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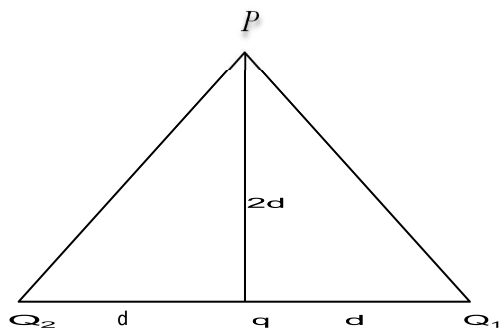
Department: Electrical / Electronics Engineering.
Course title: Electricity, Magnetism and Modern Physics.
Course Code: Phy 102
Assignment: 1
Due Date: 20th April, 2020
<u>Questions</u>:

1. (a) Explain with the aid of a diagram how you can produce a negatively charged sphere by method of induction.
   (b) Each of two small spheres is charged positively, the combined charge being $5.0 \times 10^{-5} C$. 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.
   (c) Three charges were positioned as shown in the figure below. If $Q_1 = Q_2 = 8 \mu C$ and $d = 0.5 m$, determine q if the electric field at P is zero.



2. (a) Distinguish between the terms: electric field and electric field intensity.
   (b) A positive charge is at the origin, and a second positive charge $Q_2 = 12 nC$ is on the x- 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.

3. (a) State the formulation of the following identities of charges:
   (i) Volume Charge density (ii) Surface Charge density (iii) Linear Charge density
   (b) Explain with appropriate equations, the electric potential difference
   (c) Two point charges $Q_1 = 10\mu c$ and $Q_2 = 2\mu c$ are arranged along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $v = 0$.

4 (a) What is Magnetic flux?
   (b) An electron with a rest mass of 9.11×10^{-31}kg moves in a circular orbit of radius $1.4 \times 10^{-7} m$ in a uniform magnetic field of 3.5×10^{-1} Weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron.

(c) Discuss your answer in 4b above.

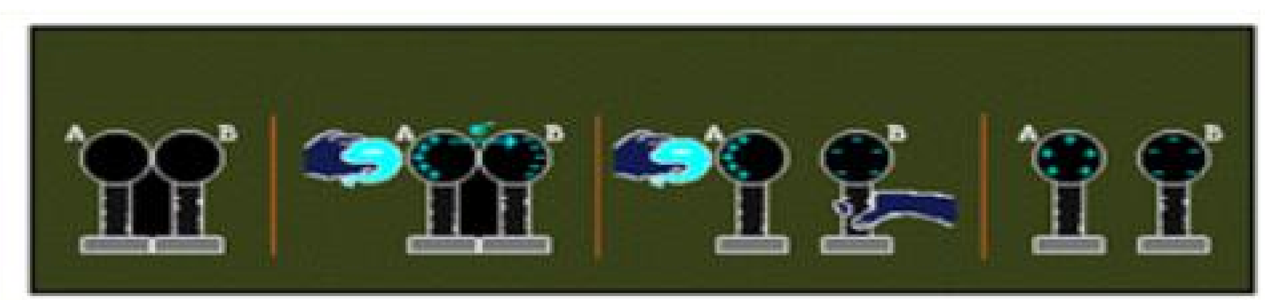
5. (a) State the Biot-Savart Law.
   (b) Using the Biot-Savart Law, show that the magnitude of the magnetic field of a straight current-carrying conductor is given as

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

6. (a) Explain the practical application of Faraday's Law in the production of sound in an electric guitar.
   (b) A coil consists of 300 turns of wire having a total resistance of 2.0Ω. Each turn is a square of side 10*cm*, and a uniform magnetic field directed perpendicular to the plane of the coil is turned on. If the field changes linearly from *0* to *10T* in 0.5 *sec*,
   (i) What is the magnitude of the induced emf in the coil while the field is changing?
   (ii) What is the magnitude of the induced current in the coil while the field is changing?
   (c) The plane of a rectangular coil of dimensions 5*cm* by 8*cm* is perpendicular to the direction of a magnetic field *B*. If the coil has 75 *turns* and a total resistance of 8Ω, at what rate must the magnitude of the *B* change in order to induce a current of 0.1*A* in the winding of the coil?

<u>Answers</u>:

1) Considering two metal spheres A and B touching each other, as shown in the figure. 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, as shown in the figure.



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.

2) The electric field is a region around a charge in which it exerts electrostatic force on another charges.While the strength of electric field at any point in space is called electric field intensity.It is a vector quantity.Its unit is NC^{-1}.

3) a) In electromagnetism, the charge density tells how much charge is present in a given length, area or volume. The greek symbol *Pho* (ρ) denotes electric charge, and the subscript V indicates the volume charge density.

i. The charge in terms of volume charge density is expressed as,

$\rho = q/v$

Where,

Pho is the charge density
q is the charge(C)
v is the total volume in m3.

ii. Surface charge describes the electric potential difference between the inner and outer surface of different states like solid and liquid, liquid and gas or gas and liquid. The surface charge density is present only in conducting surfaces and describes the whole amount of charge q per unit area A.

Hence, the Surface charge density formula is given by,

$\sigma = q / A$.

Where,

σ = surface charge density (C· m−2)

q = charge {Coulomb(C)}

A = surface area (m2)

iii. The charge in terms of Linear Charge density is expressed as,

$\lambda = ql$,

Where,

q is the **charge** and

l is the length over which it is distributed. The SI unit is Cm^{-1}.

b) 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

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

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**.

4) **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.Magnetic flux formula is given by:

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

Where,

- ΦB 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.

5) a) Once from end to end observations as well as calculations they derived an expression, that includes the density of magnetic flux (dB), is directly proportional to the element length (dl), the flow of current (I), the sine of the angle θ among the flow of current direction and the vector combining a given position of the field, with the current component is inversely proportional to the square of the distance (r) of the specified point from the current element. This is the **Biot-Savart law statement.**

6) a) It's a basic rule of physics (called **Faraday's law**) that a changing magnetic field produces electricity. So a guitar string will produce electricity only for as long as the magnetic field is changing, i.e, for only as long as the metal string is moving. Once the string stops vibrating, the sound stops. In that respect, an electric guitar is just like an acoustic one.

Unfortunately, a simple pickup with a single coil of wire is just as good at picking up stray electrical energy from power supplies and other interference, so it generates a certain amount of unwanted, background noise. Some guitars solve this problem using what are known as **hum-bucking pickups**. These have two coils of wire, arranged so they capture double the signal from the moving guitar strings to produce a richer sound. Each coil is wired up so any stray "hum" it captures from nearby electrical equipment is canceled out by the other coil. Most guitars have two or more pickups, which create a variety of different effects. Typically, there's one pickup under the bridge of the guitar (where the strings are supported) and another one slightly higher up at the bottom of the "neck" (the part of the guitar that sticks out of the main body).