds and (cgs unit is the maxwell)

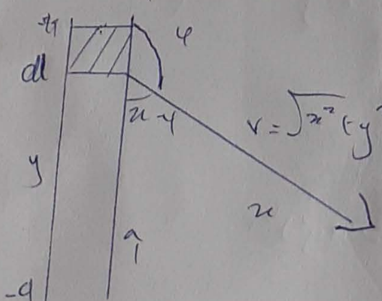
(b) $m = 9.11 \times 10^{-31}$ kg, $r = 1.4 \times 10^{-7}$ m, $B = 3.5 \times 10^{-1}$ w/m^2

$\therefore \omega = qB/m$

$$= \frac{1.60 \times 10^{-19}\,C \times 3.5 \times 10^{-1}\,w/m^2}{9.11 \times 10^{-31}\,kg} = 6.18 \times 10^{10}\ \text{rad/s}$$

(c) The Biot-Savart law is based on the following observation of the magnetic field $d\vec{B}$ at a point P associated with the length element $d\vec{l}$ of a wire carrying a steady current

<u>Magnetic field of a Straight Current Carrying Conductor</u>



Applying Biot Savart's law we find the magnitude of field dB

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

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

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

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from the diagram $r^2 = x^2 + y^2$ 19/ENG04/017

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

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

Sub eqn (2) into (1)

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

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

Recall $dl = dy$

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

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

Using Special Integrals

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

Eqn (3) therefore becomes

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

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

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

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

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

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