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COURSE CODE: PHY 102

DEPARTMENT : MEDICINE AND SURGERY

MATRIC NO: 19/MHS01/366

COVID-19 HOLIDAY ASSIGNMENT

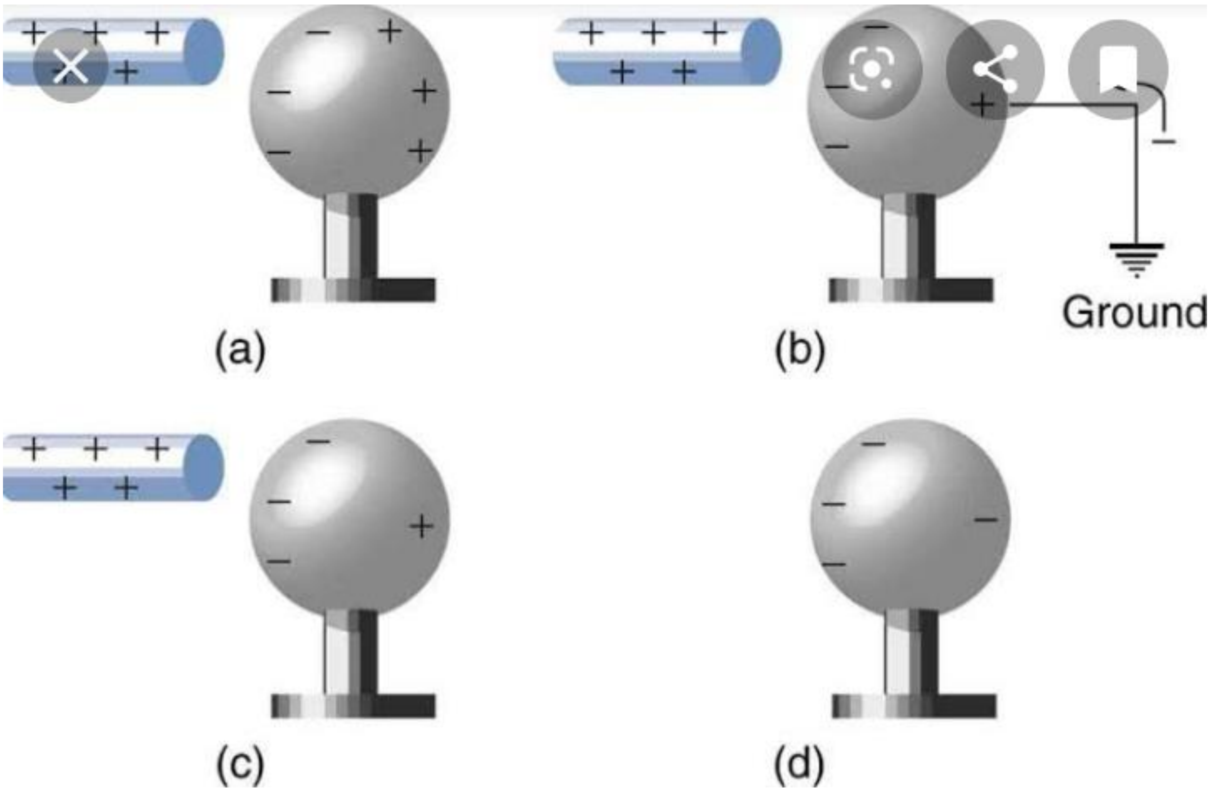
Instruction: Answer Four (4) Questions in All - two from Section A and two from section B.

SECTION A

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

CHARGING BY INDUCTION

This is a method of producing electrical charges. It does not require contact with the object it is being charged with. This method of producing charges would produce a charged sphere with an opposite charge to the object it was charged with. The sphere to be charged is insulated so there would be no conducting path to the ground. Since we are producing a negatively charged sphere, a positively charged rod would be brought close to the sphere but not in contact with it . A repulsive force between the proton in the rod and that in the sphere causes a redistribution of charges on the sphere some protons move to the part of the sphere farthest from the rod . This causes the region of the sphere closer to the rod have an excess negative charge (electron). A conducting wire is connected to the sphere causing the protons to leave to the ground. If the wire is removed, the sphere is left with excess electrons causing the sphere to be negatively charged . The rubber rod is taken away from the vicinity of the sphere and the electrons becomes uniformly distributed on the surface of the sphere.



CHARGING BY INDUCTION

(b) Each of two small spheres is charged positively, the combined charge being 5.0×10^{-5}C. If each sphere is repelled from the other by a force of 1.0N when the spheres are 2.0m apart, calculate the charge on each sphere.

1b)

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let the sphere be P and Q
let the charges on the sphere be
p C and q C

$p+q=5.0\times10^{-5}C$ — (1)

$F=1.0N$, $d=2.0m$

Recall,

$F=\frac{kq_1q_2}{r^2}$

$1.0N=\frac{9\times10^9\times p\times q}{2^2}$

$1.0\times4=9\times10^9\times pq$

$pq=\frac{4.0}{9\times10^9}$

$pq=0.44\times10^{-9}$ — (11)

from — (11)

$p=\frac{0.44\times10^{-9}}{q}$

Sub in — (1)

$\frac{0.44\times10^{-9}}{q}+q=5.0\times10^{-5}$

multiply each term by q

$0.44\times10^{-9}+q^2=5.0\times10^{-5}q$

$q^2-(5.0\times10^{-5})q+(0.44\times10^{-9})=0$

compare with

$ax^2+bx+c=0$

$a=1, b=-(5.0\times10^{-5}), c=(0.44\times10^{-9})$

Using Quadratic formular

$\frac{-b\pm\sqrt{b^2-4ac}}{2a}$

$q=\frac{-(-5.0\times10^{-5})\pm\sqrt{(-5.0\times10^{-5})^2-4(1)(0.44\times10^{-9})}}{2(1)}$

$q=\frac{(5.0\times10^{-5})\pm\sqrt{(25\times10^{-10})-(1.76\times10^{-9})}}{2}$

$q=\frac{(5.0\times10^{-5})\pm\sqrt{7.4\times10^{-10}}}{2}$

$q=\frac{(5.0\times10^{-5})+2.72\times10^{-5}}{2}$ or $\frac{(5.0\times10^{-5})-(2.72\times10^{-5})}{2}$

$q=\frac{7.72\times10^{-5}}{2}$ or $\frac{2.28\times10^{-5}}{2}$

$q=3.86\times10^{-5}C$ or $1.14\times10^{-5}C$

Recall $p+q=5.0\times10^{-5}$

$p=5.0\times10^{-5}-(3.86\times10^{-5})$
$=1.14\times10^{-5}C$

OR

$p=5.0\times10^{-5}-(1.14\times10^{-5})$
$=3.86\times10^{-5}C$

(c) Three charges were positioned as shown in the figure (I) below. If Q1=Q2=8uC and , d=0.5m, determine if the value of q if the electric field at p is zero.

1c)

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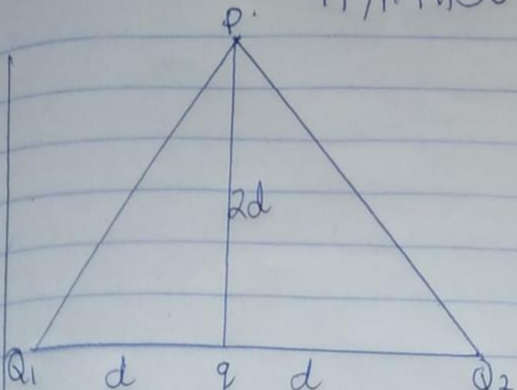
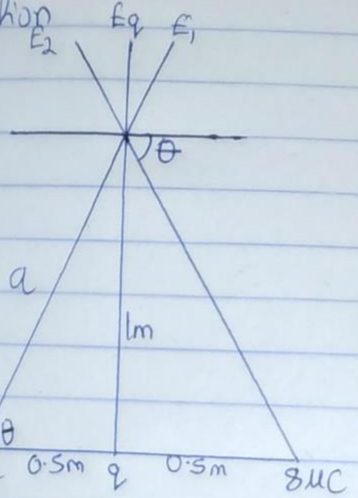


Figure (1)

Solution



$a^2 = 1^2 + 0\cdot5^2$

$a^2 = 1 + 0\cdot25$

$a = \sqrt{1\cdot25} \Rightarrow 1\cdot12m$

$E_1 = E_2 = \frac{(9\times10^9)\times(8\times10^{-6})}{(1\cdot12)^2}$

$= 57\cdot6\times10^3 N/C$

$E_q = \frac{(9\times10^9)\times q}{1}$

$= (9\times10^9)q\ N/C.$

Recall; ~~Using~~ SOH/CAH/TOA

Using TOA

$\tan\theta = \frac{1}{0\cdot5}$

$\tan\theta = 2$

$\theta = \tan^{-1}(2) \Rightarrow 63\cdot4^0.$

~~Vector~~	~~θ~~	~~X-Component~~	~~Y-Component~~
~~$57\cdot6\times10^3$~~	~~63·4~~	~~$2\cdot58\times10^{-2}$~~	
~~$57\cdot6\times10^3$~~	~~63·4~~	~~$-2\cdot58\times10^{-2}$~~	
~~$(9\times10^9)q$~~	~~90~~	0	

Vector	θ	X-Component	Y-Component
$57\cdot6\times10^3$	63·4	25790·92	51503·28
$57\cdot6\times10^3$	63·4	-25790·92	5150·3·28
$(9\times10^9)q$	90	0	$(9\times10^9)q$

$\Sigma x = 25790\cdot92 - 25790\cdot92 + 0$

$= 0$

$\Sigma y = 51503\cdot28 + 5150\cdot28 + (9\times10^9)q$

$= 103006\cdot568 + (9\times10^9)q.$

$E_p = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E_p = \sqrt{0^2 + (103006\cdot568 + (9\times10^9)q)^2}$

Recall $E_p = 0$

$0 = 103006\cdot568 + (9\times10^9)q.$

$-103006\cdot568 = (9\times10^9)q.$

$q = \frac{-103006\cdot568}{9\times10^9}$

$= 0\cdot000011 4C$

$= 11\cdot4\ \mu C$

2. (a) Distinguish between the terms: electric field and electric field intensity.

Electric field is a region of space where an electric charge experiences an electrical force WHILE electric field intensity also know as electric field strength is the force per unit charge found in an electric field.

(b) A positive charge Q1=8uC is at the origin, and a second positive charge Q2=-12uC is on the axis at x=4m . Find

(i) the net electric field at a point P on the axis at x=-7m

(ii) the electric field at a point Q on the y-axis at y=3m due to the charges.

2b)

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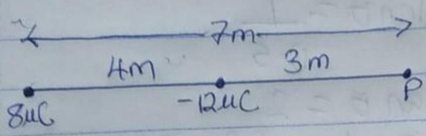
2b

(i)



$$E_1 = \frac{9\times10^9 \times 8\times10^{-9}}{7^2}$$

$= 1.47 N/C$

$$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{3^2}$$

$= 12 N/C$

Vector	θ	X-Component	Y-Component
1.47N/C	0	Cos 0 × 1.47 = 1.47	Sin 0 × 1.47 = 0
12	0	Cos 0 × 12 = 12	Sin 0 × 12 = 0

$\Sigma x = 1.47 + 12$
$= 13.47$

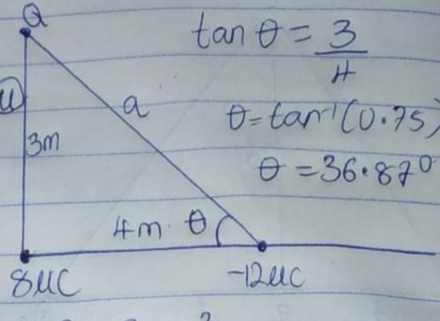
$\Sigma y = 0 + 0$
$= 0$

$E_p = \sqrt{(13.47)^2 + 0^2}$

$= 13.47$

$\simeq 13.5 N/C$

(ii)



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

$\theta = \tan^{-1}(0.75)$

$\theta = 36.87^0$

$a^2 = 3^2 + 4^2$

$a^2 = 25$

$a = \sqrt{25} = 5m$

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

$= 8 N/C$

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

$= 4.32 N/C$

Vector	θ	X-Component	Y-Component
8	90°	Cos 90 × 8 = 0	Sin 90 × 8 = 8
4.32	36.87	Cos 36.87 × 4.32 = 3.456	Sin 36.87 × 4.32 = 2.592

$\Sigma x = 0 + 3.456$
$= 3.456$

$\Sigma y = 8 + 2.592$
$= 10.592$

$E_Q = \sqrt{(3.456)^2 + (10.592)^2}$

$= 11.2 N/C$

SECTION B

4 (a) What is Magnetic flux?

Magnetic flux is the strength of a magnetic field which is indicated by magnetic lines of force. It is represented by the symbol ø.

(b) An electron with a rest mass of 9.11 x 10 -31kg moves in a circular orbit of radius 1.4×10^-7m in a uniform magnetic field of 3.5 x 10 -1 Weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron

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rest mass, $m = 9.11 \times 10^{-31}$ Kg
Radius, $r = 1.4 \times 10^{-7}$ m
Magnetic field, $B = 3.5 \times 10^{-1}$ tesla
cyclotron frequency, $\omega = ?$
charge, $q = 1.6 \times 10^{-19}$ C
Also, $\theta = 90°$
cyclotron frequency = anglar Speed, ω

Recall,

$$T = \frac{2\pi r}{v} = \frac{2\pi}{\omega}$$

$$\therefore \omega = \frac{2\pi v}{2\pi r}$$

$$\omega = v/r$$

Also, $r = \frac{mv}{qB}$

$$\therefore v = \frac{qBr}{m}$$

$$v = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$= 0.86 \times 104$$

$$= 8.6 \times 10^{3} \text{ m/s}.$$

$$\omega = \frac{8.6 \times 10^{3}}{1.4 \times 10^{-7}}$$

$$= 6.14 \times 10^{10} \text{ rad/s}$$

(c) Discuss your answer in 4b above.

The cyclotron frequency has the same value as the angular speed. This is because the electron is rotating in a type of accelerator called cyclotron.

Application Example

(1) A proton is moving in a circular orbit of 5. (a) State the Biot-Savart Law.

The **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. The mathematical equation of biot savant law is given as:

$$dB = \frac{Uo}{4¥} \frac{I\ dĺ \times ř}{r^2}$$

$Uo = 4¥ \times 10^{-7}$ T.m/A

(b) Using the Biot-Savart Law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as

$$B = \frac{UøI}{2¥r}$$

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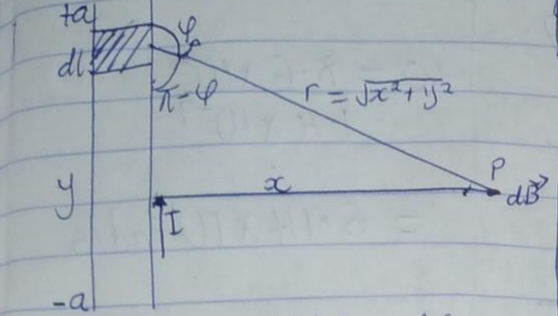

a sketch on of a straight Current Carrying conductor. FIGURE (I)

Applying Biot-Savart law;

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

Integrate

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

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

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

From figure (I) above, apply Pythagoras theorem

$$r^2 = x^2+y^2.$$

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

But $\sin(\pi-\varphi) = \dfrac{x}{\sqrt{x^2+y^2}}$ — (II).

Sub — (I) in (II)

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

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

But $dl = dy$.

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

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

Using Special Integrals.

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

Simplifying — (III)

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

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

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

When the length of the conductor, 2a is very great in comparison to its distance x from point P

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

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