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19/MHS11/028
Pharmacy
Physics 102 Assignment

1. Explain with the aid of a diagram how you can produce a negatively charged sphere by method of induction.

Answer

Let's take two spheres for example. Sphere A and sphere B touching each other as shown in the figure below. Let it take in negatively charged rubber ballon. If we bring the charged ballon near the sphere electrons within the two sphere system will be induced to move away from the due to repulsion between the electrons of the ~~electrons~~ ballons and the sphere. The electrons from the sphere A yet to be transferred to sphere B. The movement of the electrons causes sphere A to become positively charged and sphere B negatively charged. The overall two sphere system becomes electrically neutral. The sphere are then seperated using an insulating cover such as gloves or a stand.

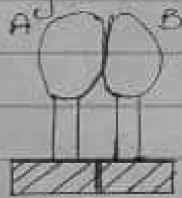

Fig I: Two spheres are mounted on an insulating stand.

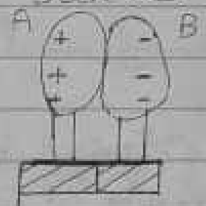

Fig II: The presence of a negatively charge induce to move from A to B. The two sphere is polarized

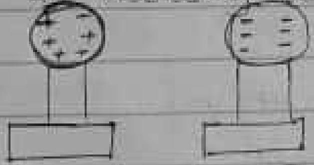

Fig III: Sphere A is seperated from sphere B using the insulating stand.

Fig IV: The excess charge distributes itself over the surface of the sphere uniformely

1b. Force = 1.0N r = 2.0m

∴ Combined charge $(q_1 + q_2) = 5.0 \times 10^{-5} C$

$F = \frac{kq_1q_2}{r^2} = 1.0N$, (Like charges repel)

$q_1q_2 = \frac{1.0r^2}{k}$

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$\Delta\Phi = BA$, $A = \pi r^2 = 3.142 \times 0.1^2$
$= 0.03142$

$\therefore \Delta\Phi = 107 \times 0.03142 = 3.362$ $\therefore$ $Emf = \frac{300 \times 3.362}{0.5} = 2017.$

$Emf = 2017.2V$

ii) Induced Current $(I) = \frac{Emf}{R} = \frac{2017.2}{20} = 100.9A$

$\therefore I = 100.9A$

6c) $I = 0.1A$, Number of turns$(N) = 75$, $R = 8\Omega$

$Area = \frac{5}{100} \times \frac{8}{100} = 0.05 \times 0.08 = 0.004m^2$ $\therefore A = 0.004m^2$

From faraday's law, $Emf = -\frac{N d\Phi}{dt}$ —(*)

$\Phi = BA$, —(**)

Combining (*) and (**) we have $Emf = NA\frac{dB}{dt}$

recall that $I = \frac{Emf}{R}$, $\therefore$ $Emf = IR$

To find the rate of change, $\frac{dB}{dt} = -\frac{IR}{NA}$

$\therefore \frac{dB}{dt} = \frac{0.1 \times 8}{75 \times 0.004}$

$\frac{dB}{dt} = \frac{0.8}{0.3}$

$\frac{dB}{dt} = 2.67 T/s$

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$\mu_0 = 4\pi \times 10^{-7} N/A$

$$dB = \frac{\mu_0}{4\pi} \cdot \frac{I dL \sin\theta}{r^2}$$

$$dB = \frac{\mu_0}{4\pi} \int \frac{I dL r}{r^2}$$

$$dB = \frac{\mu_0}{4\pi} \cdot \frac{I dL}{r}$$

We continue with integration

$$\int dB = B = \frac{\mu_0}{4\pi} \cdot \int \frac{I dL}{r} =$$

$$B = \frac{\mu_0 2L}{4\pi r} = \frac{\mu_0 L}{2\pi r}$$

where

B is magnetic field in Tesla
μ_0 is permeability of free space
L is current in the wire in ampere
r is distance from the wire in metre

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5a. The Biot-savart's law states that the magnetic intensity at any point due to a steady Current in an infinitely straight wire is directly proportional to the current and inversely proportional to the direction from point to wire. It is also an equation that describes the magnetic field created by a current-carrying wire, and allows you to calculate its strength at various points. And we also replace the electric fied E with a magnetic field element dB because a moving charge produces a magnetic field, not an electric field.

5b. The magnitude field $d\vec{B}$ due to an element $d\vec{I}$ of a current cary conductor is given as

$$d\vec{B} = \frac{\mu_0 \, d\vec{I} \, \hat{r}}{4\pi \cdot r^2}$$

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Vectors	Angle θ	horizontal Comp	Vertical Comp
E_1 = 5739.795918	63.4°	$E_1\cos\theta$ = -2570.045785	$E_1\sin\theta$ = 5132.262839
E_2 = 5739.795918	63.4°	$E_2\cos\theta$ = 2570.045785	$E_2\sin\theta$ = 5132.262839
$E_q = 9\times10^9 q$	90°	$E_q\cos\theta$ = 0	$E_q\sin\theta$ = $9\times10^9 q$
		0	$10264.52568 + 9\times10^9 q$

$$\therefore E_q = \sqrt{(Ex)^2 + (Ey)^2} = \sqrt{(0)^2 + (10264.52568 + 9\times10^9 q)^2}$$

$\cancel{9\times10^9 q = -102}$ $\therefore\ 0 + \sqrt{10264.52568 + 9\times10^9 q)^2}$

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

$$9\times10^9 q = -10264.52568 \Rightarrow q = \frac{-10264.52568}{9\times10^9}$$

$q = 1.14\times10^{-6} C = 11.4 \mu C$

2a.) Electric field is a region in which electrostatic force is exerted on a charge by another charge.

Electric field intensity is the strength of an electric field at any point in space.

2b.)

$E = \frac{kQ}{r}$

i.) $E_x = \frac{8nC}{7^2} + \frac{12nC}{4^2} \Rightarrow \frac{8\times10^{-9}}{49} + \frac{12\times10^{-9}}{16}$

$E_x = 163.5\times10^{-12} + 15.0\times10^{-12} = 913.3\times10^{-12} C$

ii.) $E_y = \frac{8nC}{(7-4)^2} = \frac{8\times10^{-9}}{3^2} = \frac{8\times10^{-9}}{9}$

$\therefore E_y = 888.9\times10^{-12} C$

6a.) Faraday's Law is a basic rule/law in physics. The electric guitar consists of a string which will produce electricity only for as long as the magnetic field is changing. This simply means that a changing magnetic field produces electricity. If the metal strings stops moving, the sound stops.

6b.) $R = 20\Omega$, $r = 10cm = 0.1m$, Number of turns $(N) = 500$

$t = 0.5sec$ $B = 10T$

(i) Emf (electromotive force in coil) $= N\frac{\Delta\phi}{\Delta t}$

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$K = 8.99 \times 10^{9}\ N.m^2C^{2}$

$q_1q_2 = \frac{1 \times 2^{3}}{8.99 \times 10^{9}} = \frac{4 \times 10^{-9}}{8.99} \Longrightarrow q_1q_2 = 4.449 \times 10^{-10}C^{2}$

We now have two equation for two unknown charges(q_1 and q_2)

$q_1(5.0 \times 10^{-5} - q_1) = 4.449 \times 10^{-10} \Rightarrow (5.0 \times 10^{-5})q_1 - q_1^{2} = 4.449 \times 10^{-10}$

$\therefore q_1^{2} - (5.0 \times 10^{-5})q_1 + 4.449 \times 10^{-10} = 0$

From quadratic equation formula $\left(-b \pm \frac{\sqrt{b^2 - 4ac}}{2a}\right)$

$q_1q_2 = \frac{-(5.0 \times 10^{-5}) \pm \sqrt{(5.0 \times 10^{-5})^{2} - 4 \times 1 \times 4.449 \times 10^{-10}}}{2(1)}$

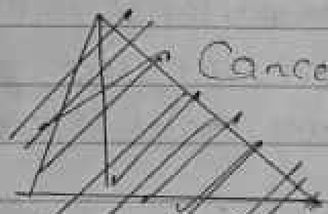
$= \frac{-5 \times 10^{-5} \pm \sqrt{0.0070999}}{2} \Rightarrow \frac{-5.0 \times 10^{-5} \pm 0.8426}{2}$

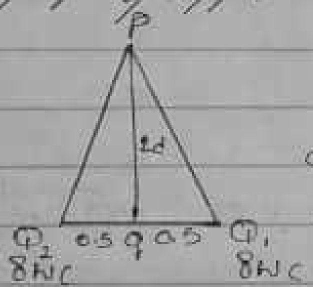
$q_1q_2 = -5.0 \times 10^{-5} \pm 0.4213$

$\therefore q_1 = -5.0 \times 10^{-5} + 0.4213 = 3.84 \times 10^{-5}C$

$\therefore q_2 = -5.0 \times 10^{-5} - 0.4213 = 1.16 \times 10^{-5}C$

1c.)



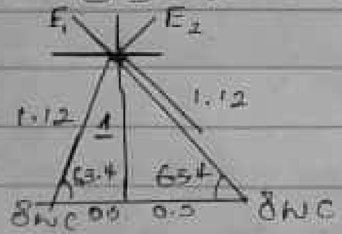


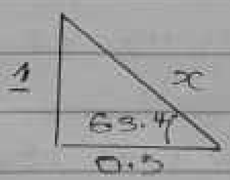
$Q_1 = Q_2 = 8\mu C$, $d = 0.5m$

determine Q if electric field is at a point $P = 0$

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

$\tan\theta = 1/0.5 = 2$ $\therefore \theta = \tan^{-1}2 = 63.4$





From pythagoras

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

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

$x = 1.12$

$E_1 = \frac{Kq_1}{r^2} = \frac{9 \times 10^{9} \times 8 \times 10^{-6}}{(1.12)^{2}} = 5739.795918$, $E_1 = E_2 = 5739.795918$

$E_q = \frac{Kq}{r^2} = \frac{9 \times 10^{9} \times q}{1^{2}} = 9 \times 10^{9}ev$

Using tabular vector method