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MATRIC NO:19 /ENG05/042

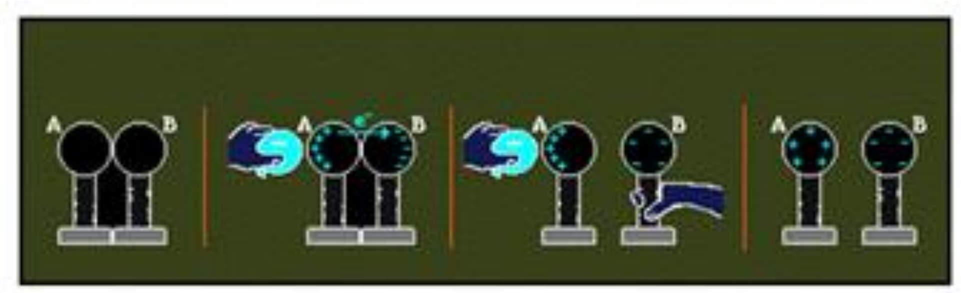
DEPARTMENT: MECHATRONICS

COURSE TITLE: GENERAL PYSICS

COURSE CODE:PHY102

ASSIGNMENT

1a. Most objects are electrically neutral which means that they have an equal number of positive and negative charges. In order to charge an object, one has to alter the charge balance of positive and negative charges. There are three ways to do it: friction, conduction and induction. The induction charging is a charging method that charges an object without actually touching the object to any another charged object. The charging by induction process is where the charged particle is held near an uncharged conductive material that is grounded on a neutrally charged material. The charge flows between two objects and the uncharged conductive material develop a charge with opposite polarity. Let us take a negatively charged rubber balloon. If we bring the charged balloon near the spheres, electrons within the two-sphere system will be induced to move away from the balloon due to the repulsion between the electrons of the balloon and the spheres. Subsequently, the electrons from sphere A get transferred to sphere B. The migration of electrons causes 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 separated using an insulating cover such as gloves or a stand as shown in the figure (avoiding direct contact with the metal). When we remove the balloon, the charge gets redistributed, spreading throughout the spheres



When a negatively charged balloon is brought near the sphere system, the electrons in the sphere will be forced to move away due to repulsion. The migration of electrons causes sphere A to become completely positive and sphere B to become negative.

1b. We are not given the values of the individual charges;

let them be q1 and q2.

The condition on the combined charge of the spheres gives us:

$q_1+q_2=5.0\times10^{-5}C$

The next condition concerns the electrostatic force, and so it involves Coulomb’s Law. Both charges are positive because their sum is positive and they repel each other, thus

$|q1|=q1$ and $|q2|=q2$

Now $F = k\frac{q1q2}{r2}$ =1.0N

We know k and r, so we can solve for the value of the product of the charges:

$q_1q_2= (1.0N)\frac{r2}{K}$

$(1.0N)(2.0m)_2 8.99\times10_9 N\cdot m_2 C_2=4.449\times10_{-10}C_2$

Now we have two equations for the two unknowns q1 and q2.

$q_2=5.0\times10_{-5}-q_1$

$q_1q_2=4.449\times10_{-10}$

$q_1(5.0\times10_{-5}-q_1)=4.449\times10_{-10}$

$(5.0\times10_{-5}q_1-q_{21})=4.449\times10_{-10}$

$q_{21}-(5.0\times10_{-5}C)q1+4.449\times10_{-10}=0$

Use a quadratic formula

$q_{1,2=} = \frac{(5\times10-5 \pm\sqrt{(5\times10-5)^2-4(4.449\times10-10)}}{2}$ $q_1=3.84\times10_{-5}C$;

$q_2=1.16\times10_{-5}C$

1c.

1c $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$

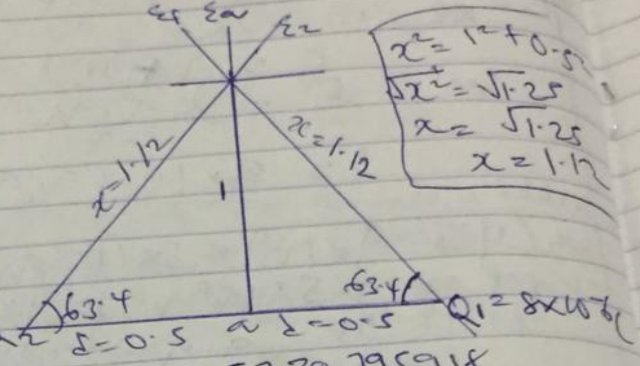
determine Q if electric field at a point p is zero.

Tan θ = opp/adj

Tan θ = $\frac{1}{0.5} = 2$

θ = $Tan^{-1}(2)$

θ = 63.4



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

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

$x = \sqrt{1.25}$

$x = 1.12$

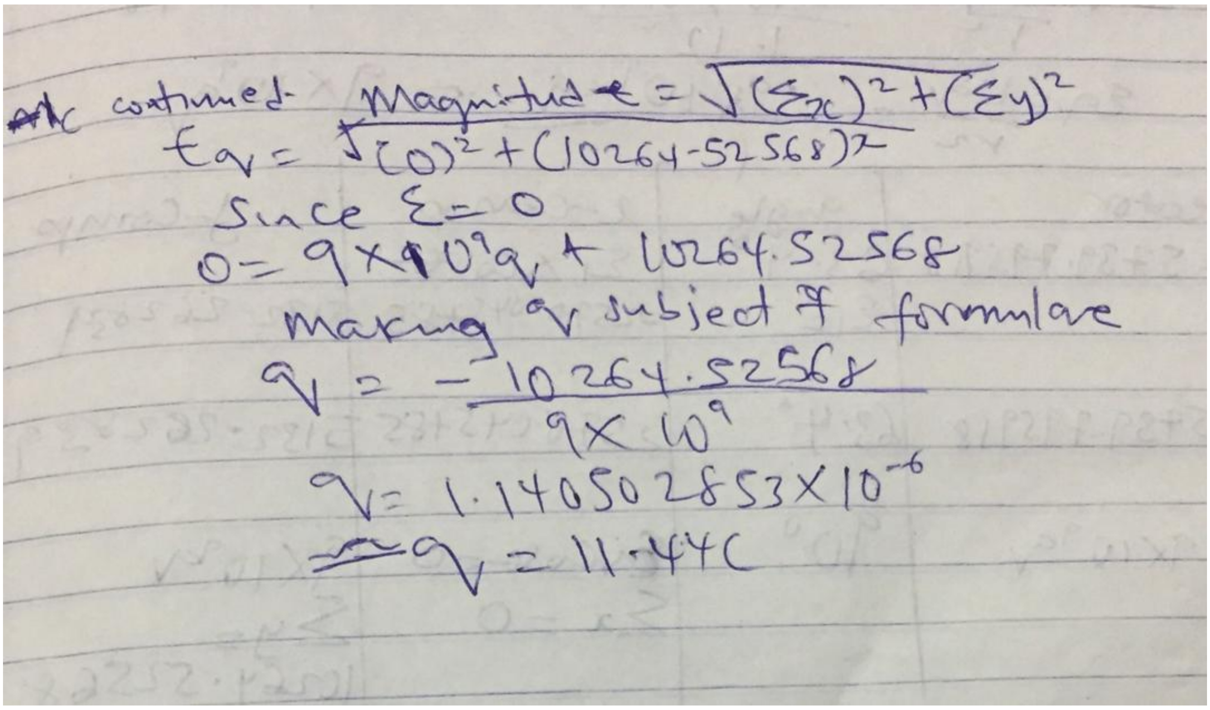
$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 5739.795918$

$E_2 = \frac{kq_1}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{1.12^2} = 5739.795918$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{1.12^2} = 5739.795918$

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

Vector	angle	x-comp	y-comp
$E_1 = 5739.795918$	63.4° $E_1 =$	$E_1 \times \cos\theta$ -2570.045785	5132.262839
$E_2 = 5739.795918$	63.4°	2570.045785	5132.262839
$E_q = 9\times10^9 q$	90°	$E_q\cos\theta = 0$ $\sum x = 0$	$9\times10^9 q$ $\sum y = 10264.52568$



4c continued: Magnitude $E = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E_q = \sqrt{(0)^2 + (10264\text{-}52568)^2}$

Since $E = 0$

$0 = 9 \times 10^9 q + 10264.52568$

making q subject of formulae

$q = -\frac{10264.52568}{9 \times 10^9}$

$q = 1.140502853 \times 10^{-6}$

$q = 11.44C$

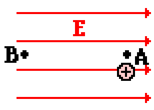
3a.

(i) Volume charge density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

(ii) Surface charge density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

(iii) Linear charge density, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

3b. Electric potential is a location-dependent quantity that expresses the amount of potential energy per unit of charge at a specified location. When a Coulomb of charge (or any given amount of charge) possesses a relatively large quantity of potential energy at a given location, then that location is said to be a location of high electric potential. And similarly, if a Coulomb of charge (or any given amount of charge) possesses a relatively small quantity of potential energy at a given location, then that location is said to be a location of low electric potential.

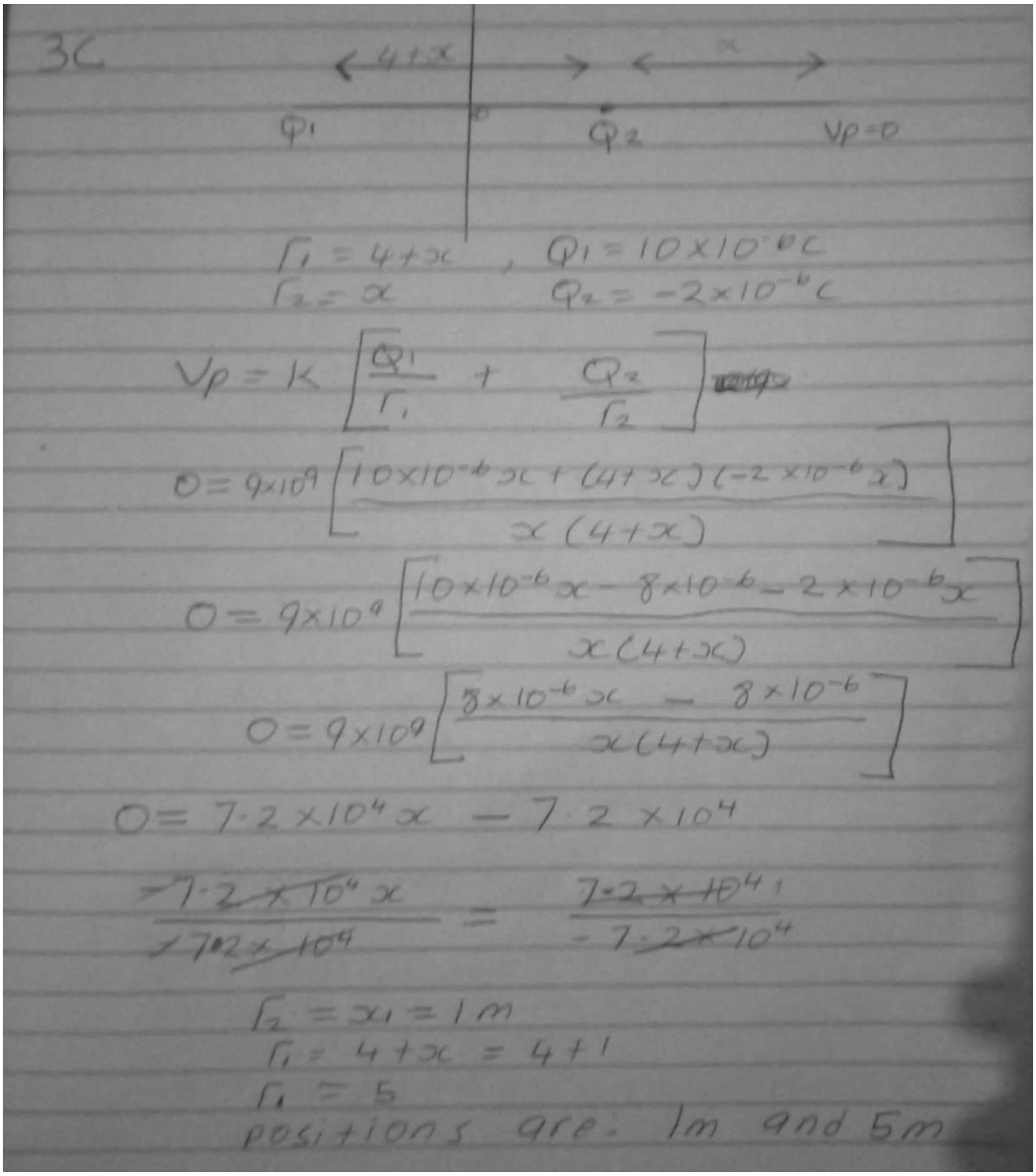


Consider the task of moving a positive test charge within a uniform electric field from location A to location B as shown in the diagram at the right. In moving the charge against the electric field from location A to location B, work will have to be done on the charge by an external force. The work done on the charge changes its potential energy to a higher value; and the amount of work that is done is equal to the change in the potential energy. As a result of this change in potential energy, there is also a difference in electric potential between locations A and B. This difference in electric potential is represented by the symbol **ΔV** and is formally referred to as the **electric potential difference**. By definition, the electric potential difference is the difference in electric potential (V) between the final and the initial location when work is done upon a charge to change its potential energy. In equation form, the electric potential difference is

$$\Delta V = V_B - V_A = \frac{\text{Work}}{\text{Charge}} = \frac{\Delta PE}{\text{Charge}}$$

The standard metric unit on electric potential difference is the volt, abbreviated **V** and named in honor of Alessandro Volta. One Volt is equivalent to one Joule per Coulomb. If the electric potential difference between two locations is 1 volt, then one Coulomb of charge will gain 1 joule of potential energy when moved between those two locations. If the electric potential difference between two locations is 3 volts, then one coulomb of charge will gain 3 joules of potential energy when moved between those two locations. And finally, if the electric potential difference between two locations is 12 volts, then one coulomb of charge will gain 12 joules of potential energy when moved between those two locations. Because electric potential difference is expressed in units of volts, it is sometimes referred to as the **voltage**.

3c.


3C

$\longleftarrow 4+x \longrightarrow \quad \longleftarrow x \longrightarrow$

$Q_1 \qquad Q_2 \qquad V_P = 0$

$r_1 = 4+x\ ,\quad Q_1 = 10\times10^{-6}C$

$r_2 = x \qquad Q_2 = -2\times10^{-6}C$

$$V_P = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}x + (4+x)(-2\times10^{-6}x)}{x(4+x)}\right]$$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}x - 8\times10^{-6} - 2\times10^{-6}x}{x(4+x)}\right]$$

$$0 = 9\times10^9\left[\frac{8\times10^{-6}x - 8\times10^{-6}}{x(4+x)}\right]$$

$$0 = 7.2\times10^4 x - 7.2\times10^4$$

$$\frac{-7.2\times10^4 x}{-7.2\times10^4} = \frac{7.2\times10^4}{-7.2\times10^4}$$

$r_2 = x = 1m$

$r_1 = 4+x = 4+1$

$r_1 = 5$

positions are: 1m and 5m

4a. **Magnetic Flux** is defined as the number of magnetic field lines passing through a given closed surface. It gives the measurement of the total magnetic field that passes through a given surface area. Here, the area under consideration can be of any size and under any orientation with respect to the direction of the magnetic field.

Magnetic flux formula is given by:

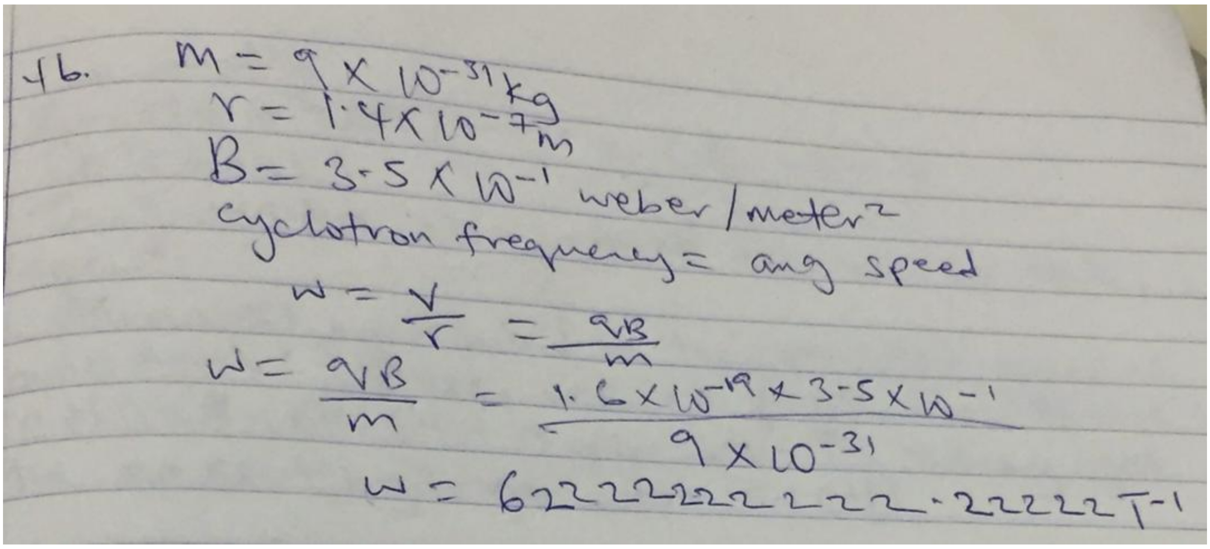
$\phi B = B.A = BA\cos\Theta$

Where,

- Φ_B is the magnetic flux.
- B is the magnetic field

- A is the area
- θ the angle at which the field lines pass through the given surface area

4b.

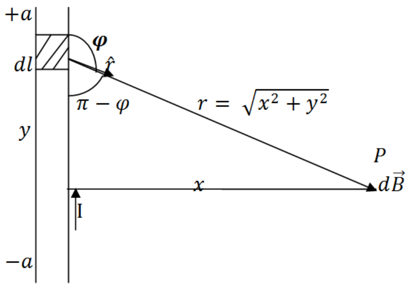

4b. $m = 9 \times 10^{-31}$ kg
$r = 1.4 \times 10^{-7}$ m
$B = 3.5 \times 10^{-1}$ weber/meter^2
cyclotron frequency = ang speed
$w = \frac{v}{r} = \frac{qB}{m}$
$w = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$
$w = 62222222222.22222\ T^{-1}$

5. A law of physics which states that the magnetic flux density (magnetic induction) near a long, straight conductor is directly proportional to the current in the conductor and inversely proportional to the distance from the conductor. The field near a straight conductor can be found by application of Ampère's law. The magnetic flux density near a long, straight conductor is at every point perpendicular to the plane determined by the point and the line of the conductor. Therefore, the lines of induction are circles with their centers at the conductor. Furthermore, each line of induction is a closed line. This observation concerning flux about a straight conductor may be generalized to include lines of induction due to a conductor of any shape by the statement that every line of induction forms a closed path.

According to this law, a small segment of a conductor Δl along which a current of strength / is flowing creates—at a given point *M* in space, located at a distance *r* from the segment Δl (Δl << *r*)—a magnetic field of strength

$$\Delta H = k \frac{I \Delta l \sin \theta}{r^2}$$

5b. 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 $\vec{dB}$

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

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

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

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

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

$$But\ \sin(\pi-\varphi) = \frac{x}{\sqrt{x^2 + y^2}} = \frac{x}{(x^2 + y^2)^{1/2}} \quad \dots \quad (**)$$

Substituting

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

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

Recall $dl = dy$

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

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

Using special integrals:

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

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

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

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

When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. That is, when a is much larger than$x$,

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

$$\therefore B = \frac{\mu_o I}{2\pi x}$$

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

$$B = \frac{\mu_o I}{2\pi r} \qquad \dots \qquad (\#)$$

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