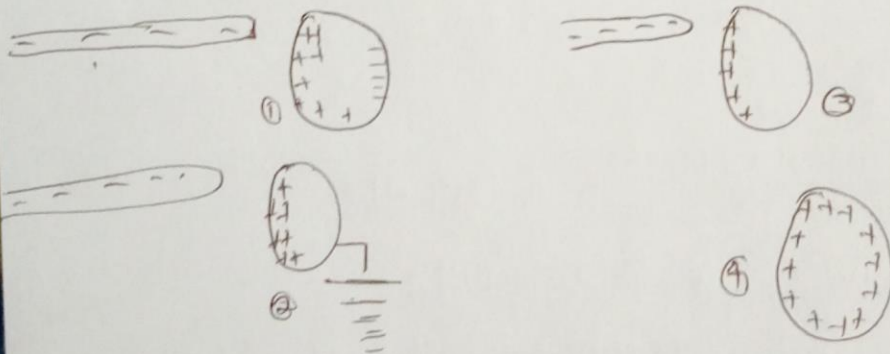


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1. Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conductive path to the ground as shown below. The repulsive force between the electrons in the rod and those on the sphere causes a redistribution of charges on the sphere so that some of the electrons move to the side of the sphere farthest away from the rod.

The region of the sphere nearest the relatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere, some of the electrons leave the sphere and travel to the earth. If the wire is then removed, the sphere is left with an excess of induced positive charge.

Finally, when the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.



$$q_1 + q_2 = 5 \times 10^{-5} \text{ C}, \quad q_1 = 5 \times 10^{-5} - q_2$$

$$F = K \frac{q_1 q_2}{r^2}, \quad 4 = \frac{9 \times 10^9 q_1 q_2}{2^2}$$

$$4 = 9 \times 10^9 \times (5 \times 10^{-5} - q_2) q_2$$

$$4 = 4 \cdot 5 \times 10^{-5} q_2 - 9 \times 10^9 q_2^2$$

$$-9 \times 10^9 q_2^2 + 4 \cdot 5 \times 10^{-5} q_2 - 4 = 0$$

using quadratic formula,  $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$$q_2 = \frac{-4 \cdot 5 \times 10^{-5} \pm \sqrt{(4 \cdot 5 \times 10^{-5})^2 - 4(-9 \times 10^9)(-4)}}{2(-9 \times 10^9)}$$

$$q_2 = \frac{4 \cdot 5 \times 10^{-5} \pm \sqrt{5 \cdot 8 \times 10^{10}}}{-18 \times 10^9}$$

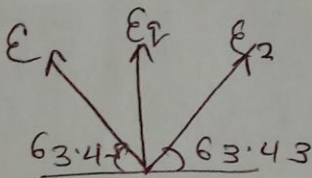
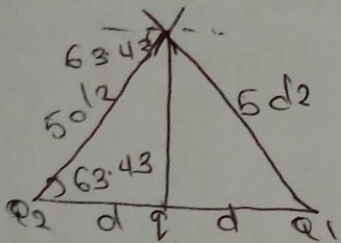
$$q_2 = \frac{4 \cdot 5 \times 10^{-5} \pm 241869}{-18 \times 10^9}$$

$$q_2 = 1 \cdot 156 \times 10^{-5} \text{ C or } 3 \cdot 84 \times 10^{-5} \text{ C}$$

$$q_1 = 1 \cdot 156 \times 10^{-5} \text{ C}$$

$$q_2 = 3 \cdot 84 \times 10^{-5} \text{ C}$$

c)



$$\sqrt{d^2 + d^2} = d\sqrt{5}, \quad \tan \theta = \frac{2d}{d}$$

$$\tan^{-1}(2) = 63.43^\circ$$

$$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times (8 \times 10^{-6})}{(d\sqrt{5})^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(\sqrt{5}/2)^2} = 57600 \text{ N/C}$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{9 \times 10^9 \times (8 \times 10^{-6})}{(d\sqrt{5})^2} = 57600 \text{ N/C}$$

$$EQ = \frac{kQ}{r^2} = \frac{9 \times 10^9 \times 9}{(2d)^2} = \frac{9 \times 10^9}{1^2} = 9 \times 10^9 \text{ N/C}$$

vector $\vec{A}$	$\theta$	x component	y component
$\vec{A}_1 = 57600 \text{ N/C}$	$63.43^\circ$	$57600 \cos 63.43$ $= -25764$	$57600 \sin 63.43$ $= +51516.8$
$\vec{A}_2 = 57600 \text{ N/C}$	$63.43^\circ$	$57600 \cos 63.43$ $= +25764$	$57600 \sin 63.43$ $= +51516.8$
$\vec{A}_3 = 9 \times 10^9 \text{ N/C}$	$90^\circ$	$9 \times 10^9 \cos 90$ $= 0$	$9 \times 10^9 \sin 90$ $= 9 \times 10^9$
		$\vec{E}_x = 0$	$\vec{E}_y = 103033.6 + 9 \times 10^9$

$$E_{\text{net}} = \sqrt{E_x^2 + E_y^2}$$

but  $E_{\text{net}} \text{ at point P} = 0$

$$0 = \sqrt{0^2 + (103033.6 + 9 \times 10^9)^2}$$

$$0 = 103033.6 + 9 \times 10^9$$

$$q = \frac{-103033.6}{9 \times 10^9}$$

$$q = -1.1448127778 \times 10^{-5}$$

$$q = -11.4 \times 10^{-6}$$

$$q = -11.4 \text{ nC}$$



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4) The magnetic flux is defined as the strength of a magnetic field represented by lines of force. It is usually represented by the symbol  $\Phi$

4b)  $m_e = 9.11 \times 10^{-31} \text{ kg}$ ,  $r = 1.4 \times 10^{-7} \text{ m}$   $\theta = 90^\circ$   
 magnetic field =  $3.5 \times 10^{-1} \text{ Weber meter}^2 \text{ s}^{-1} \theta = 1$   

$$W = \frac{qB}{m} \quad W = \frac{1.6 \times 10^{-19} \times (3.5 \times 10^{-1})}{9.11 \times 10^{-31}}$$

$$W = 6.15 \times 10^{10} \text{ rad/s}$$

4c) An electron of mass  $9.11 \times 10^{-31} \text{ kg}$  and charge  $1.6 \times 10^{-19} \text{ C}$  in motion in a magnetic field of  $3.5 \times 10^{-1} \text{ Tesla}$  perpendicular with the field will have an angular frequency of  $6.15 \times 10^{10} \text{ rad/s}$

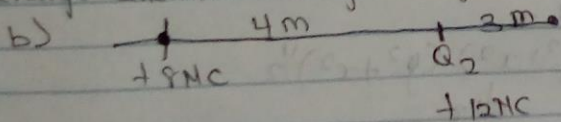
5a) The vector  $d\vec{B}$  is perpendicular to  $d\vec{l}$  which points in the direction of the current and to the unit vector  $\hat{r}$  directed from  $d\vec{l}$  towards  $P$   
 b) The magnitude of  $\vec{B}$  is perpendicular to  $d\vec{l}$  which points in the direction

b) The magnitude of  $d\vec{B}$  is inversely proportional to  $r^2$  where  $r$  is the distance from  $d\vec{l}$  to  $P$

c) The magnitude of  $d\vec{B}$  is proportional to the current  $I$  and to the magnitude of the length element  $d\vec{l}$

d) The magnitude of  $d\vec{B}$  is proportional to  $\sin \theta$ , where  $\theta$  is the angle between  $\hat{r}$  and  $d\vec{l}$

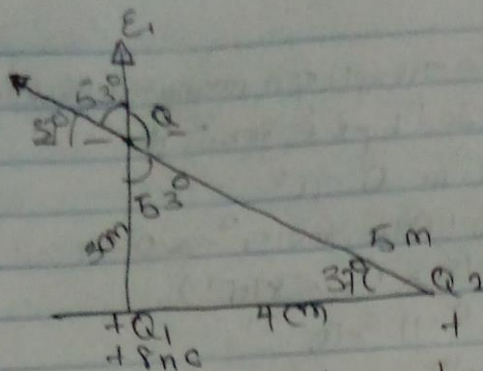
2a) An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the per unit charge experienced by a charge in an electric field.



$$F_1 = \frac{kQ_1}{r^2} = \frac{(9 \times 10^9) \times (9 \times 10^{-9})}{7^2} = 1.49 \text{ N/C}$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{(9 \times 10^9) \times (12 \times 10^{-9})}{8^2} = 12 \text{ N/C}$$

$$E_{\text{net}} = 1.474 + 12 = 13.47 \text{ N/C}$$



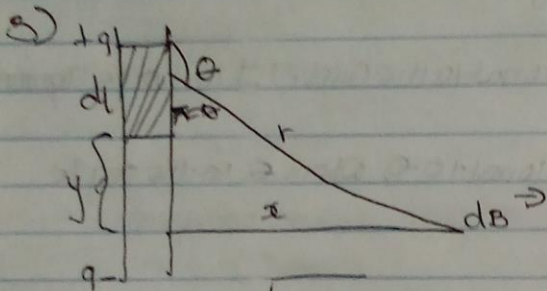
$$E_1 = \frac{kQ_1}{r^2} = \frac{9 \times 10^9 \times (8 \times 10^{-9})}{5^2} = 8 \text{ N/C}$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{(9 \times 10^9) \times (12 \times 10^{-9})}{5^2} = 4.32 \text{ N/C}$$

Vector	Angle	X-component	Y-component
$E_1 = 8 \text{ N/C}$	$90^\circ$	$8 \cos 90^\circ = 0$	$8 \sin 90^\circ = +8$
$E_2 = 4.32 \text{ N/C}$	$37^\circ$	$4.32 \cos 37^\circ = -3.45$	$4.32 \sin 37^\circ = +2.60$
		$E_x = -3.45 \text{ N/C}$	$E_y = 10.6 \text{ N/C}$

The resultant  $E$

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{(-3.45)^2 + (10.6)^2} = \sqrt{11.9025 + 112.36} = \sqrt{124.2625} = 11.147 \text{ N/C}$$



$$r = \sqrt{y^2 + x^2}$$

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

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

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

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

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

$$B = \frac{N_0 I}{2\pi r} \left[ \frac{a}{(a^2 + r^2)^{3/2}} \right]$$

$$(a^2 + r^2)^{3/2} \approx a^3$$

$$a \gg r$$

$$B = \frac{N_0 I}{2\pi r} \frac{a}{(a^2)^{3/2}}$$

$$= \frac{N_0 I}{2\pi r}$$

$$r = r$$

$$B = \frac{N_0 I}{2\pi r}$$

$$2\pi r //$$

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