5. Biot savart law states the magnetic field is directly proportional to the product permeability of free space (μ), the 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 μ_B is a constant called permeability of free space

$$\mu = 4\pi \times 10^{-7}\ T.m/A.$$

Unit of B is weber / metre square

5b. Magnetic field of a straight current carrying conductor

Recall $dl = dy$

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

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

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

Equation (3) become $B = \frac{\mu_0 i x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$

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

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

3a. volume charge density, $\rho = \frac{dQ}{dv}$ in $dQ = \rho\, dv$

surface charge density $\sigma = \frac{dQ}{dA}$ in $dQ = \sigma\, dA$

linear charge density $\lambda = \frac{dQ}{dL}$ in $dQ = \lambda\, dL$

3b. The electric potential difference between two Points in a electric field can be defined as the workdone per unit Charge against electric forces when a charge is transpo from one point to another. it is measured in volt(v) or Joules per coulomb(J/c) it is a scalar quantity.

Elemental work done dw is given as

$$dw = F \cdot dL \quad -(1)$$

$$F = -q_0 E \quad -(2)$$

substituting equation (2) in (1) = $dw = -q_0 E\, dL$ — (3)

Total work done in moving the test charge from A t

$$W(A \rightarrow B)_{Aq} = -q_0 \int_A^B E\, dL \quad -(4)$$

From the definition of electric potential difference it follow

$$V_B - V_A = \frac{W(A \rightarrow B)_{Aq}}{q_0} \quad -(5)$$

Putting equation (4) in (5) yields $V_B - V_A = -\int_A^B E\, dL$ — (6)

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$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.9598$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

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

vector	Angle	x-Component	y-Component
$E_1 = 51397.95918$	63.4°	$E_1 \cos\theta =$ 2570.045785	$E_1 \sin\theta =$ 5132.262839
$E_2 = 51397.95918$	63.4°	2570 = 045785	5132.262839
$E_q = 9\times10^9 q$	90°	$E_q \cos\theta = 0$ $E_x = 0$	$9\times10^9 q$ $E_y = 10264.52568$

$\text{Magnitude} = \sqrt{(E_x)^2 + (E_y)^2}$

$E_q = \sqrt{(0)^2 + (10264.525681)^2}$

Since $E_q = 0$

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

Making q subject of formula

$q = \frac{10264.52568}{9\times10^9}$ $\quad q = 1.140502853\times10^{-6}$

$q = 11.4\mu C$

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Section A

1a charging by induction

Electric charges can be obtained on an object without touching it by a process called electrostatic induction. Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the electrons in the rod, and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the negatively 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 in (fig 1.38), some of the electrons leave the sphere and travel to the earth. if the wire to ground is then removed, the conducting 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

The electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electric forces when a charge is transpo from one point to another. it is measured in volt(v) or Joules per coulomb(J/c) it is a scalar quantity.

Elemental work done dw is given as

$$dw = F \cdot dL \quad - (1)$$

$$F = -q_0 E \quad - (2)$$

substituting equation (2) in (1) = $dw = -q_0 E dL$ - (3)

Total work done in moving the test charge from A to

$$W(A \to B)_{Ag} = -q_0 \int_A^B E dL \quad - (4)$$

From the definition of electric potential difference it follows

$$V_B - V_A = \frac{W(A \to B)_{Ag}}{q_0} \quad - (5)$$

Putting equation (4) in (5) yields $V_B - V_A = -\int_A^B E dL$ - (6)

SECTION 3

4a magnetic flux is defined as the strength of the Magnetic field which can be represented by line of forces. it is represented by the symbol Φ. mathematically as $\Phi = B \cdot A$

4b $m = 9 \times 10^{-31} kg$

$r = 1.4 \times 10^{-9} m$

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

Cyclotron frequency = angular speed

$w = \frac{v}{r} = \frac{qB}{m}$

$w = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 35 \times 10^{-1}}{16.9 \times 10^{-5}}$

$w = 6.22 \times 10^{10} T^{-1}$ //

4c Mass of electron = $9.11 \times 10^{-31} kg$

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

magnetic field = 3.5×10^{-1} weber/meter^2

cyclotron frequency can be called Angular speed

Recall that Angular speed $w = \frac{v}{r} = \frac{qB}{m}$

Substituting we have $w = \frac{v}{r} = \frac{qB}{M} = \frac{1.6 \times 10^{-19} \times 35 \times 10^{-1}}{9.11 \times 10^{-31}}$

$= 6.22 \times 10^{10} T^{-1}$

so cyclotron frequency $= 6.22 \times 10^{10} T^{-1}$, the unit is equal to unit of frequency dimensionally

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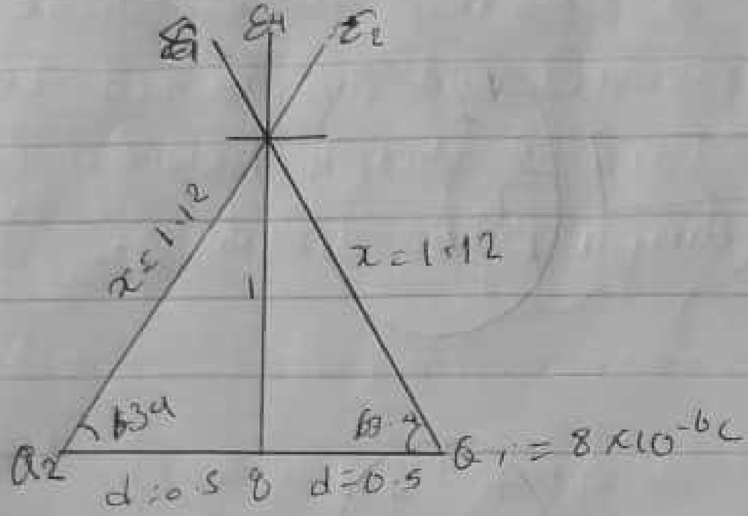
When the length of the conductor is very great in comparison to its distance x from point P, we consider it in pin Hely long That B, when q is much lager than x, $(x^2+q^2)^{1/2} = q$, 959 - 4

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

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

is $B = \frac{\mu_0 i}{2\pi r}$ ...



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

$x^2 = \sqrt{1.25}$

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = \frac{opp}{adj}$

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

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

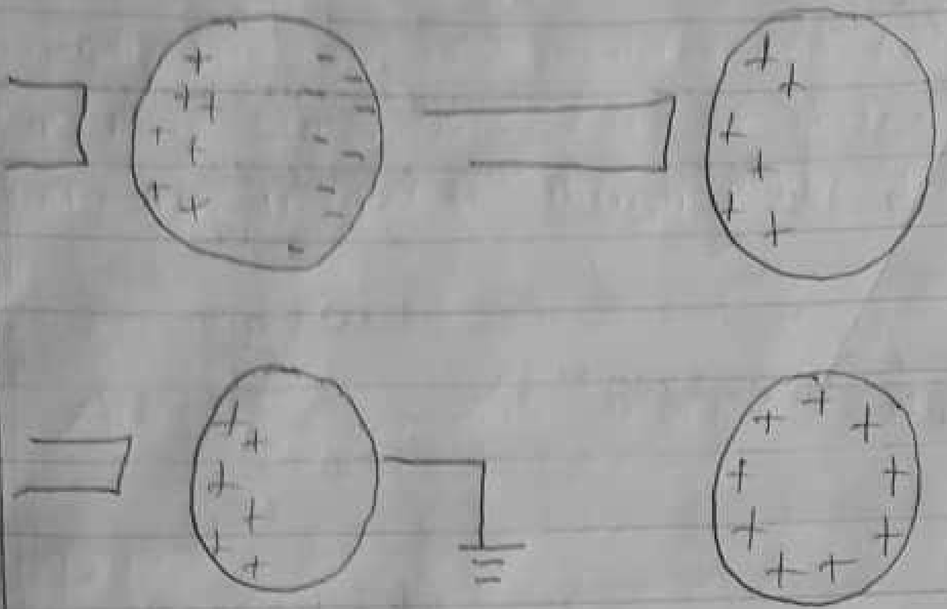
$\theta = 63.4$

$= \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.9598$

$= \frac{kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

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

ector	Angle	x-Component	y-Component
51397.95918	63.4°	$E_1 \cos\theta =$ 2570.045785	$E_1 \sin\theta =$ 5132.262839
51397.95918	63.4°	2570.045785	5132.262839
$= 9\times10^9 q$	90°	$E_9 \cos\theta = 0$	9×10^9



1b $k = 9 \times 10^9$

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

$f = 1N$

$d = 2m$

Charge on each sphere = ?

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

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

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

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

Quadratic equation

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

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

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

1c $Q_1 = Q_2 = 84C$

$d = 0.5m$

~~at~~ if Electric field at point P is zero