Sample Question Paper -01 (2018-19)

Physics

Class- XII

Time:- 3hrs. M.M.70

General Instructions:

1. All questions are compulsory. There are 27 questions in all.
2. This question paper has four sections: Section A, Section B, Section C and Section D.
3. Section A contains five questions of one mark each, Section B contains seven questions of two marks each, Section C contains twelve questions of three marks each, and Section D contains three questions of five marks each.
4. There is no overall choice. However, internal choices have been provided in two questions of one mark, two questions of two marks, four questions of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.
5. You may use the following values of physical constants wherever necessary.

$c = 3 \times 10^8$ m/s

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_o = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2 N^{-1} m^{-2}$

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N $m^2 C^{-2}$

$m_e = 9.1 \times 10^{-31}$ kg

mass of neutron $= 1.675 \times 10^{-27}$ kg

mass of proton $= 1.673 \times 10^{-27}$ kg

Avogadro's number $= 6.023 \times 10^{23}$ per gram mole

Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

SECTION A

1 A 500 μC charge is at the centre of a square of side 10 cm. Find the work done in moving a charge of 10 μC between two diagonally opposite points on the square. 1

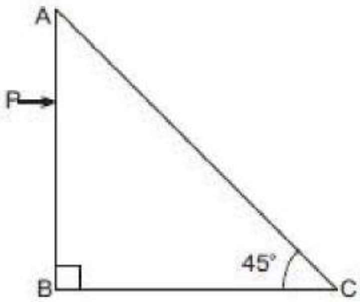
2 A cell of emf 'E' and internal resistance 'r' is connected across a variable resistor 'R'. Plot a graph showing the variation of terminal potential ' V ' with resistance R. Predict from the graph the condition under which 'V' becomes equal to 'E'. 1

3 Name the physical quantity which remains same for microwaves of wavelength 1 mm and UV radiations of 1600 Å in vacuum. 1

OR

Write two uses of infrared rays.

4 A right angle prism is placed as shown in the figure. Given that the prism is made of glass with critical angle 40°, trace the path of the ray *P* incident normal to the face *AC*. 1



5 Define the terms (i) 'cut-off voltage' and (ii) 'threshold frequency' in relation to the phenomenon of photoelectric effect. 1

OR

How does the stopping potential applied to a photocell change, if the distance between the light source and the cathode of the cell is doubled?

SECTION B

6 A conductor of length 'l' is connected to a dc source of potential 'V'. If the length of the conductor is doubled by gradually stretching it, keeping 'V' constant, how will 2

(i) drift speed of electrons and

(ii) resistance of the conductor be affected?

Justify your answer.

OR

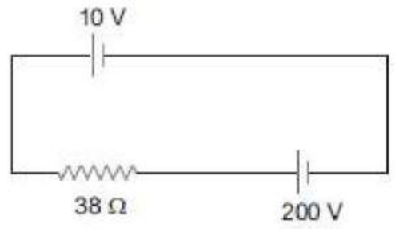
You are required to select a carbon resistor of resistance 47 $k\Omega \pm 10\%$ from a large collection. What should be the sequence of colour bands used to code it?

7 In the figure a long uniform potentiometer wire AB is having a constant potential gradient along its length. The null points for the two primary cells of emfs ε_1 and ε_2 connected in the manner shown are obtained at a distance of 120 cm and 300 cm from the end A. Find $\varepsilon_1 / \varepsilon_2$. 2

How is the sensitivity of a potentiometer increased?

OR

A 10 V battery of negligible internal resistance is connected across a 200 V battery and a resistance of 38 Ω as shown in the figure. Find the value of the current in circuit.



8 A horizontal straight wire of length L extending from east to west is falling with speed v at right angles to the horizontal component of Earth's magnetic field B. 2

(i) Write the expression for the instantaneous value of the e.m.f. induced in the wire.

(ii) What is the direction of the e.m.f.?

9 When an ideal capacitor is charged by a dc battery, no current flows. However, when an ac source is used, the current flows continuously. How does one explain this, based on the concept of displacement current? 2

10 Two polaroids 'A' and 'B' are kept in crossed position. How should a third polaroid 'C' be placed between them so that the intensity of polarised light transmitted by polaroid B reduces to 1/8th of the intensity of unpolarised light incident on A? 2

11 Can we take one slab of p-type semiconductor and physically join it to another n-type semiconductor to get p-n junction? 2

12 Why are high frequency carrier waves used for transmission? 2

SECTION C

13 An electric dipole is held in a uniform electric field. 3

(i) Show that the net force acting on it is zero.

(ii) The dipole is aligned parallel to the field. Find the work done in rotating it through the angle of 180°

14 A slab of material of dielectric constant K has the same area as that of the plates of a parallel plate capacitor but has the thickness d/2, where d is the separation between the plates. Find out the expression for its capacitance when the slab is inserted between the plates of the capacitor. 3

15 a) State the principle on which the working of a meter bridge is based. 3

b) Answer the following:

(i) Why are the connections between resistors in a meter bridge made of thick copper strips?

(ii) Why is it generally preferred to obtain the balance point near the middle of the bridge wire in meter bridge experiments?

16 Draw a schematic diagram of a cyclotron. Explain its underlying principle and working, starting clearly the function of the electric and magnetic fields applied on a charged particle. 3

OR

Using Ampere's circuital law, derive an expression for the magnetic field along the axis of a toroidal solenoid.

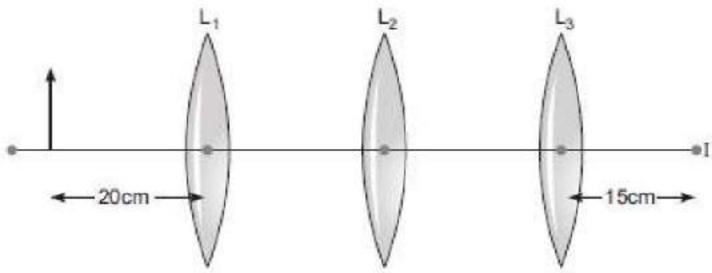
17 Describe briefly, with the help of a labelled diagram, working of a step-up transformer. A step-up transformer converts a low voltage into high voltage. Does it not violate the principle of conservation of energy? Explain. 3

18 Show that in an a.c. circuit containing a pure inductor, the voltage is ahead of current by $\pi/2$ in phase. 3

OR

An alternating voltage $V = V_m \sin \omega t$ applied to a series LCR circuit drives a current given by $i = i_m \sin(\omega t + \phi)$. Deduce an expression for the average power dissipated over a cycle.

19 You are given three lenses L_1, L_2 and L_3 each of focal length 15 cm. An object is kept at 20 cm in front of L_1, as shown. The final real image is formed at the focus 'I' of L_3. Find the separations between L_1, L_2 and L_3. 3



OR

Use Huygens' geometrical construction to show the propagation of a plane wavefront from a rarer medium (*i*) to a denser medium (*ii*) undergoing refraction. Hence derive Snell's law of refraction.

20 Draw a ray diagram of a reflecting type telescope. State two advantages of this telescope over a refracting telescope. 3

21 Write Einstein's photoelectric equation. State clearly the three salient features observed in photoelectric effect, which can be explained on the basis of the above equation. 3

22 Using de Broglie's hypothesis, explain with the help of a suitable diagram, Bohr's second postulate of quantization of energy levels in a hydrogen atom. 3

23 (*i*) What characteristic property of nuclear force explains the constancy of binding energy per nucleon (BE/A) in the range of mass number 'A' lying $30 < A < 170$? 3

(ii) Show that the density of nucleus over a wide range of nuclei is constant independent of mass number A.

OR

A radioactive nucleus 'A' undergoes a series of decays according to the following scheme :

$$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$$

The mass number and atomic number of A are 180 and 72 respectively. What are these numbers for A_4 ?

24 Explain briefly the following terms used in communication system: 3

(*i*) Transducer

(*ii*) Repeater

(*iii*) Amplification

SECTION D

25 Why is a zener diode considered as a special purpose semiconductor diode? 5

Draw the I–V characteristic of a zener diode and explain briefly how reverse current suddenly increases at the breakdown voltage.

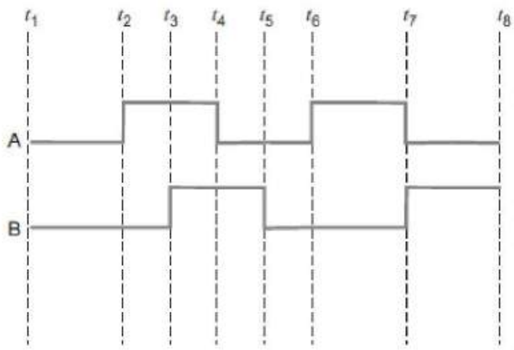
Describe briefly with the help of a circuit diagram how a zener diode works to obtain a constant dc voltage from the unregulated dc output of a rectifier.

OR

a) Draw the circuit diagram of a full wave rectifier using p-n junction diode. Explain its working and show the output, input waveforms.

b) Show the output waveforms (Y) for the following inputs A and B of

(*i*) OR gate (*ii*) NAND gate



26 a) What is the effect on the interference fringes in a Young's double slit experiment when 5

(i) the separation between the two slits in decreased?

(ii) the width of the source slit is increased?

(iii) the monochromatic source is replaced by a source of white light?

(iv) Justify your answer in each case.

b) The intensity at the central maxima in Young's double slit experimental set-up is I_0. Show that the intensity at a point where the path difference is $\lambda/3$ is $I_0/4$.

OR

a) Obtain the conditions for the bright and dark fringes in diffraction pattern due to a single narrow slit illuminated by a monochromatic source. Explain clearly why the secondary maxima go on becoming weaker with increasing n.

b) When the width of the slit is made double, how would this affect the size and intensity of the central diffraction band? Justify.

27 a) With the help of a diagram, explain the principle and working of a moving coil galvanometer. 5

b) What is the importance of a radial magnetic field and how is it produced

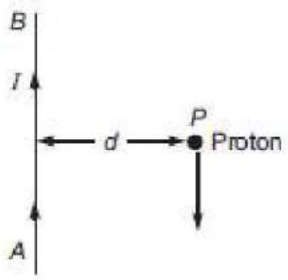
c) Why is it that while using a moving coil galvanometer as a voltmeter a high resistance in series is required whereas in an ammeter a shunt is used?

OR

a) Derive an expression for the force between two long parallel current carrying conductors.

b) Use this expression to define S. I. unit of current.

c) A long straight wire *AB* carries a current *I*. A proton *P* travels with a speed *v*, parallel to the wire, at a distance *d* from it in a direction opposite to the current as shown in the figure. What is the force experienced by the proton and what is its direction?

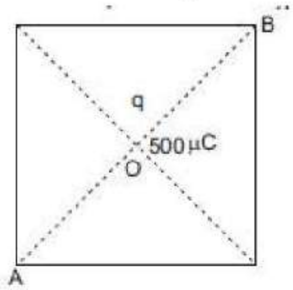


Physics

Class- XII

SECTION A

1 The points A and B are equidistant from the centre of square where charge q = 500 μC is located; therefore, points A and B are at the same potential i.e., $V_A = V_B$. ½



$\therefore$ Work done in moving charge $q_0 = 10\ \mu C$ from A to B is $W = q_0 (V_B - V_A) = 0$ ½

2 Terminal potential difference,

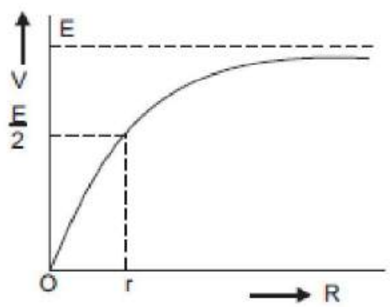
$$V = IR = \left(\frac{E}{R+r}\right)R = \frac{E}{1+\frac{r}{R}}$$ ½

When $R \to 0, V = 0$

When $R = r, V = \frac{E}{2}$

When $R = \infty, V = E$

The graph is shown in fig.



½

3 Velocity ($c = 3\times10^8$ m/s) ½

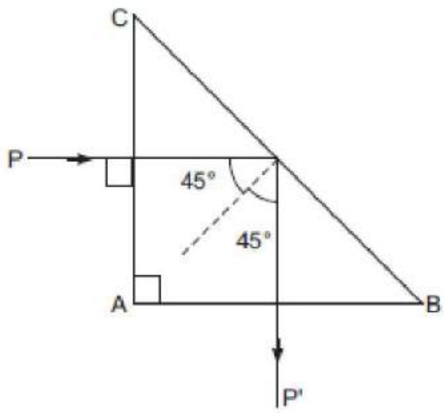
This is because both are electromagnetic waves. ½

OR

(*i*) Doctors use infrared lamps to treat skin diseases and relieve the pain of sore muscles ½

(*ii*) In electronic devices for example semiconductor light emitting diodes. ½

4 1



5 (i) Cut off or stopping potential is that minimum value of negative potential at anode which just stops the photo electric current. ½

(ii) For a given material, there is a minimum frequency of light below which no photo electric emission will take place, this frequency is called as threshold frequency. ½

OR

Stopping potential remains unchanged. 1

SECTION B

6 (*i*) We know that drift speed ½

$v_d = -\frac{eV\tau}{ml} \propto \frac{1}{l}$

When length of the conductor is doubled, drift velocity gets halved. ½

As $R = \frac{\rho l}{A}$

Now, $l' = 2l$ and $A' = \frac{A}{2}$

$\therefore$ New resistance, $R' = \frac{\rho(2l)}{\frac{A}{2}} = 4\frac{\rho l}{A}$ ½

Thus, resistance becomes four times ½

OR

Yellow ½

Violet ½

Orange and ½

Silver ½

7 Let k = potential gradient in V/cm

$\varepsilon1 + \varepsilon2 = 300k$ ...(*i*) ½

$\varepsilon1 - \varepsilon2 = 120k$ ...(*ii*) ½

We can solve, ½

$\frac{\varepsilon_1}{\varepsilon_2} = \frac{7}{3}$ ½

By decreasing potential gradient

OR

If cells are in oppositions 1

$E_{net} = E_1 - E_2$

$= (200 - 10)\ V = 190\ V$

Current $I = \frac{E_{net}}{R_{eq}} = \frac{190}{38} = 5A$ 1

8 (*i*) Induced emf $\varepsilon = B_H VL$ 1

Where B_H is horizontal component of earth's magnetic field directed from S to N.

(*ii*) West to east. 1

9 When an ideal capacitor is charged by dc battery, charge flows (momentarily) till the capacitor gets fully charged.

When an ac source is connected then conduction current

$i_c = \frac{dq}{dt}$ 1

keep on flowing in the connecting wire. Due to changing current, charge deposited on the plates of the capacitor changes with time. This causes change in electric field between the plates of the capacitor which causes the electric flux to change and gives rise to a displacement current in the region between the plates of the capacitor.

As we know, displacement current

$i_d = \varepsilon_0 \frac{d\phi_E}{dt}$

and $i_d = i_c$ at all instants. 1

10 Let the angle between the pass axis of A and $C = \theta$

Intensity of light passing through $A = \frac{I_0}{2}$ ½

Intensity of light passing through $C = \frac{I_0}{2}\cos^2\theta$

Intensity of light passing through $B = \frac{I_0}{2}\cos^2\theta . \cos^2(90-\theta)$

$= \frac{I_0}{2}\cos^2\theta . \sin^2\theta = \frac{I_0}{2}(\cos\theta . \sin\theta)^2$ ½

According to question

$$\frac{I_0}{2}(\cos\theta \sin\theta)^2 = \frac{I_0}{8}$$

$$\frac{I_0}{2}\left(\frac{2\sin\theta\cos\theta}{2}\right)^2 = \frac{I_0}{8}$$ ½

$$\sin 2\theta = 1$$

or, $2\theta = 90^\circ \Rightarrow \theta = 45^\circ$

The third polaroid is placed at $\theta = 45^\circ$. ½

11 No! Any slab, howsoever flat, will have roughness much larger than the inter-atomic crystal spacing (~2 to 3 Å) and hence *continuous contact* at the atomic level will not be possible. The junction will behave as a *discontinuity* for the flowing charge carriers. 2

12 **Use of high frequency carrier wave in transmission of signals:**

(i) High frequencey carrier wave reduces the size of antenna as $h = \lambda/2$ or $\lambda/4$

(ii) High frequency carrier wave radiates more power in space as $P \propto \upsilon^2$. 1

(iii) High frequency carrier wave avoids mixing up of message signals.

(Any two) 1

SECTION C

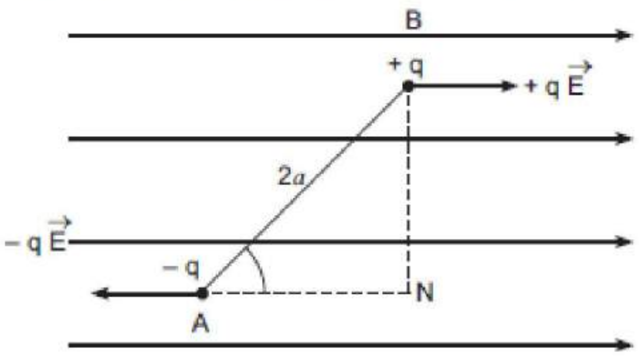
13 (*i*) The dipole moment of dipole is

$$|\vec{P}| = q \times (2a)$$

Force on $-q$ at $A = -q\vec{E}$

Force on $+q$ at $B = +q\vec{E}$ 1

Net force on the dipole $= q\vec{E} - q\vec{E} = 0$



(*ii*) Work done on dipole

$$W = \Delta U = PE(\cos\theta_1 - \cos\theta_2)$$ 1

$$= PE(\cos 0^\circ - \cos 180^\circ)$$

$$W = 2PE$$ 1

14

$$C=\frac{\varepsilon_0 A}{d-t+\frac{t}{K}}$$ ½

$$t=\frac{d}{2}$$ ½

$$C=\frac{\varepsilon_0 A}{d-\frac{d}{2}+\frac{d}{2K}}$$ 1

$$=\frac{\varepsilon_0 A}{\frac{d}{2}+\frac{d}{2K}}$$

$$=\frac{\varepsilon_0 A}{\frac{d}{2}\left(1+\frac{1}{K}\right)}$$ 1

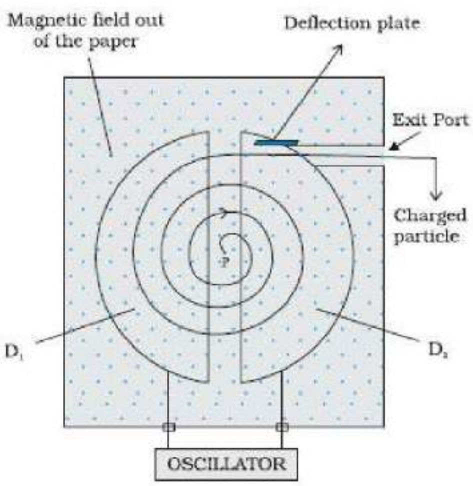
$$=\frac{2\varepsilon_0 AK}{d(K+1)}$$

15 (a) If ratio of arms resistors in wheat stone bridge is constant, then no current flows through the galvanometer . 1

(b) (i) The resistivity of copper is several times less than the resistivity of the experimental alloy wire. As such area of thick copper strips is more, so copper strips almost offer zero resistance in the circuit. 1

(ii) If any one resistance in wheat stone bridge is either very small (or very large) in respect of other, then balance point might be very close to terminal A or terminal B. So generally balance point is taken in the middle of the bridge wire. 1

16 **Cyclotron:** The cyclotron, devised by Lawrence and Livingston, is a device for accelerating ions to high speed by the repeated application of accelerating potentials.



1

Principle: The positive ions produced from a source are accelerated. Due to the presence of perpendicular magnetic field the ion will move in a circular path. The phenomenon is continued till the ion reaches at the periphery where an auxiliary negative electrode (deflecting plate) deflects the accelerated ion on the target to be bombarded. 1

Working: The principle of action of the apparatus is shown in fig. The positive ions produced from a source *S* at the centre are accelerated by a dee which is at negative potential at that moment. Due to the presence of perpendicular magnetic field the ion will move in a circular path inside the dees. The magnetic field and the frequency of the applied voltages are so chosen that as the ion comes out of a dee, the dees change their polarity (positive becoming negative and vice-versa) and the ion is further accelerated and moves with higher velocity along a circular path of greater radius. The phenomenon is continued till the ion reaches at the

periphery of the dees where an auxiliary negative electrode (deflecting plate) deflects the accelerated ion on the target to be bombarded.

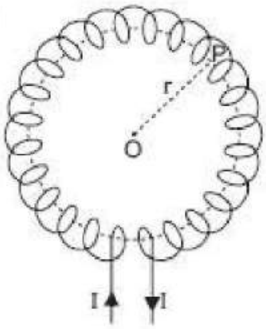
The function of electric field is to accelerate the charged particle and so to impart energy to the charged particle.

The function of magnetic field is to provide circular path to charged particle and so to provide the location where charged particle is capable of gaining energy from electric field. 1

OR

For points inside the core of toroid

Consider a circle of radius *r* in the region enclosed by turns of toroid.



1

Now we apply Ampere's circuital law to this circular path, *i. e.*,

$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \mu I$$

$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{l}} = \oint B dl \cos 0 = B \cdot 2\pi r$$ 1

Length of toroid $= 2\pi r$

Number of turns in toroid $= n(2\pi r)$

current in one-turn $= I$

$\therefore$ Current enclosed by circular path $= (n\,2\pi r) \cdot I$

$$B\,2\pi r = \mu_0\,(n\,2\pi r I)$$

$$B = \mu_0\,nI$$ 1

17 Labeled diagram 1

Step up Transformer: It transforms the alternating low voltage to alternating high voltage and in this the number of turns in secondary coil is more than that in primary coil. (i. e. , NS > Np). ½

Working: When alternating current source is connected to the ends of primary coil, the current changes continuously in the primary coil; due to
which the magnetic flux linked with the secondary coil changes continuously, therefore the alternating emf of same frequency is developed across the secondary. Let Np be the number of turns in primary coil, NS the number of turns in secondary coil and f the magnetic flux linked with each turn. We assume that there is no leakage of flux so that the flux linked with each turn of primary coil and secondary coil is the same. According to Faraday's laws the emf induced in the primary coil ½

$$\varepsilon_p = -N_p \frac{\Delta\phi}{\Delta t}$$

and emf induced in the secondary coil

$$\varepsilon_S = -N_S \frac{\Delta\phi}{\Delta t}$$

therefore

$$\frac{\varepsilon_S}{\varepsilon_p} = \frac{N_S}{N_p}$$

If the resistance of primary coil is negligible, the emf (e_p) induced in the primary coil, will be equal to the applied potential difference (V_p) across its ends. Similarly if the secondary circuit is open, then the potential difference V_S across its ends will be equal to the emf (e_S) induced in it; therefore

$$\frac{V_S}{V_p} = \frac{\varepsilon_S}{\varepsilon_p} = \frac{N_S}{N_p} = r \text{ (say)}$$ ½

where r is called the transformation ratio.

In step up transformer, $N_s > N_p \rightarrow r > 1$;

So $V_S > V_p$ and $i_S < i_p$

i.e. step up transformer increases the voltage.

When output voltage increases, the output current automatically decreases to keep the power same. Thus, there is no violation of conservation of energy in a step up transformer. ½

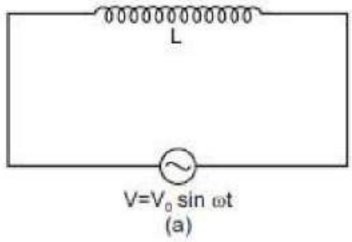
18 **AC circuit containing pure inductance:** Consider a coil of self-inductance L and negligible ohmic resistance. An alternating potential difference is applied across its ends. ½
The magnitude and direction of AC changes periodically, due to which there is a continual change in magnetic flux linked with the coil. Therefore according to Faraday's law, an induced emf is produced in the coil, which opposes the applied voltage. As a result the current in the circuit is reduced. That is ***inductance acts like a resistance in ac circuit.*** The instantaneous value of alternating voltage applied ½

$$V = V_0 \sin \omega t \qquad ...(i)$$

If i is the instantaneous current in the circuit and $\frac{di}{dt}$, the rate of change of current in the circuit at that instant, then instantaneous induced emf

$$\varepsilon = -L\frac{di}{dt}$$ ½

According to Kirchhoff's second law in closed circuit.



$$V + \varepsilon = 0 \Rightarrow V - L\frac{di}{dt} = 0$$

or $$V = L\frac{di}{dt} \quad \text{or} \quad \frac{di}{dt} = \frac{V}{L}$$

or $$\frac{di}{dt} = \frac{V_0 \sin \omega t}{L} \quad \text{or} \quad di = \frac{V_0 \sin \omega t}{L}dt$$ 1

Integrating with respect to time 't',

$$i = \frac{V_0}{L}\int \sin \omega t\, dt = \frac{V_0}{L}\left\{-\frac{\cos \omega t}{\omega}\right\} = -\frac{V_0}{\omega L}\cos \omega t$$

$$= -\frac{V_0}{\omega L}\sin\left(\frac{\pi}{2} - \omega t\right)$$

or $$i = \frac{V_0}{\omega L}\sin\left(\omega t - \frac{\pi}{2}\right) \qquad ...(ii)$$ ½

This is required expression for current ½

or $$i = i_0 \sin\left(\omega t - \frac{\pi}{2}\right) \qquad ...(iii)$$

OR

½

$V = V_m \sin \omega t$

$i = i_m (\omega t + \phi)$

and instantaneous power, $P = Vi$

$$= V_m \sin \omega t \,.\, i_0 \sin(\omega t + \phi) = V_m\, i_m \sin \omega t \sin(\omega t + \phi)$$

$$= \frac{1}{2}V_m i_m\, 2 \sin \omega t \,.\, \sin(\omega t + \phi)$$ 1

From trigonometric formula

$$2 \sin A \sin B = \cos(A - B) - \cos(A + B)$$

$\therefore$ Instantaneous power, $$P = \frac{1}{2}V_m i_m[\cos(\omega t + \phi - \omega t) - \cos(\omega t + \phi + \omega t)]$$

$$= \frac{1}{2}V_m\, i_m\,[\cos\phi - \cos(2\omega t + \phi)] \qquad ...\text{(i)}$$

Average power for complete cycle

$$\vec{P} = \frac{1}{2} V_m i_m [\cos\phi - \overline{\cos(2\omega t + \phi)}]$$

where $\cos\overline{(2\omega t + \phi)}$ is the mean value of $\cos(2\omega t + \phi)$ over complete cycle. But for a complete cycle, $\overline{\cos(2\omega t + \phi)} = 0$ 1

$\therefore$ Average power,

$$\vec{P} = \frac{1}{2} V_m i_m \cos\phi$$

$$= \frac{V_0}{\sqrt{2}} \frac{i_0}{\sqrt{2}} \cos\phi$$

$$\vec{P} = V_{rms}\, i_{rms} \cos\phi$$

19 Given $f_1 = f_2 = f_3 = 15\text{cm}$

We have, lens formula

$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1} \quad \therefore \quad u_1 = -20 \text{ cm}, f_1 = 15 \text{ cm}$$ 1

$$\frac{1}{v_1} = \frac{1}{15} + \frac{1}{-20} \quad \Rightarrow \quad v_1 = 60 \text{ cm}$$

So, the image formed by lens L_2 is at infinity.

It means that the object for L_2 lies at its focus. 1

So, $u_2 = 15$ cm

Hence, distance between L_1 and L_2 is

$$d_1 = v_1 + u_2 = 60 + 15 = 75 \text{ cm}$$

As the image formed by lens L_2 lies at infinity then, the distance between L_2 and L_3 does not matter. Hence, the distance between L_2 and L_3 can have any value. 1

OR

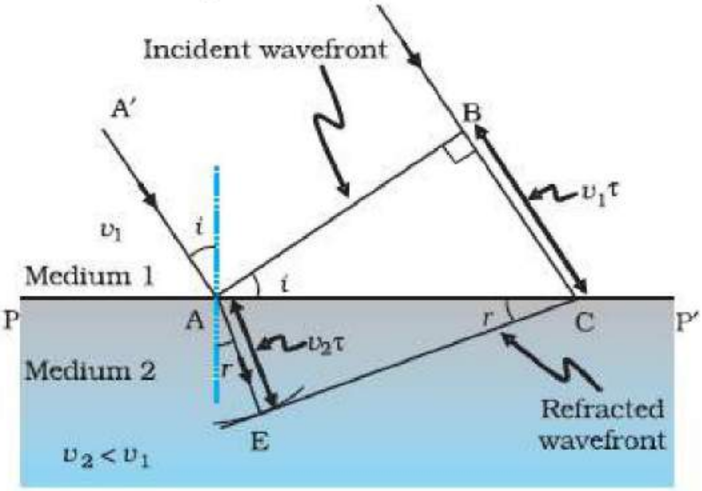
Proof of Snell's law of Refraction using Huygen's wave theory : When a wave starting from one homogeneous medium enters the another homogeneous medium, it is deviated from its path. This phenomenon is called **refraction.** In transversing from first medium to another medium, the frequency of wave remains unchanged but its speed and the wavelength both are changed. Let XY be a surface separating the two media '1' and '2'. Let $v1$ and $v2$

be the speeds of waves in these media. Suppose a plane wavefront AB in first medium is incident obliquely on the boundary surface XY and its end A touches the surface at A at time $t = 0$ while the other end B reaches the surface at point B' after time-interval t. Clearly $BB' = v1t$. As the wavefront AB advances, it strikes the points between A and B' of boundary surface. According to Huygen's principle, secondary spherical wavelets originate from these points, which travel with speed $v1$ in the first medium and speed $v2$ in the second medium.

First of all secondary wavelet starts from A, which traverses a distance AA' ($=v2t$) in second medium in time t. In the same time-interval t, the point of wavefront traverses a distance BB' ($=v1t$) in first medium and reaches B', from, where the secondary wavelet now starts. Clearly $BB' = v1t$ and $AA' = v2t$. ½

Assuming A as centre, we draw a spherical arc of radius AA' ($=v2t$) and draw tangent $B'A'$ on this arc from B'. As the incident wavefront AB advances, the secondary wavelets start from points between A and B', one after the other and will touch $A'B'$ simultaneously.

According to Huygen's principle $A'\,B'$ is the new position of wavefront AB in the second medium. Hence ***A′ B′ will be the refracted wavefront***.



1

In right-angled triangle $AB'B$, $\angle ABB' = 90°$

$\therefore \quad \sin i = \sin \angle BAB' = \dfrac{BB'}{AB'} = \dfrac{v_1 t}{AB'}$ ...(i) ½

Similarly in right-angled triangle $AA'B'$, $\angle AA'B' = 90°$

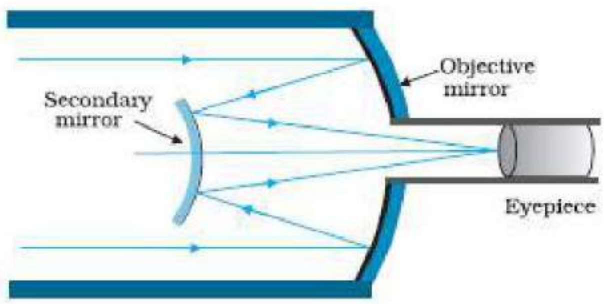
$\therefore \quad \sin r = \sin \angle AB'A' = \dfrac{AA'}{AB'} = \dfrac{v_2 t}{AB'}$ ...(ii) ½

Dividing equation (i) by (ii), we get

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \text{constant} \quad ...(iii)$$

The ratio of sine of angle of incidence and the sine of angle of refraction is a constant and is equal to the ratio of velocities of waves in the two media. This is the second law of refraction, and is called the Snell's law. ½

20 2



½

½

Advantages: (i) It is free from chromatic aberration.

(ii) Its resolving power is greater than refracting telescope due to larger aperture of mirror.

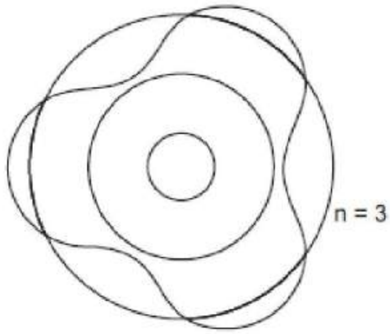
21 Einstein's photoelectric equation is $Ek = h\nu - W$ for a single photon ejecting a single electron.

(i) **Explanation of frequency law:** When frequency of incident photon (ν), increases, the kinetic energy of emitted electron increases. Intensity has no effect on kinetic energy of photoelectrons. 1

(ii) **Explanation of intensity law:** When intensity of incident light increases, the number of incident photons increases, as one photon ejects one electron; the increase in intensity will increase the number of ejected electrons. In other words, photocurrent will increase with increase of intensity. Frequency has no effect on photocurrent. 1 1

(iii) **Explanation of no time lag law:** When the energy of incident photon is greater than work function, the photoelectron is immediately ejected. Thus there is no time lag between incidence of light and emission of photoelectrons.

22 According to de Broglie's hypothesis,



½

½

$\lambda = h/mv$ ...(*i*)

According to de Broglie's condition of stationary orbits, the stationary orbits are those which

contain complete de-Broglie wavelength. 1

$2\pi r = n\lambda$ ...(*ii*)

Substituting value of λ from (*ii*) in (*i*), we get

$2\pi r = nh/mv$ 1

$\Rightarrow mvr = nh/2\pi$ ...(*iii*)

23 (*i*) Saturation or short range nature of nuclear forces. 1

(*ii*) We have

$$R = R_0 A^{1/3}$$

Let m = mass of nucleon ½

$$\therefore \text{Density } (\rho) = \frac{mA}{\frac{4}{3}\pi\left(R_0 A^{1/3}\right)^3} = \frac{mA}{\frac{4}{3}\pi R_0^3 A} = \frac{m}{\frac{4}{3}\pi R_0^3}$$ 1

Hence ρ is independent of A. ½

OR

$${}^{180}_{72}\text{A} \xrightarrow{\alpha} {}^{176}_{70}\text{A}_1 \xrightarrow{\beta^-} {}^{176}_{71}\text{A}_2 \xrightarrow{\alpha} {}^{172}_{69}\text{A}_3 \xrightarrow{\gamma} {}^{172}_{69}\text{A}_4$$ 3

Thus, mass number of A_4 is 172 and atomic number is 69.

24 (i) **Transducer:** Any device which converts one form of energy into another. 1

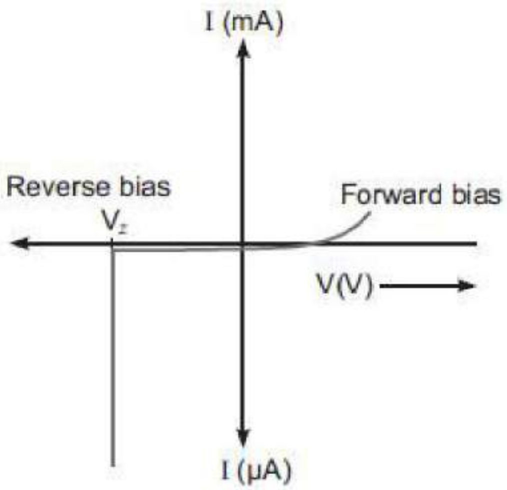
(ii) **Repeater:** It is a combination of a receiver and a transmitter. A repeater, picks up the signal from the transmitter, amplifies and retransmits it to receiver sometimes with a change in carrier frequency. 1

(iii) **Amplification:** It is the process of increasing the amplitude of a signal using an electronic circuit. (i.e., amplifier). It is necessary to compensate for attenuation of signal in communication system. 1

SECTION D

25 A zener diode is considered as a special purpose semiconductor diode because it is designed to operate under reverse bias in the breakdown region. 1

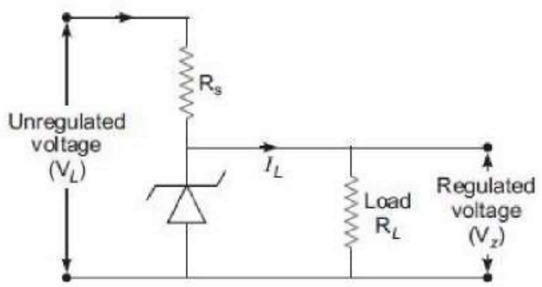
We know that reverse current is due to the flow of electrons (minority carriers) from $p \rightarrow n$ and holes from $n \rightarrow p$. As the reverse bias voltage is increased, the electric field at the junction becomes significant. When the reverse bias voltage $V = Vz$, then the electric field strength is high enough to pull valence electrons from the host atoms on the p-side which are accelerated to n-side. These electrons causes high current at breakdown. 1



1

Working:

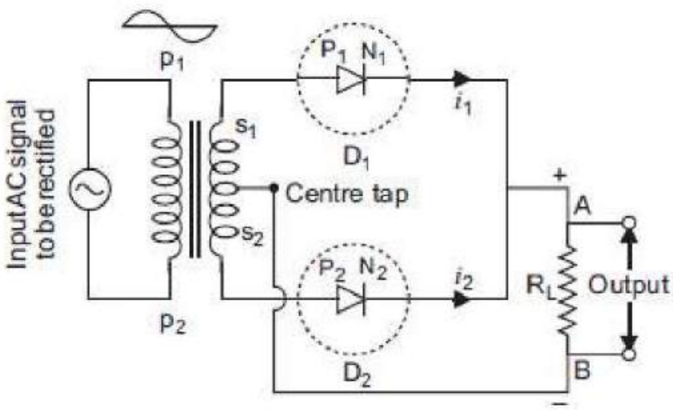
The unregulated dc voltage output of a rectifier is connected to the zener diode through a series resistance Rs such that the zener diode is reverse biased. Now, any increase/decrease in the input voltage results in increase/decrease of the voltage drop across Rs without any change in voltage across the zener diode. Thus, the zener diode acts as a voltage regulator. 1



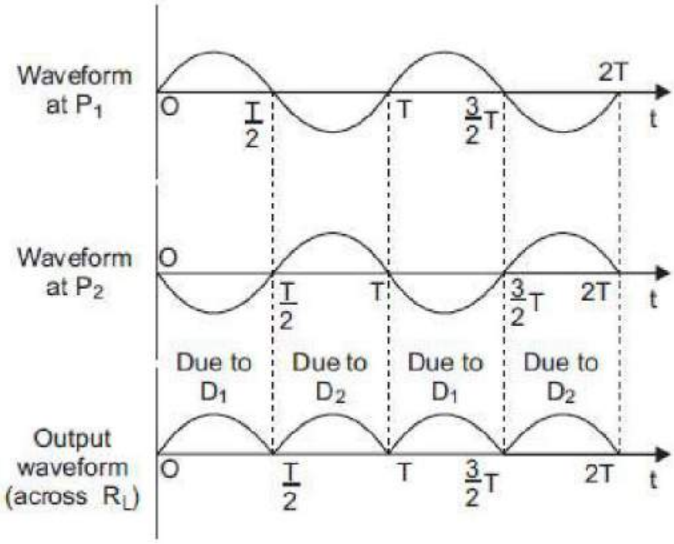
1

OR

(*a*) 1 +



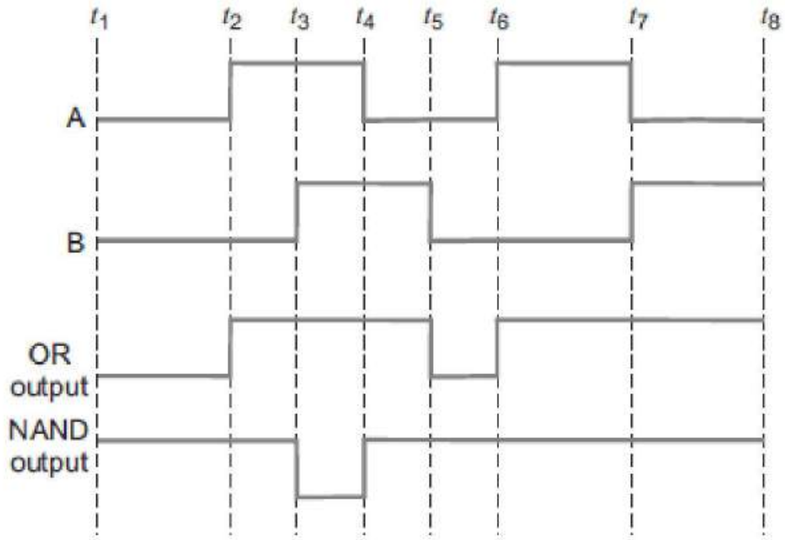
Working: The AC input voltage across secondary *s*1 and *s*2 changes polarity after each half cycle. Suppose during the first half cycle of input AC signal, the terminal *s*1 is positive relative to centre tap *O* and *s*2 is negative relative to *O*. Then diode *D*1 is forward biased and diode *D*2 is reverse biased. Therefore, diode *D*1 conducts while diode *D*2 does not. The direction of current (*i*1) due to diode *D*1 in load resistance *RL* is directed from *A* to *B*. In nexthalf cycle, the terminal *s*1 is negative and *s*2 is positive relative to centre tap *O*. The diode *D*1 is reverse biased and diode *D*2 is forward biased. Therefore, diode *D*2 conducts while *D*1 does not. The direction of current (*i*2) due to diode *D*2 in load resistance *RL* is still from *A* to *B*. Thus the current in load resistance *RL* is in the same direction for both half cycles of input AC voltage. Thus *for input AC signal the output current is a continuous series of unidirectional pulses.* 1



1

In a full wave rectifier, if input frequency is *f* hertz, then output frequency will be 2*f* hertz because for each cycle of input, two positive half cycles of output are obtained.

(*b*) Output waveforms for the following inputs *A* and *B* of OR gate and NAND gate. 1



1

26 (*a*) (*i*) Fringe width (β) =λ*D*/*d* If *d* decreases, β increases

(*ii*) For interference fringe, the condition is *s*/*D*< *d* /λ

where *s* = size of source, *D* = distance of source from slits. 1

If the source slit width increases, fringe pattern gets less sharp or faint.

When the source slit is made wide which does not fullfil the above condition and interference pattern not visible.

(*iii*) The central fringes are white. On the either side of the central white fringe the coloured bands (few coloured maxima and minima) will appear. This is because fringes of different colours overlap. 1

(*b*) Intensity at a point is 1

$$I = I_0 \cos^2 \frac{\phi}{2}$$

At path difference $\frac{\lambda}{3}$, the phase difference, $\phi = \frac{2\pi}{\lambda} . \frac{\lambda}{3} = \frac{2\pi}{3}$

$$\therefore \quad I = I_0 \cos^2 \frac{1}{2}\left(\frac{2\pi}{3}\right) = I_0 \cos^2\left(\frac{\pi}{3}\right) = \frac{I_0}{4}$$ 1

OR

(*a*) Let *AB* be a slit of width *'a'* and a parallel beam of monochromatic light is incident on it. According to Fresnel the diffraction pattern is the result of superposition of a large number of waves, starting from different points of illuminated slit. 1

Let θ be the angle of diffraction for waves reaching at point *P* of screen and *AN* the perpendicular dropped from *A* on wave diffracted from *B*.

1

The path difference between rays diffracted at points *A* and *B*,

$\Delta = BP - AP = BN$

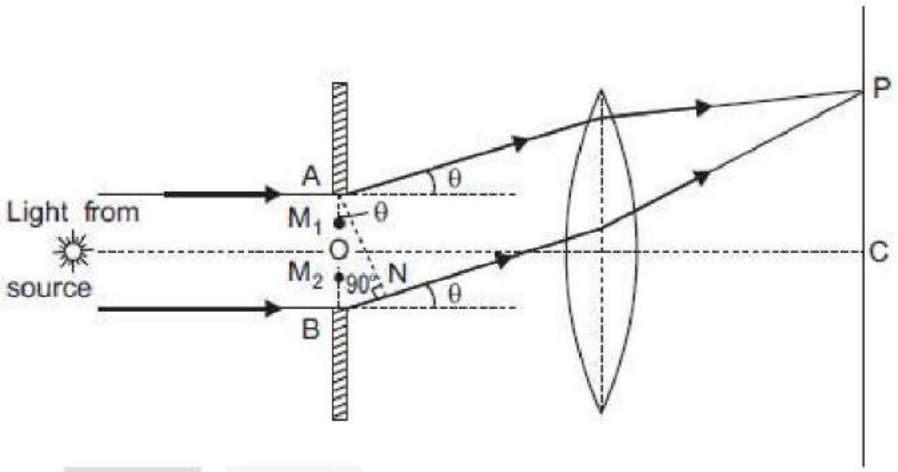
In ΔANB, $\angle ANB = 90°$ $\therefore$ and $\angle BAN = \theta$

$\therefore$ $\sin\theta = \frac{BN}{AB}$ or $BN = AB\sin\theta$

As AB = width of slit $= a$

$\therefore$ Path difference, ½

$$\Delta = a\sin\theta \quad ....($$



At the central point C of the screen, the angle θ is zero. Hence the waves starting from all points of slit arrive in the same phase. This gives maximum intensity at the central point C. ½
If point P on screen is such that the path difference between rays starting from edges A and B
is λ, then path difference

$$a\sin\theta = \lambda \Rightarrow \sin\theta = \frac{\lambda}{a}$$

If angle θ is small, $\sin\theta = \theta = \frac{\lambda}{a}$ ...(*ii*)

Minima : Now we divide the slit into two equal halves AO and OB, each of width $\frac{a}{2}$. Now for every point, M_1 in AO, there is a corresponding point M_2 in OB, such that $M_1M_2 = \frac{a}{2}$; Then path difference between waves arriving at P and starting from M_1 and M_2 will be $\frac{a}{2}\sin\theta = \frac{\lambda}{2}$. This means that the contributions from the two halves of slit AO and OB are opposite in phase and so cancel each other. Thus equation (2) gives the angle of diffraction at which intensity falls to zero. Similarly it may be shown that the intensity is zero for $\sin\theta = \frac{n\lambda}{a}$, with n as integer. Thus the general condition of **minima** is ½

$$a\sin\theta = n\lambda \quad ...(iii)$$

Secondary Maxima : Let us now consider angle θ such that

½

$$\sin\theta = \theta = \frac{3\lambda}{2a}$$

which is midway between two dark bands given by

$$\sin\theta = \theta = \frac{\lambda}{a} \text{ and } \sin\theta = \theta = \frac{2\lambda}{a}$$

Let us now divide the slit into three parts. If we take the first two of parts of slit, the path difference between rays diffracted from the extreme ends of the first two parts

$$\frac{2}{3}a\sin\theta = \frac{2}{3}a \times \frac{3\lambda}{2a} = \lambda$$

Then the first two parts will have a path difference of $\frac{\lambda}{2}$ and cancel the effect of each other.

The remaining third part will contribute to the intensity at a point between two minima. Clearly there will be a maxima between first two minima, but this maxima will be of much weaker intensity than central maximum. This is called *first secondary maxima.* In a similar manner we can show that there are secondary maxima between any two consecutive minima; and the intensity of maxima will go on decreasing with increase of order of maxima. In general the position of nth maxima will be given by 1

$$a\sin\theta = \left(n + \frac{1}{2}\right)\lambda, \quad [n = 1, 2, 3, 4, \ldots.] \quad \ldots(iv)$$

The intensity of secondary maxima decrease with increase of order n because with increasing n, the contribution of slit decreases. 1

For $n = 2$, it is one-fifth, for $n = 3$, it is one-seventh and so on.

(*b*) Width of central Maxima ' $\beta' = \frac{2D\lambda}{a}$

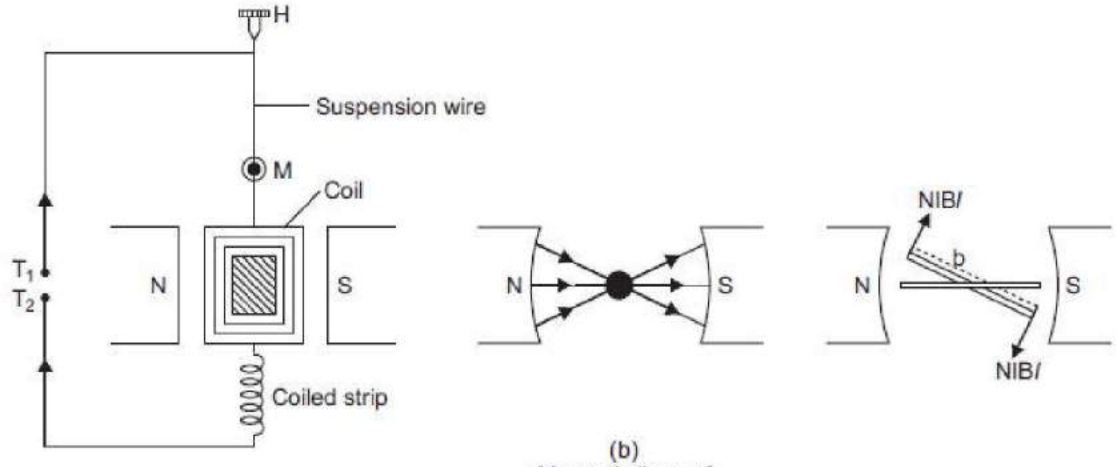
$a \rightarrow$ size of slit

If size of slit is doubled, width of central maxima becomes half. Intensity varies as square of slit width. It width of slit is doubled, intensity gets four times.

27 (*a*) **Principle and work ing:** When curr ent (I) is passed in the coil, torque τ acts on the coil, given by 1

$$\tau = NIAB\sin\theta$$

where θ is the angle between the normal to plane of coil and the magnetic field of strength B, N is the number of turns in a coil.



(a) (b) Magnetic lines of force of radial magnetic field (c)

When the magnetic field is radial, as in the case of cylindrical pole pieces and soft iron core then in every position of coil the plane of the coil, is parallel to the magnetic field lines, so that $\theta = 90°$ and $\sin 90° = 1$

Deflecting torque, $\tau = NIAB$

If C is the torsional rigidity of the wire and θ is the twist of suspension strip, then restoring torque $= C\,\theta$ 1

For equilibrium, deflecting torque = restoring torque

i.e. $NIAB = C\,\theta$

$\therefore$ $\theta = \dfrac{NAB}{C} I$ ...(*i*)

i.e. $\theta \propto I$

deflection of coil is directly proportional to current flowing in the coil and hence we can construct a linear scale.

(*b*) **Importance (or function) of uniform radial magnetic field:** In radial magnetic field $\sin\theta = 1$, so torque is $\tau = NIAB$. This makes the deflection (θ) proportional to current. In other words, the radial magnetic field makes the **scale linear.**

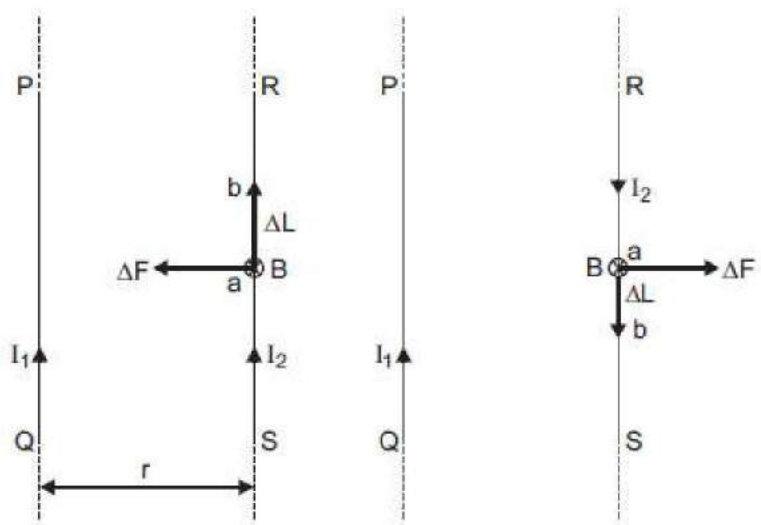
To produce radial magnetic field pole pieces of permanent magnet are made cylindrical and a soft iron core is placed between them. The soft iron core helps in making the field radial and reduce energy losses produced due to eddy currents.

(*c*) A voltmeter is used to measure p.d. across a resistance in an electrical circuit. It is connected in parallel across the resistance. If a voltmeter has very high resistance, it will not affect the resistance of circuit, hence reading will be true. That is why while using a moving coil galvanometer on a voltmeter, a high resistance in series is required. 1

An ammeter is used to measure current in circuit, hence it is connected in series with the circuit. If an ammeter has very low resistance it will not affect the circuit - resistance and so reading will be true. That is why while using a moving coil galvanometer as an ammeter, a shunt (small resistance in parallel) is used.

OR

Derivation 1



1

2

(*b*) **Definition S.I. unit of Current (Ampere):** In S.I. system of fundamental unit of currer 'ampere' has been defined assuming the force between the two current carrying wires a 1 standard.

The force between two parallel current carrying conductors of separation r is

$$f = \frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}\ \text{N/ m}$$

If $I_1 = I_2 = 1\,\text{A}, r = 1\,\text{m}$, then

$$f = \frac{\mu_0}{2\pi} = 2\times 10^{-7}\ \text{N/m}$$

1

Thus ***I ampere is the current which when flowing in each of parallel conductors placed at separation 1 m in vacuum exert a force of*** $\mathbf{2\times 10^{-7}}$ ***on 1 m length of either wire.***

(*c*) Magnetic field due to current carrying wire is perpendicular to plane of paper – downward.

i.e., $\vec{B} = -\frac{\mu_0 I}{2\pi d}\hat{k}$ 1

Force $\vec{F} = q\,\vec{v}\times\vec{B}$

$$= e(-v\hat{j})\times\left(-\frac{\mu_0 I}{2\pi d}\hat{k}\right) = \frac{\mu_0 evI}{2\pi d}\hat{i}$$

That is the magnetic force has magnitude $\frac{\mu_0 evI}{2\pi d}$ and is directed along positive x-axis *ie.*, in the plane of paper perpendicular to direction of $\vec{v}$ and to the right.


I CAN
and
I WILL.