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Medicine and Surgery
19/MHS01/412
PHY 102 covid-19 Holiday Assignment

1. Charging by Induction:

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod (fig 1.3a). The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If a grounded conducting wire is then connected to the sphere, as in (fig 1.3b), some of the protons leave the sphere and travel to the Earth. If the wire to ground is then removed (fig 1.3c), the conducting sphere is left with an excess of induced negative charge. Finally, when the rubber rod is removed from the vicinity of ~~of~~ the sphere (fig. 1.3d) the induced negatively charged remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagram:

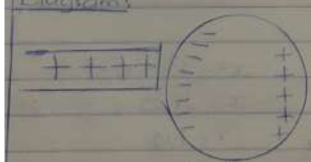


fig 1.3a


fig 1.3c

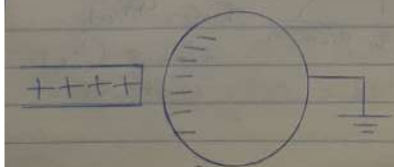


fig 1.3b


fig 1.3d

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

$+ Q_2 = 5\times10^{-5}C$

$F = 1N$

$d = 2m$

Recall that

$K = 9\times10^{9}$

$F = \frac{KQ_1Q_2}{r^2}$

$1 = \frac{9\times10^{9}\times(Q_1q_2\ 5\times10^{-5})}{2^2}$

~~$4 = 9\times10^{9}\times 5\times10^{-5}q_1 + 5\times10^{-5}q_2$~~

$q_1q_2 = \frac{Fr^2}{K}$

$q_1q_2 = \frac{1\times2^2}{9\times10^{9}} = 4.444\times10^{-10}$

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

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

$q_1(5.0\times10^{-5} - q_1) = 4.444\times10^{-10}$

$5.0\times10^{-5}q_1 - q_1^2 = 4.444\times10^{-10}$

$q_1^2 - 5.0\times10^{-5}q_1 + 4.444\times10^{-10} = 0$

$\frac{5.0\times10^{-5} + \sqrt{(5.0\times10^{-5})^2 - 4(4.444\times10^{-10})}}{2}$

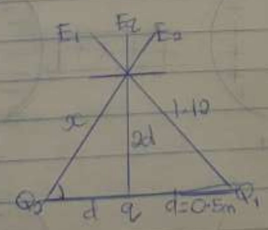
$q_1 = 3.84\times10^{-5}C$

$q_2 = 5.0\times10^{-5} - 3.84\times10^{-5}$

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

$Q_1 = Q_2 = 8\mu C$

$d = 0.5m$



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

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = opp/adj$

$\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.43°$

$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

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

Vector	Angle	x-component	y-component
$E_1 = 57397.95918$	$63.4°$	$E_1\cos\theta = -25700.45785$	$E_1\sin\theta = 51322.62839$
$E_2 = 57397.95918$	$63.4°$	$E_2\cos\theta = 25700.45785$	$E_2\sin\theta = 51322.62839$
$E_q = 9\times10^9 q$	$90°$	$E_q\cos\theta = 0$	$E_q\sin\theta = 9\times10^9 q$
		$\Sigma x = 0$	$\Sigma y = 102645.2568$

$E_q = \sqrt{0^2 + 102645.2568}$

$E_q = 0 + 102645.2568$

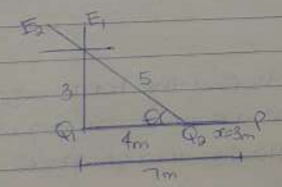
$E_q = 102645.2568$

$q = \frac{E_q}{9\times10^9} = \frac{102645.2568}{9\times10^9}$

$q = 1.14\times10^{-5}\,C$

2a Electric field : It is a region or space in which an electric charge will experience an electric field while
Electric field intensity is the force per unit charge.

2b



$\tan\theta = \frac{opp}{adj} = \frac{3}{4}$

$\theta = \tan^{-1}(3/4)$

$\theta = 36.9°$

i. $E_{net} = E_1 + E_2$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469\ N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12\ N/C$

$E_{net} = 12 + 1.469 = 13.469$ or $13.5\ N/C$

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
$E_1 = 8$	$90°$	$E_1\cos\theta = 0$	$E_1\sin\theta = 8$
$E_2 = 4.32$	$36.9°$	$E_2\cos\theta = -3.45$	$E_2\sin\theta = 2.59$
		$\Sigma_x = -3.45$	$\Sigma_y = 10.59$

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

$E_{net} = 11.14\ N/C$

4a. Magnetic flux is defined as the strength of the magne field which can be represented by line of forces. It is represented by the symbol ϕ.

b. $m = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$

$B = 3.5\times10^{-1} weber/m^2$; $q = -1.6\times10^{-19}$

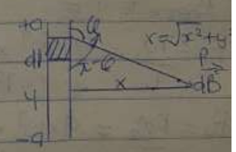
$\omega = \frac{qB}{m} = \frac{-1.6\times10^{-19} \times 3.5\times10^{-1}}{9.11\times10^{-31}}$

$\omega = -6.15\times10^{10} rad/s$

c. The answer is negative because we are dealing with an electron but the electron is moving at a cyclotron fre of 6.15×10^{10} rad/s.

5a. The Biot-Savart law is used to find the total magn field created at some point on a current carrying wi curren consisting of charges flowing through space

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



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

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

From diagram: $r^2 = x^2+y^2$

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

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but $\sin(\pi - \theta) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ ---- (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 $dl = dy$

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

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

using special integrals

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

Equation 3 becomes

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

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

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

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

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