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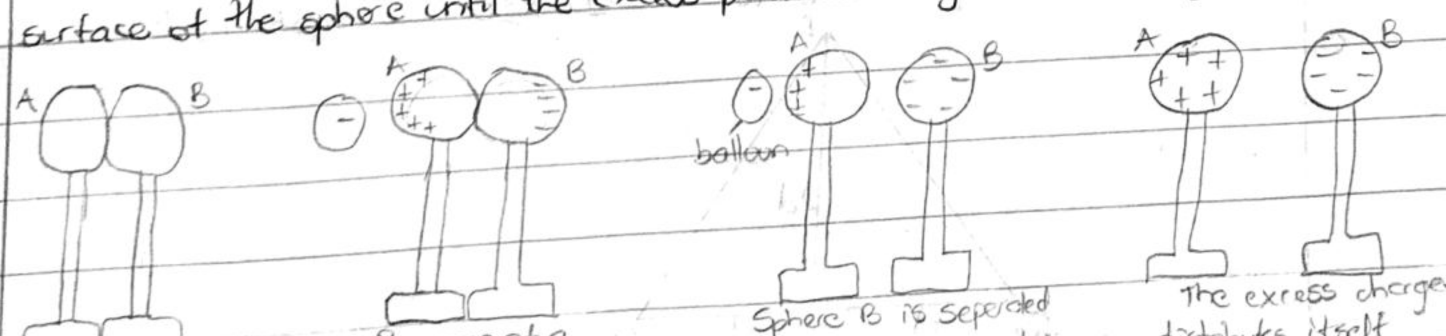
COURSE: PHY 102

1a. The metal spheres are supported by insulating stands so that any charge acquired by the spheres cannot travel to the ground. The spheres are placed side by side so as to form a two-sphere system. Being made of metal, electrons are free to move between the spheres. If a rubber ballon is charged negatively and brought near the spheres, electrons withing the two-sphere system will be induced to move away from the ballon due to the principle that like charges repel. the electrons are repelled by the negatively charged balloon. Subsequently a mass migration occurs from sphere A to B. this electron migration causes the two-sphere system to be polarized. The two-sphere system is electrically neutral. the movement of electrons out of sphere A and into sphere B seperates the negative charge from the positive charge. Therefore, sphere A is positively charged and sphere B is negatively charged. Sphere B is seperated from sphere A using the insulating stand. Being pulled further from the balloon, the negative charge likely redistributes itself uniformly about sphere B. Meanwhile, the excess positive charge on sphere A remains located near the negatively charged balloon, consistent with the principle that opposite charges attract. As the balloon is pulled away, there is a uniform redistribution of charge about the surface of both spheres. The distribution occurs as the remaining electrons in sphere A move across the surface of the sphere until the excess positive charge is uniformly distributed.



Two metal spheres are mounted on insulating stands

Presence of a -charge induces e- to move from A to B. The two spheres are

Sphere B is seperated from A using insulating stands. The two spheres have opposite charges

The excess charges distributes itself uniformly over the surfaces of the spheres

b. $r = 2.0m$; $F = 1.0N$; $q_1 + q_2 = 5.0 \times 10^{-5} C$

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

$$q_1 q_2 = \frac{Fr^2}{q}$$

$$= \frac{1 \times 2^2}{9 \times 10^9} = \frac{4}{9 \times 10^9} = 4.44 \times 10^{-10} C.$$

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

$$q_1 q_2 = 4.44 \times 10^{-10} C \quad - ii$$

$$q_2 = \frac{4.44 \times 10^{-10}}{q_1} \quad - iii$$

Substitute eq (iii) into i

$$q_1 + \frac{4.44 \times 10^{-10}}{q_1} = 5.0 \times 10^{-5}$$

Let $q_1 = x$

$$\frac{x}{1} + \frac{4.44 \times 10^{-10}}{x} = 5.0 \times 10^{-5}$$

$$\frac{x^2 + 4.44 \times 10^{-10}}{x} = 5.0 \times 10^{-5}$$

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

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

$$x = 3.85 \times 10^{-5}, \quad x = 1.15 \times 10^{-5}$$

Recall $x = q_1$

From equation i

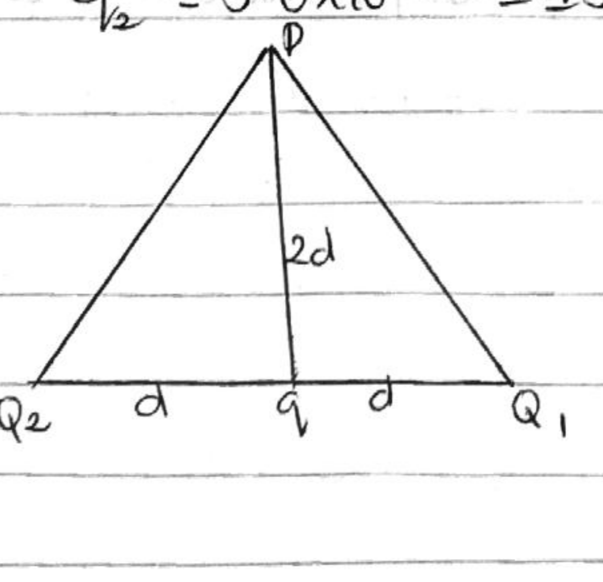
When $q_1 = 3.85 \times 10^{-5}$

$$q_2 = 5.0 \times 10^{-5} - 3.85 \times 10^{-5} = 1.15 \times 10^{-5}$$

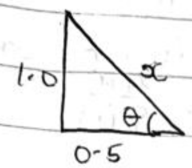
When $q_1 = 1.15 \times 10^{-5}$

$$q_2 = 5.0 \times 10^{-5} - 1.15 \times 10^{-5} = 3.85 \times 10^{-5}$$

c



$d = 0.5m$; $Q_1 = Q_2 = 8\mu C = 8\times10^{-6} C$, $P = 0$; $2d = 1m$



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

$x^2 = 1.25$

$x = \sqrt{1.25} = \sqrt{5}/2$

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

$\tan\theta = 2$

$\theta = \tan^{-1}(2)$

$\theta = 63.43$.

$F_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(\sqrt{5}/2)^2} = 57600 C$

$F_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(\sqrt{5}/2)^2} = 57600 C$

$F_3 = \frac{kq}{r^2} = \frac{9\times10^9 \times q}{1^2} = 9\times10^9 q C$

Vector	Angle	x-Component	Y-component
57600	63.43°	-25781.93	51507.78
57600	63.43°	-25781.93	51507.78
$9\times10^9 q$	90°	0	$9\times10^9 q$
		$\Sigma f_x = 0$	$\Sigma f_y = 103015.5 \times 9\times10^9 q$

$E = \sqrt{\Sigma f_x + \Sigma f_y}$

$0 = \sqrt{(0)^2 + (103015.56 \times 9\times10^9 q)^2}$

$0 = \sqrt{(103015.56 \times 9\times10^9 q)^2}$

$0 = 103015.56 \times 9\times10^9 q$

$q = \frac{103015.56}{9\times10^9}$

$q = 1.1446\times10^{-5} C$

$q = 11.45\times10^{-6} C$

$q = 11\mu C$

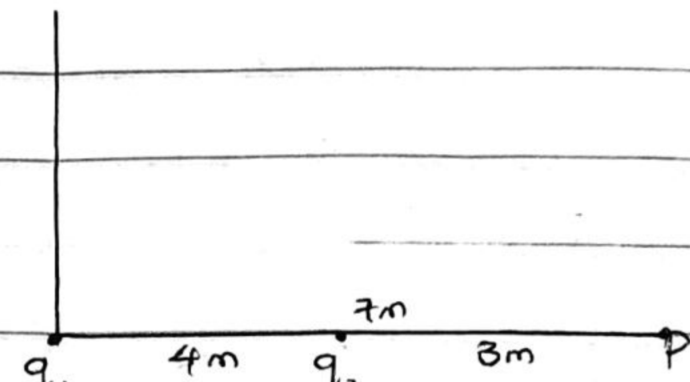
2a

Electric field	Electric field intensity.
An electric field is a region of space in which an electric charge will experience an electric force	Electric field intensity E can be defined as the force per unit charge. $E = \frac{F(N)}{q_0(C)}$

bi

$Q_1 = 8nC$

$Q_2 = 12nC$

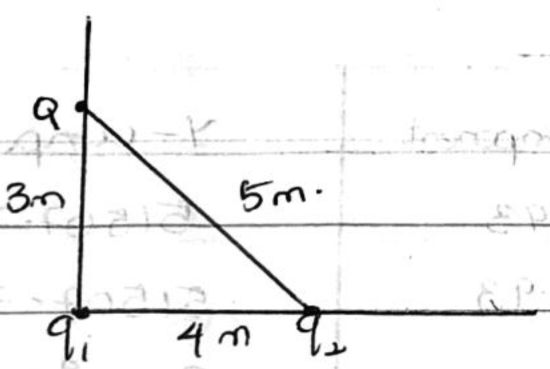


$E_1 = \frac{Kq_1}{r_1^2} = \frac{(9\times10^9)(8\times10^{-9})}{(7)^2} = 1.47$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{(9\times10^9)(12\times10^{-9})}{(3)^2} = 12$

$E_{net} = E_1 + E_2 = 1.47 + 12 = 13.47 \simeq 13.5\,N/C.$

ii



$3^2 + 4^2$
$= \sqrt{9+16} = \sqrt{25}$
$= 5m$

$E_1 = \frac{Kq_1}{r_1^2} = \frac{(9\times10^9)(8\times10^{-9})}{(3)^2} = 8$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{(9\times10^9)(12\times10^{-9})}{(5)^2} = 4.32$

$E_{net} = E_1 + E_2 = 8 + 4.32 = 12.32 \simeq 12.3\,N/C.$

4a Magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by Φ

b. $m = \cancel{9.11}\ 9.11\times10^{-3}kg$; $r = 1.4\times10^{-7}m$; $B = 3.5\times10^{-1}$ weber/meter^2

$q = 1.6\times10^{-19}C$

$$\text{Cyclotron frequency} = \frac{qB}{m}$$

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

$$= \frac{5.6\times10^{-20}}{9.11\times10^{-31}}$$

$$= 6.15\times10^{10}\ \text{rad/s.}$$

a) Biot-Savart Law is an equation that describes the magnetic field created by a current-carrying wire, and allows you to calculate its strength at various points

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

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

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

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

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

Substituting ii into i

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

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

Recall $dl = dy$

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

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

Using special integrals

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

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

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

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

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,

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

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

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

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