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Computer Science

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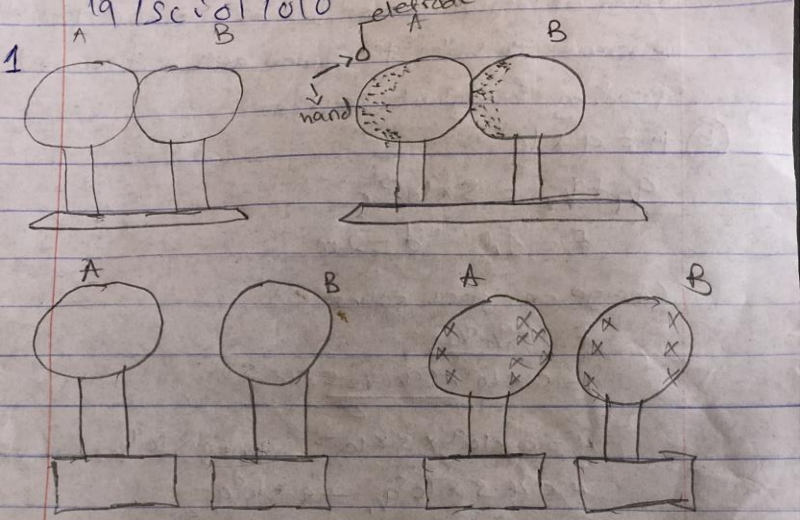


Considering the above diagram, two metal spheres A and B touching each other, A negatively charged rubber baloon is ~~bro~~ brought. If we bring the charged ballon near the spheres, electrons within two sphere system will be induced to move away from the ballon due to the repulsion between the electrons of the ballon and the spheres. Subsequently, the electrons from sphere A get transferred to sphere B. The migration of electrons cause the sphere A to become positively charged and the sphere B to be negatively charged. The overall two-sphere system is hence electrically neutral. The spheres are then seperated

using an insulating cover such as gloves or a stand. When we remove the ballon, the charge gets re distributed spreading throughout the spheres.

(b) $k = 9 \times 10^{9}$

$q_1 + q_2 = 5 \times 10^{-5} c$

$F = 1N \quad d = 2m$

Charge on each sphere = ?

$F = \frac{kq_1 q_2}{r^2}$

$1 = 9 \times 10^{9} \times \frac{(q_1 q_2 \; 5 \times 10^{-5})}{2^2}$

$4 = 9 \times 10^{9} \times 5 \times 10^{-5} \quad q_1 + 9 \times 10^{9} q_2$

$4 = 4.5 \times 10^{5} q_1 + 9 \times 10^{9} q_2$

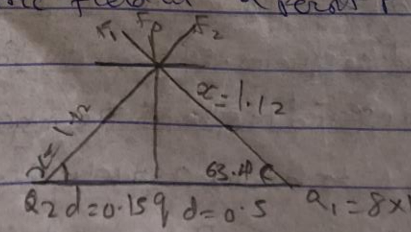
$9 \times 10^{9} q_2 - 4.5 \times 10^{5} q_1 + 4 = 0$

$q_1 = 0.0000111C \cong 1.11 \times 10^{-5} c$

$q_2 = 0.000038C \cong 3.8 \times 10^{-5} c$

(c) $q_1 = q_2 = 8uc \qquad d = 0.5m$

If electric field at a point P is zero



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

make q S.O.F

$$q = \frac{10269.52568}{9\times10^{9}}$$

$$q = 1.1405028\,53\times10^{-16}$$

$$q = 11.4\mu\, C$$

3a Volume Charge density: Formulation for the volume charge density is $\rho = \frac{q}{V}$, where ρ in volume density

q is the charge

V is the volume of distributio

S.I unit for volume charge density is Cm^{-3}

(ii) Surface Charge density: Formulation for surface Charg density is $6 = \frac{q}{A}$, where 6 is surface Charge

q is the Charge

A is the area of surfac

S.I unit for ~~volume~~ Surface Charge density is Cm^{-2}

(iii) Linear Charge density; Formulation for linear Charge density is $\lambda = \frac{q}{L}$, where λ is linear Char

q is the Charge

L is the length over wh is distributed.

S.I unit of linear Charge is Cm^{-1}

$$\sqrt{x^2} = \sqrt{1.25}$$

$$x = \sqrt{1.25}$$

$$x = 1.12$$

$$\tan\theta = \text{opp}/\text{adj}$$

$$\tan\theta = 1/0.5$$

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

$$\theta = 63.4$$

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2}$$

$$= 57397.9578$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

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

Vector		Angle	x-Component	y-Component
E_1	57397.95918	63.4°	$E_1\cos\theta = 2570.043785$	$E_1\sin\theta = 5132.262839$
E_2	57397.95918	63.4°	2570.043785	5132.262839
E_q	$= 9\times10^{9}q$	90	$E_q\cos\theta = 0$	$9\times10^{9}q$
			$Ex = 0$	$Ey = 10264.52568$

$$\text{magnitude} = \sqrt{(Ex)^2+(Ey)^2}$$

$$E_q = \sqrt{(0)^2+(10264.52568)^2}$$

Since $E_q = 0$

$$0 = 9\times10^{9}q + 10264.52568$$

4(a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of force. It is represented by the given symbol ~~ϕ~~ ϕ mathematically as $\oint B \cdot dn$

(b) $m = 9 \times 10^{-31}$ kg

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

$B = 3.5 \times 10^{-1}$ weber/meter^2

Cyclotron frequency = angular speed

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

$$\omega = qB/m = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$

$$\omega = 6.22 \times 10^{10}\ s^{-1}$$

(c) mass of electron = 9.11×10^{-31} kg

radius = 1.4×10^{-7} m

magnetic field = 3.5×10^{-1} weber/meter

cyclotron frequency can be called angular

Recall angular speed $(\phi) = v/r = \frac{qB}{m}$

(b) Electric potential difference is the amount of work done to carry a unit charge from one point to another in an electric field. It is measured in volt (V) or joules per coulombs (J/C). It's a scalar quantity.

Elemental works done dw is given as

$$dw = f \cdot dl \ldots (1)$$

$$F = q_0 F \ldots (2)$$

substituting equation 2 in 1 = $dw = -q_0 E dl \ldots (3)$

Total work done in moving the test charge from A to B is $W(A' \cap B)_{Ag} = -q_0 \int_A^B E dl \ldots (4)$

From definition of electrical potential difference. It follows that

$$VB - VA = \frac{W(A' \cap B)_{Ag}}{q_0} \ldots (5)$$

Putting equation 4 into 5 gives

$$VB - VA = \int_A^B E dl \ldots (6)$$

substituting we have $W = V/r = qB/m = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$

$= 6.22\times10^{10}\,T^{-1}$

so cyclotron frequency $= 6.22\times10^{10}\,T^{-1}$, the w in equal to the unit of frequency dimensionally.

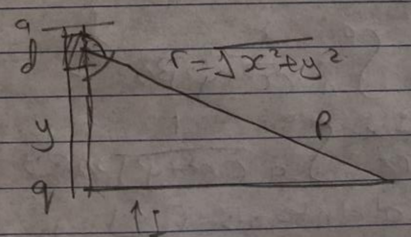
5(a) Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (u), to current (I) the change in length, the radius and inversely proportional to the square of radius (r^2) it can be represented mathematically by:

$dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$ where u is a constant called permeability of free space.

$u = 4\pi\times10^{9}\,T\,m/A$

unit of B is weber/metre square

(b) magnetic field of a straight current carrying conductor.



A section of a straight current carrying conductor

Applying the Biot-Savart law, we find the magnitude of the field

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

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

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

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

$\cancel{\therefore B = \frac{\mu_0 I}{4\pi}}$

from diagram, $r^2 = x^2+y^2$ (Pythagoras theorem)

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

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

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

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

Recall $dl = dy$

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

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

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

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

When the length $2a$ of the conductor is very great in comparison to it's distance from point P, we consider it infinitely. That B, when a is much larger than x, $(x^2+a^2)^{1/2} \simeq a$, as $a \to \infty$

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

In a physical situation, we have a axial symmetry about y-axis, ... at all point on a circle conductor, the magnitude of B is

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

magnitude of the magnetic field of flux density B near a long straight current carrying conductor).