LIBERTY PAPER SET

STD. 12 : Physics

Full Solution

Time : 3 Hours **ASSIGNTMENT PAPER 1**

Section A

1. (B) **2.** (A) **3.** (A) **4.** (C) **5.** (C) **6.** (A) **7.** (B) **8.** (A) **9.** (C) **10.** (D) **11.** (A) **12.** (D) **13.** (D) **14.** (D)
15. (B) **16.** (A) **17.** (C) **18.** (B) **19.** (B) **20.** (C) **21.** (A) **22.** (D) **23.** (D) **24.** (C) **25.** (D) **26.** (B) **27.** (B)
28. (A) **29.** (C) **30.** (B) **31.** (D) **32.** (C) **33.** (C) **34.** (D) **35.** (C) **36.** (C) **37.** (D) **38.** (A) **39.** (B) **40.** (A)
41. (C) **42.** (C) **43.** (A) **44.** (A) **45.** (C) **46.** (C) **47.** (B) **48.** (D) **49.** (C) **50.** (D)

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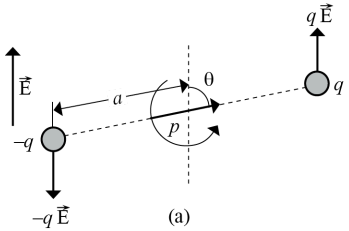
Section A

➢ **Write the answer of the following questions : (Each carries 2 Mark)**

1.

➥



(a)

➥ As shown in figure, the electric dipole is placed in uniform electric field at θ angle.

➥ The force exerted on $+q$ electric charge in electric field $\vec{E}$ is,

$$\vec{F}_+ = q\vec{E}$$

➥ The force exerted on - q electric charge

$$\vec{F}_- = -q\vec{E}$$

➥ The net force on the dipole is zero, since E is uniform.

➥ However, the charges are separated, so the forces act at different points, resulting in a torque on the dipole.

➥ When the net force is zero, the torque (couple) is independent of the origin. Its magnitude equals the magnitude of each force multiplied by the arm of the couple (perpendicular distance between the two antiparallel forces).

➥ Magnitude of torque = q E × 2 a *sin* θ

$= (2\ q\ a)$ E *sin* θ = pE *sin* θ

$$\vec{\tau} = \vec{p} \cdot \vec{E}$$

➥ The magnitude of $\vec{p} \times \vec{E}$ is also p E *sin* θ and its direction is normal to the paper, coming out of it.

➥ Special cases :

(i) If electric dipole moment and electric field both are in one direction.

∴ θ = 0

∴ τ = 0

This condition is called stable equilibrium.

(ii) Both electric dipole moment and electric field are perpendicular.

$\therefore \theta = \frac{\pi}{2}$

$\therefore \tau = pE\ sin\ \frac{\pi}{2}$

∴ τ = pE → Which is maximum

(iii) Electric dipole moment and electric field are arranged anti parallel direction.

∴ τ = pE *sin* π

∴ τ = 0 → Unstable equilibrium

2.

➥ $r = 2$ cm $= 2 \cdot 10^{-2}$ m

E = $9 \cdot 10^4$ N/C

λ = ?

➥ As per the formula, electric field at a distance 'r' from a very long (infinite) line charge,

$$E = \frac{2k\lambda}{r}$$

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$$\therefore \lambda = \frac{Er}{2k}$$

$$= \frac{9\times10^{4}\times2\times10^{-2}}{2\times9\times10^{9}}$$

$$\therefore \lambda = 0.1\cdot10^{-6}$$

$$\therefore \lambda = 0.1\ \propto C/m$$

3.

➥ Conductivity of conductor arises from mobile charge carriers.

➥ In metals, electrons are mobile charge carriers. In an electrolyte they are positive and negative ions while in an ionised gas, they are electrons and positive charged ions. In semi conductors, free electrons and holes are mobile charge carriers.

➥ *"The magnitude of the drift velocity per unit electric field is called the mobility (∝)."*

$$\propto = \frac{|\vec{v}_d|}{E} \quad \ldots (1)$$

➥ The SI unit of mobility is m^2/Vs and practical unit is cm^2/Vs

➥ Dimensional formula of mobility is $M^{-1}L^{0}T^{2}A^{1}$

➥ Using drift velocity $|\vec{v}_d| = \frac{Ee}{m}\cdot\tau$

in equation (1).

we get,

$$\propto = \frac{\frac{eE}{m}\tau}{E}$$

$$\therefore \propto = \frac{e\tau}{m}$$

where τ is the average collision time for electrons.

4.

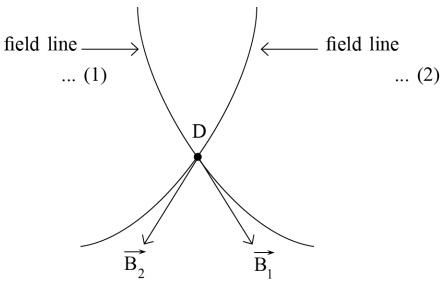
➥ Characteristics of magnetic field lines are as follows :

(i) The magnetic field lines form continuous closed loops. In the region outside a magnet, the magnetic field lines are from N to S, whereas in the region inside the magnet, the field lines are from S to N.

(ii) The tangent to the field line at a given point represents the direction of the magnetic field ($\vec{B}$) at that point.

(iii) The larger the number of field lines crossing per unit area, the stronger is the magnitude of the magnetic field $\vec{B}$.

(iv) Two magnetic field lines do not intersect each other. Because if they do, at the point of intersection, the magnetic field would have two directions, which is not possible.



5.

➥ (a) Magnetic energy stored in solenoid

$$U_B = \frac{1}{2}LI^2$$

$$= \frac{1}{2}L\left(\frac{B}{\mu_0 n}\right)^2$$

$(\because$ for solenoid, $B = \propto_0 nI \Rightarrow I = \frac{B}{\mu_0 n})$

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$= \frac{1}{2} (\propto_0 n^2 A l) \left(\frac{B}{\mu_0 n}\right)^2$

($\because$ Self inductance of solenoid $L = \propto_0 n^2 A l$)

$= \frac{1}{2} \propto_0 n^2 A l \times \frac{B^2}{\mu_0^2 n^2}$

$U_B = \frac{1}{2\mu_0} (B^2 A l)$... (1)

(b) Magnetic energy per unit volume

$\rho_B = \frac{U_B}{V}$ ($\because$ V = Volume)

$= \frac{U_B}{Al}$ ($\because$ Volume $V = Al$)

$= \frac{1}{2\mu_0} \frac{B^2 Al}{Al}$ (from eq. 1)

$\rho_B = \frac{B^2}{2\mu_0}$ ... (2)

➠ Electrostatic energy stored per unit volume in parallel plate capacitor.

$\rho_E = \frac{1}{2} \varepsilon_0 E^2$... (3)

➠ From equation (2) & (3), energy is directly proportional to square of field intensity in both cases.

6.

➥ V = 220 V

ν = 50 Hz

R = 100 Ω

(a) rms value of current in circuit,

$I = \frac{V}{R}$

$\therefore I = \frac{220}{100}$

$\therefore$ I = 2.2 A

(b) Power consumed over a full cycle,

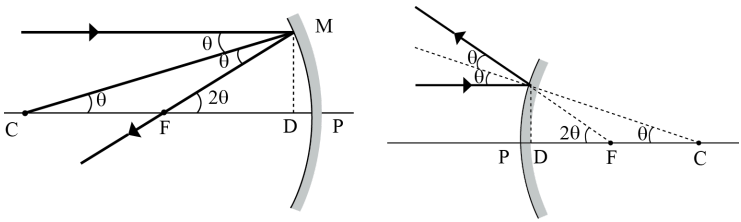
P = VI

$\therefore$ P = (220) (2.2)

$\therefore$ P = 484 W

7.

➥



(a) (b)

➥ As shown in figure, C is center of curvature of the mirror and F is the principal focus of the mirror.

➥ As shown in figure, a ray is incident at an angle θ near a point M on the mirror. CM is the perpendicular drawn to the surface. MD is the perpendicular drawn from point M on the principal axis.

➥ From figure, ∠MCP = θ and ∠MFP = 2θ

➥ Now, $\tan\theta = \frac{MD}{CD}$ ... (1)

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and $tan\ 2\theta = \frac{MD}{FD}$ ... (2)

➥ Since θ is extremely small for paraxial rays

$tan\ \theta \approx \theta$ and $tan\ 2\theta \approx 2\theta$

➥ From equation (1) and equation (2),

$\theta = \frac{MD}{CD}$ and $2\theta = \frac{MD}{FD}$

$\therefore\ 2\left(\frac{MD}{CD}\right) = \frac{MD}{FD}$

$\therefore\ \frac{2}{CD} = \frac{1}{FD}$

$\therefore\ CD = 2FD$ ... (3)

➥ Now for small θ the point D is very close to the point P.

➥ Therefore, FD = FP = f and CD = CP = R

Substituting above values in equation (3),

$R = 2f$

or $f = \frac{R}{2}$

8.

➥ Consider a plane wave AB incident at an angle i on a reflecting surface MN.

➥ If υ is the speed of wave in the given medium, τ represents the time taken by the wavefront to advance from point B to C, then the distance BC = υτ.

➥ In order to construct the reflected wavefront we draw a sphere of radius υτ from the point A as shown in fig.

➥ Let CE represent the tangent plane drawn from the point C to this sphere.

➥ Obviously,

AE = BC = υτ

➥ From fig., incident and reflected wave fronts make angle i and r with reflecting surface, MN respectively.

➥ From fig.,

AC is the common side between ΔAEC and ΔABC.

Also, ∠AEC = ∠ABC = $\frac{\pi}{2}$

and AE = BC = υτ

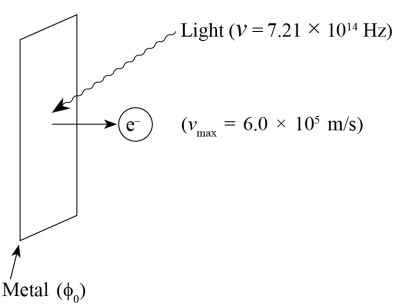
➥ So ΔAEC and ΔABC are congruent.

➥ And therfore, $\angle i = \angle r$,

which is law of reflection.

9.

➥



➥ $\nu = 7.21 \times 10^{14}$ Hz

$v_{max} = 6.0 \times 10^5$ m/s

$v_0 = ?$

$K_{max} = h\nu - \varphi_0$

$\therefore \frac{1}{2} mv^2_{max} = hv - \varphi_0 \; (\because K_{max} = \frac{1}{2} mv^2_{max})$

$\therefore \varphi_0 = hv - \frac{1}{2} mv^2_{max}$

$\therefore hv_0 = hv - \frac{1}{2} mv^2_{max} \; (\because \varphi_0 = hv_0)$

$\therefore v_0 = v - \frac{m\upsilon^2_{max}}{2h}$

$\therefore v = (7.21 \times 10^{14}) - \left(\frac{9.1 \times 10^{-31} \times (6.0 \times 10^5)^2}{2 \times 6.625 \times 10^{-34}} \right)$

$v_0 = (7.21 \times 10^{14}) - (2.472 \times 10^{14})$

$v_0 = 4.738 \times 10^{14}$ Hz

10.

➥ $n = 4$

$\lambda = ?$

$v = ?$

➥ Total energy of electron

$E_n = - \frac{13.6}{n^2} \; eV \; ... (1)$

➥ For ground state, $n = 1$

$E_1 = - \frac{13.6}{1^2} \; eV$

$= -13.6 \; eV$

➥ Using $n = 4$ in equation (1)

$E_4 = - \frac{-13.6}{(4)^2} \; eV$

$= \frac{-13.6}{16} \; eV$

$E_4 = - 0.85 \; eV$

➥ Energy of incident photon

$E_4 - E_1 = - 0.85 - (- 13.6)$

$E_4 - E_1 = 12.75 \; eV$

But, $E_i - E_f = hv$

$hv = 12.75 \; eV$

$\therefore v = \frac{12.75 \times 1.6 \times 10^{-19}}{6.625 \times 10^{-34}}$

$\therefore v = 3.08 \times 10^{15}$ Hz

➥ Wavelength of incident radiation

$\lambda = \frac{c}{v} = \frac{3 \times 10^8}{3.08 \times 10^{15}}$

$\therefore \lambda = 0.974 \times 10^{-7}$ m

$\therefore \lambda = 97.4$ nm

11.

➥ The nucleus is made up of neutrons and protons. Therefore, it may be expected that the mass of the nucleus is equal to the total mass of its individual protons and neutrons.

➥ But the nuclear mass M is found to be always less than the total mass of its individual protons and neutrons.

➥ For example :

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$_8O^{16}$, a nucleus which has 8 neutrons and 8 protons.

Mass of 8 neutrons = $8 \cdot 1.00866\ u$

Mass of 8 protons = $8 \cdot 1.00727\ u$

Mass of 8 electrons = $8 \cdot 0.00055\ u$

➥ Therefore, the expected mass of $_8O^{16}$ nucleus

$= (8 \cdot 1.00866 + 8 \cdot 1.00727)$

$= 8(1.00866 + 1.00727)$

$= 8 \cdot 2.01593\ u$

$= 16.12744\ u$

➥ The atomic mass of $_8O^{16}$ found from mass spectroscopy experiments is seen to be 15.99493 u.

➥ Subtracting the mass of 8 electrons

($8 \cdot 0.00055\ u = 0.0044\ u$) from this we get the experimental mass of $_8O^{16}$ nucleus to be 15.99053 u.

➥ Thus, the mass of the $_8O^{16}$ nucleus is less than the total mass of its constituents by

$(16.12744 - 15.99053) = 0.13691\ u$.

➥ *"The difference in mass of a nucleus and its constituents, ΔM is called the mass defect"* and is given by

$\Delta M = [Zm_p + (A - Z)m_n] - M$

Where, Z = number of protons

A – Z = N = neutron number

m_p - mass of proton

m_n - mass of neutron

M - mass of a nucleus

➥ The energy equivalent to this mass defect is called the binding energy of nucleus.

$\therefore$ Binding energy $E_b = \Delta Mc^2$

➥ Binding energy per nucleon is the binding energy divided by the total number of nucleons.

$$\therefore E_{bn} = \frac{E_b}{A}$$

➥ The binding energy per nucleon gives a measure of the stability of the nucleus.

➥ A nucleus for which the value of E_{bn} is comparatively higher is said to be more stable and for a nucleus for which the value of E_{bn} is comparatively less is said to be less stable.

12.

➥ number of atoms in pure $Si = 5 \times 10^{28}\ m^{-3}$

➥ Concentration of As = 1 ppm

Impurity proportion is kept as 1 in 10^6 pure atoms.

$$\text{Total atoms of As} = \frac{5 \times 10^{28}}{10^6} = 5 \times 10^{22}\ m^{-3}$$

➥ As is pentavalent impurity. Thus As is donating one extra electron. So electron number density due to As atom,

$n_e = n_D = 5 \times 10^{22}\ m^{-3}$

➥ Now $n_i^2 = n_e\, n_h$

$$\therefore n_h = \frac{n_i^2}{n_e}$$

$$\therefore n_h = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}}$$

$$\therefore n_h = \frac{2.25 \times 10^{32}}{5 \times 10^{22}}$$

$\therefore n_h = 4.5 \times 10^9\ m^{-3}$

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Section B

➢ **Write the answer of the following questions : (Each carries 3 Mark)**

13.

➥ (a) Given (actually it should be spherical shell) sphere is a conductor, so the electric charge is established only on the surface of the conductor. Hence the net charge inside the spherical conductor, will be zero hence the electric field inside shell will be zero.

➥ (b) on the surface of the sphere :

(/ Just outside the sphere)

$q = 1.6 \times 10^{-7}$ C

$R = 12 \times 10^{-2}$ m

Electric field $E = \frac{kq}{R^2}$

$E = \frac{9 \times 10^9 \times 1.6 \times 10^{-7}}{(12 \times 10^{-2})^2}$

$\therefore E = \frac{14.4 \times 10^2}{144 \times 10^{-4}}$

$\therefore E = 1 \times 10^5 \frac{N}{C}$

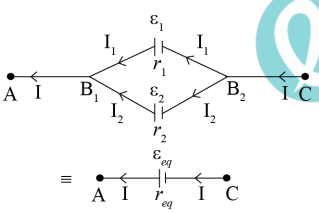
➥ (c) At a point 18 cm from the centre of the sphere : (E at distance $r > R$)

$\therefore E = \frac{kq}{r^2} = \frac{9 \times 10^9 \times 1.6 \times 10^{-7}}{(18 \times 10^{-2})^2}$

$\therefore E = 4.4 \times 10^4 \frac{N}{C}$

14.

➥ If the positive (or negative) terminal of two cells are connected to one point and their negative (or positive) terminal to another point, such connection of cells is called the parallel connection.



➥ The figure shows a parallel combination of two cells, the *emf* of cells are ε_1 and ε_2 respectively and the internal resistances are r_1 and r_2 respectively.

➥ The currents leaving the positive terminals of the cells are I_1 and I_2 respectively. These currents meet near point B_1 so the total current at point B_1 is $I = I_1 + I_2$

➥ Let $V(B_1)$ and $V(B_2)$ be the potentials at B_1 and B_2. The potential diference across terminals of the first cell is

$V = V(B_1) - V(B_2) = \varepsilon_1 - I_1 r_1$

$\therefore I_1 r_1 = \varepsilon_1 - V$

$\therefore I_1 = \frac{\varepsilon_1 - V}{r_1}$ ... (1)

➥ The potential difference across terminals of the second cell is

$V = V(B_1) - V(B_2) = \varepsilon_2 - I_2 r_2$

$\therefore I_2 r_2 = \varepsilon_2 - V$

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$$\therefore I_2 = \frac{\varepsilon_2 - V}{r_2} \quad \ldots (2)$$

➥ But the total current is $I = I_1 + I_2$

➥ Putting the values from equation (1) and (2) in above equation :

$$\therefore I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$$

$$\therefore I = \frac{\varepsilon_1}{r_1} - \frac{V}{r_1} + \frac{\varepsilon_2}{r_2} - \frac{V}{r_2}$$

$$\therefore I = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$\therefore V\left(\frac{1}{r_1} + \frac{1}{r_2}\right) = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} - I$$

$$\therefore V\left(\frac{r_1 + r_2}{r_1 r_2}\right) = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1 - I r_1 r_2}{r_1 r_2}$$

$$\therefore V(r_1 + r_2) = \varepsilon_1 r_2 + \varepsilon_2 r_1 - I r_1 r_2$$

$$\therefore V = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} - I\left(\frac{r_1 r_2}{r_1 + r_2}\right) \quad \ldots (3)$$

➥ Let the equivalent *emf* ε_{eq} and equivalent internal resistance r_{eq} for this combination.

$$\therefore V = \varepsilon_{eq} - I r_{eq} \quad \ldots (4)$$

by comparing equation (3) and (4)

$$\therefore \varepsilon_{eq} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2} \text{ and } r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$$

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 + r_2}}{\frac{r_1 r_2}{r_1 + r_2}} = \frac{\varepsilon_1 r_2 + \varepsilon_2 r_1}{r_1 r_2} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$$

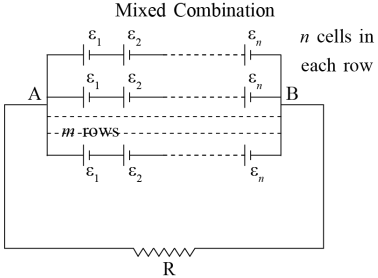
➥ If there are n cells of *emf* $\varepsilon_1, \varepsilon_2, \varepsilon_3 \ldots \varepsilon_n$ and internal resistances $r_1, r_2, r_3 \ldots r_n$ respectively are connected in parallel, the combination is equivalent to a single cell of *emf* ε_{eq} and internal resistance r_{eq}.

$$\therefore \frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \ldots + \frac{1}{r_n}$$

$$\therefore \frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \frac{\varepsilon_3}{r_3} + \ldots + \frac{\varepsilon_n}{r_n}$$

Remember

Mixed Combination



Mixed combination of cells is shown in the figure. If n cells of *emf* $\varepsilon_1, \varepsilon_2, \varepsilon_3 \ldots \varepsilon_n$ and internal resistances $r_1, r_1, r_3 \ldots r_n$ are connected in series to make a row and m such rows are connected in parallel, then it is called mixed connection of cells. The current in mixed connection,

$$I = \frac{\sum_{i=1}^{n} \varepsilon_i}{R + \frac{1}{m}\sum_{i=1}^{n} r_i}$$

where, R - external resistance connected in circuit

m - number of rows

n - number of cells in a row

If *emfs* and internal resistances of all the cells are equal then

$$\therefore \quad I = \frac{n\varepsilon}{R + \frac{nr}{m}} = \frac{nm\varepsilon}{mR + nr}$$

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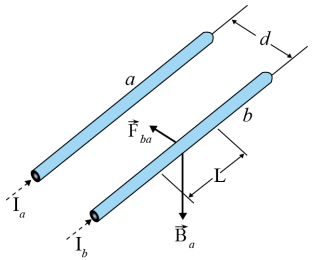
15.

➥ As shown in the figure, two long parallel wires *a* and *b* separated by a distance *d* and carrying currents I_a and I_b respectively.



➥ A uniform magnetic field $\vec{B}_a$ is produced by the conductor '*a*' at every point on the conductor '*b*'

➥ The right-hand rule indicates that the direction of the field is downwards.

➥ From Ampere's circuital law,

$$B_a = \frac{\mu_0 I_a}{2\pi d} \quad \ldots (1)$$

➥ This magnetic field causes a force on wire *b*.

➥ To calculate this force, a segment is considered on the wire *b* as shown in the figure. The length of the segment is L.

➥ The force acting on this segment is $F_{ba} = I_b L B_a$

Putting the value from equation (1)

$$F_{ba} = I_b L \left(\frac{\mu_0 I_a}{2\pi d}\right)$$

$$\therefore F_{ba} = \frac{\mu_0 I_a I_b L}{2\pi d} \quad \ldots (2)$$

➥ The direction of this force is from *b* to *a*

➥ Similarly, the force exerted by wire *b* on wire *a* of a segment of length L is

$$F_{ab} = \frac{\mu_0 I_a I_b L}{2\pi d} \quad \ldots (3)$$

➥ The direction of this force is from *a* to *b*.

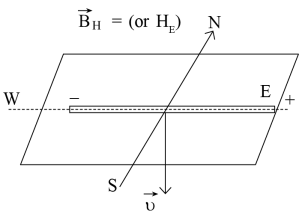
➥ Thus, $\vec{F}_{ab} = -\vec{F}_{ba}$

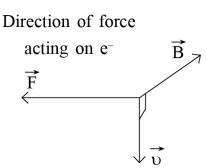
➥ Both the forces are equal in magnitude and opposite in direction. This force is attractive.

➥ So, if current flows in the same direction in both wires, the force is attractive and if current flows in opposite direction, the force is repulsive.

16.

➥





➥ *l* = 10 m

υ = 5.0 m/sec

$B_H = 0.30 \times 10^{-4}$ T

(a) Induced *emf* in rod

$\varepsilon = B_H \upsilon l$

$= 0.30 \times 10^{-4} \times 5 \times 10$

$= 15 \times 10^{-4}$ V

= 1.5 mV

(b) *emf* is induced in wire in such a direction that it opposes its (wire's) motion. Thus, direction of *emf* is from West to East.

(c) When the wire is in free fall a free electron in the wire experiences a force according to the formula $\vec{F} = -e(\vec{\upsilon} \times \vec{B})$.

- From Fleming's left-hand rule of thumb the direction of this force is taken to mean that the force on the electron is towards, the west end of the wire.
- Thus the free electrons of the wire accumulate at the west end, there by exposing the east end of the wire to a positive charge.
- Thus the eastern end of the string is in a high potential.

17.

- When an AC voltage is applied to primary, the resulting current produces an alternating magnetic flux, which links the secondary and induces an emf in it. The value of this emf depends on number of turns in secondary.
- We consider an ideal transformer in which the primary has negligible resistance and all the flux in the core links both primary and secondary windings.
- Let φ be the flux in each turn in the core at time t due to current in the primary when a voltage (υ_p) is applied to it.
- Then the induced emf or voltage (E), in the secondary

$$\varepsilon_s = -N_s \frac{d\phi}{dt} \quad \ldots (1)$$

where, N_s is no. of turns in secondary.

- The alternating flux, φ also induces an *emf* called the back emf in the primary. This is,

$$\varepsilon_p = -N_p \frac{d\phi}{dt} \quad \ldots (2)$$

Where, N_p is no. of turns in the primary.

- But $\varepsilon_p = \upsilon_p$ If this were not so, the primary current would be infinite due to zero resistance. (as assumed)
- If the secondary is an open circuit or the current taken from it is small, then to a good approximation, $\varepsilon_s = \upsilon_s$
- From eq. (1) and (2),

$$\upsilon_s = -N_s \frac{d\phi}{dt} \quad \ldots (3) \text{ and } \upsilon_p = -N_p \frac{d\phi}{dt} \quad \ldots (4)$$

(where υ_s is the voltage a cross secondary)

- By taking the ratio of eq. (3) and (4),

$$\frac{\upsilon_s}{\upsilon_p} = \frac{N_s}{N_p} \quad \ldots (5)$$

- Following three assumptions are used in obtaining the above relation :

(1) The primary resistance and current are small;

(2) The same flux links both the primary as well as secondary (as very less flux escapes from the core)

(3) The secondary current is small.

18.

- (i) $f = 0.5$ m

$\Rightarrow$ Power of lens $P = \frac{1}{f}$

$\therefore P = \frac{1}{0.5}$

$\therefore P = 2$ D

Liberty

➥ (ii) $R_1 = 10$ cm $R_2 = -15$ cm

$f = 12$ cm $n_1 = 1$ (air)

$n_2 = (?)$

$\Rightarrow$ From lens maker's formula,

$$\frac{1}{f} = \left(\frac{n_2 - n_1}{n_1}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\therefore \frac{1}{12} = \frac{(n_2 - 1)}{1}\left(\frac{1}{10} + \frac{1}{15}\right)$$

$$\therefore \frac{1}{12} = (n_2 - 1)\left(\frac{3 + 2}{30}\right)$$

$$\therefore \frac{1}{12} = (n_2 - 1)\left(\frac{5}{30}\right)$$

$$\therefore \frac{1}{12} = (n_2 - 1)\left(\frac{1}{6}\right)$$

$$\therefore \frac{1}{2} = n_2 - 1$$

$$\therefore n_2 = 1 + \frac{1}{2} = \frac{3}{2}\ (1.5)$$

➠ The refractive index of material of lens is 1.5.

➥ (iii) $f_a = 20$ cm , $f_w = ?$

$n_a = 1$ $n_w = 1.33$ $n_g = 1.5$

➠ for lens in air,

$$\frac{1}{f_a} = \left(\frac{n_g - n_a}{n_a}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \ldots (1)$$

➠ for lens in water,

$$\frac{1}{f_w} = \left(\frac{n_g - n_w}{n_w}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad \ldots (2)$$

➠ By taking ratio of equation (1) & (2),

$$\frac{f_w}{f_a} = \left(\frac{n_g - n_a}{n_a}\right)\left(\frac{n_w}{n_g - n_w}\right)$$

$$\therefore \frac{f_w}{20} = \left(\frac{1.5 - 1}{1}\right)\left(\frac{1.33}{1.5 - 1.33}\right)$$

$$\therefore \frac{f_w}{20} = (0.5)\left(\frac{1.33}{0.17}\right)$$

$\therefore f_w = 78.23$ cm

19.

➥ As shown in the fig., two polaroids P_1 and P_3 are arranged such that their pass axis are perpendicular to each other.

➥ Polaroid P_2 is rotated between two crossed polaroids.

➥ Suppose, during some position of P_2, the angle between the pass axis of P_1 and P_2 is θ, since P_1 and P_3 are crossed, the angle between the pass axis of P_2 and P_3 will be $\frac{\pi}{2} - \theta$.

➥ Let I_0 be the intensity of polarised light after passing through the first polariser P_1 ($I_1 = I_0$).

➥ Then the intensity of light after passing through second polariser P_2 will be

$$I_2 = I_0 \cos^2 \theta \text{ (from Malus law) } \ldots (1)$$

➥ This light is incident on polariser P_3 at an angle $\frac{\pi}{2} - \theta$. Hence the intensity of light energing from P_3 will be :

$$I_3 = I_2 \cos^2\left(\frac{\pi}{2} - \theta\right)$$

➥ Substituting the value from equation (1),

$I_3 = I_0 \cos^2\theta \cos^2\left(\frac{\pi}{2} - \theta\right)$

$I_3 = I_0 \cos^2\theta \sin^2\theta$

$I_3 = \frac{I_0}{4}(4 \sin^2\theta \cos^2\theta)$

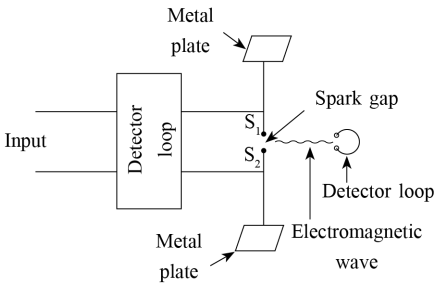
$\therefore I_3 = \frac{I_0}{4}(\sin^2 2\theta)$

➥ When $\theta = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$ or 2π, $I_3 = 0$ (Minimum intensity)

➥ When $\theta = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$, $I_3 = \frac{I_0}{4}$ (Maximum intensity)

20.

➥ In an experiment to produce electromagnetic waves in a laboratory, when negatively charged particles (electrons) are emitted from a metal plate and passed through a spark gap, a spark is generated in front of a detector loop and electromagnetic waves are emitted.



(Note : This figure is only for understanding.)

➥ Hertz observed that when rays of ultraviolet light were irradiated on a metal surface with an arc lamp, the spark before the detector loop increased. That is the number of electrons passing through the spark gap also increases.

➥ When ultraviolet light is incident on a metal plate the free electrons in the metal must absorb the energy of the radiation and since this energy is sufficient the electrons must escape from the attraction of the positive ions of the metal, which is the photoelectric effect.

➥ Thus, Hertz first observed the photoelectric effect in 1887 during his experiments on the emission of electromagnetic waves.

21.

➥ Bohr combined classical and early quantum concepts and gave his theory in the form of three postulates. These are :

➥ (i) Bohr's first postulate : An electron in an atom could revolve in certain stable orbits without the emission of radiant energy.

➠ According to this postulate, each atom has certain definite stable states in which it can exist, and each possible state has definite total energy. These are called the stationary states of the atom.

➠ This contrary to the predictions of electromagnetic theory.

➥ (ii) Bohr's second postulate : The electron revolves around the nucleus only in those orbits for which the angular momentum is in integral multiple of $\frac{h}{2\pi}$.

➠ Where, h is Planck's constant

$h = 6.625 \times 10^{-34}$ J s.

$L = \frac{nh}{2\pi}$ Where, $n = 1, 2, 3....$

➥ (iii) Bohr's third postulate : An electron makes a transition from one of its specified non-radiating orbits to another of lower energy. When it does so, a photon is emitted having energy equal to the energy difference between the initial and final states.

➠ The frequency of the emitted photon is then given by

$h\nu = E_i - E_f$

Where E_i and E_f are the energies of the initial and final states and $E_i > E_f$.

We want to find electric potential at this point P.

➥ Electric potential at point P due to charge $+q$,

$$V_1 = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_1}$$

➥ Electric potential at point P due to charge $-q$,

$$V_2 = \frac{1}{4\pi\varepsilon_0} \frac{(-q)}{r_2}$$

$$= -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_2}$$

➥ Total electric potential at point P as per super position principle,

$$V = V_1 + V_2$$

$$\therefore V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_1} - \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r_2}$$

$$\therefore V = \frac{q}{4\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \text{... (1)}$$

➥ As shown in the figure (a), position vector of point P with respect to origin O is $\vec{r}$.

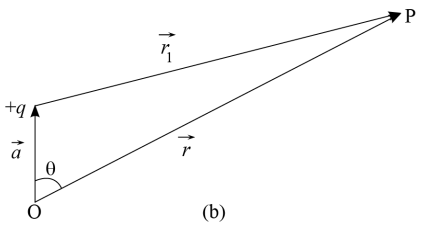
Position vector of point P with respect to

$+q$ is $\vec{r_1}$.

Position vector of point P with respect to

$-q$ is $\vec{r_2}$.

➥



(b)

➥ From figure (b),

$$\vec{r} = \vec{a} + \vec{r_1}$$

$$\therefore \vec{r_1} = \vec{r} - \vec{a}$$

$$\therefore r_1^2 = r^2 + a^2 - 2ra\cos\theta \ (\theta \text{ is angle between } \vec{r} \text{ and } \vec{a})$$

$$\therefore r_1^2 = r^2\left(1 + \frac{a^2}{r^2} - \frac{2a\cos\theta}{r}\right)$$

➥

But value of $\frac{a^2}{r^2}$ is very less for $r >> a$,

so it can be neglected from equation.

$$\therefore r_1^2 = r^2\left(1 - \frac{2a\cos\theta}{r}\right)$$

$$\therefore r_1 = r\left(1 - \frac{2a\cos\theta}{r}\right)^{\frac{1}{2}}$$

$$\therefore \frac{1}{r_1} = \frac{1}{r}\left(1 - \frac{2a\cos\theta}{r}\right)^{-\frac{1}{2}}$$