STUDY mate
helps score more

Studymate Solutions to CBSE Board Examination 2015-2016

Series : ONS/1

Code No. 55/1/1/D

Roll No. | | | | | | | |

Candidates must write the Code on the title page of the answer-book.

- *Please check that this question paper contains* **15** *printed pages.*
- *Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.*
- *Please check that this question paper contains* **26** *questions.*
- ***Please write down the Serial Number of the questions before attempting it.***
- *15 minutes time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the student will read the question paper only and will not write any answer on the answer script during this period.*

Physics (Core)

[Time allowed : 3 hours] *[Maximum marks : 70]*

General Instructions:

(i) All questions are compulsory.

(ii) There are 26 questions in total. All questions are complusory.

(iii) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.

(iv) Section A contains (question Nos. 1 to 5) are very short answer type questions and carry one mark each.

(v) Section B contains (question Nos. 6 to 10) carry two marks each. Section C contains (question Nos. 11 to 22) carry three marks each and Section D contains value based question (question no. 23) carry four marks each. Section E contains (questin no. 24 to 26) carry five marks each.

(vi) There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all three questions of five marks each weightage. You have to attempt only one of the choices in such questions.

(vii) Use of calculators is not permitted. However, you may use log tables if necessary.

(viii) 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

$\mu_0 = 4\pi \times 10^{-7}$ T mA^{-1}

$\varepsilon_0 = 9 \times 10^9$ Nm^2 C^{-2}

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

Mass of electron = 9.1×10^{-31} kg

Mass of neutron = 1.675×10^{-27} kg

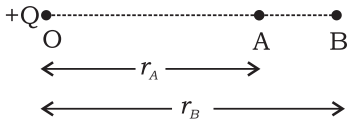
Mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{-23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

Section – A

1. A point charge +Q is placed at point O as shown in the figure. Is the potential difference $V_A - V_B$ positive, negative or zero. **[1]**



Ans. $V_A = \dfrac{Q}{4\pi\varepsilon_0 r_A}$

$V_B = \dfrac{Q}{4\pi\varepsilon_0 r_B}$

Since $r_A < r_B \Rightarrow V_A > V_B$

Hence, $V_A - V_B$ is positive

2. How does the electric flux due to a point charge enclosed by a spherical Gaussian surface get affected when its radius is increased? **[1]**

Ans. According to Gauss's law

$$\phi = \oint \vec{E}.\vec{ds} = \frac{q_{en}}{\varepsilon_0}$$

Flux depends only on the charge enclosed.

Hence, the electric flux remains cosnstant.

3. Write the underlying principle of a moving coil galvanometer. **[1]**

Ans. When a current carrying coil is placed in magnetic field then it experiences a torque.

NIAB = Kα

$$\Rightarrow \quad I = \left(\frac{K}{NAB}\right)\alpha$$

N ⇒ The number of turns.
I ⇒ current
A ⇒ Area of the loop
B ⇒ Magnetic field
K ⇒ Torsional cosntant of the wire.
α ⇒ Angle of deflection

4. Why are microwaves considered suitable for radar systems used in aircraft navigation? **[1]**

Ans. Microwaves of frequency range 1 GHZ to 300 GHZ bounces of even the smallest air craft so that they are suitable to avoid getting bombed. Microwaves can penetrate through clouds also

5. Define 'quality factor' of resonance in series LCR circuit. What is its SI unit? **[1]**

Ans. The Q factor of series resonance circuit is defined as the ratio of the voltage developed across the inductor or capacitor at resonance to the impressed voltage, which is the voltage across R

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

It is dimensionless hence, it has no units.

Section – B

6. Explain the terms (i) Attenuation and (ii) Demodulation used in Communication System. **[2]**

Ans. (i) **Attenuation :** The loss of strenght of a signal while propagating through a medium is known as attenuation.

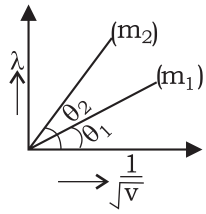
(*ii*) **Demodulation :** The process of retrieval of information from the carrier wave at the receiver is termed demodulation. This is the reverse process of modulation.

7. Plot a graph showing variation of de-Broglie wavelength λ versus $\frac{1}{\sqrt{V}}$, where V is accelerating potential for two particles A and B carrying same charge but of masses m_1, m_2 ($m_1 > m_2$). Which one of the two represents a particle of smaller mass and why? **[2]**

Ans. $qV = \frac{1}{2}mv^2$

$qV = \frac{p^2}{2m} \Rightarrow p = \sqrt{2mqV} = \frac{h}{\lambda} \Rightarrow \lambda = \frac{h}{\sqrt{2mqV}}$

$\Rightarrow$ Slope $\propto \frac{1}{\sqrt{m}}$



8. A nucleus with mass number A = 240 and BE/A = 7.6 MeV breaks into two fragments each of A = 120 with BE/A = 8.5 MeV. calculate the released energy. **[2]**

Ans. Gain in binding energy for nucleon is about 0.9 MeV.

Hence, the total gain in binding energy

$\Delta E = 240 \times 0.9$

$\Delta E = 216$ MeV.

OR

Calculate the energy in fusion reaction:

${}_1^2H + {}_1^2H \longrightarrow {}_2^3H + n$, where BE of ${}_1^2H = 2.23$ MeV and of ${}_2^3He = 7.73$ MeV.

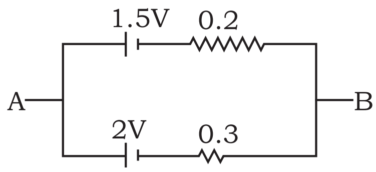
Ans. $\Delta E = (7.73) - 2(2.23)$

$\Delta E = 7.73 - 4.46$

$\Delta E = 3.27$ MeV.

9. Two cells of emfs 1.5 V and 2.0 V having internal resistances 0.2Ω and 0.3Ω respectively are connected in parallel. Calculate the emf and internal resistance of the equivalent cell. **[2]**

Ans.



Equivalent emf = $\frac{\frac{E_1}{r_1} + \frac{E_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{(1.5 \times 0.3) + (2 \times 0.2)}{0.2 + 0.3}$

$= \frac{0.45 + 0.4}{0.5} = \frac{0.85}{0.5} = 1.7$ volt

Equivalent interval resistance

$= \frac{r_1 r_2}{r_1 + r_2} = \frac{0.2 \times 0.3}{0.2 + 0.3} = \frac{0.06}{0.5}$

$r_{eq.} = 0.12\ \Omega$.

10. State Brewster's law.

The value of Brewster angle for a transparent medium is different for light of different colours. Give reason. **[2]**

Ans. Brewster law : The law states that the tangent of the polarising angle of incidence of a transparent medium is equal to its refractive index.

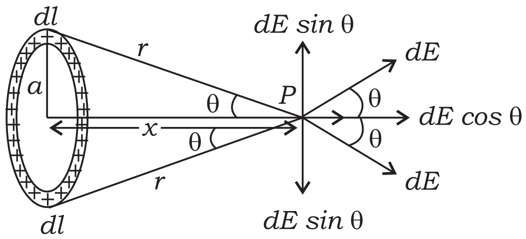
$\mu = \tan i_p$

The refractive index of a material depends on the color or wavelength of light. As the polarising angle depends on refractive index ($\mu = \tan i_p$), so it also depends on wavelength of light.

Section – C

11. A charge is distributed uniformly over a ring of radius 'a'. Obtain an expression for the electric intensity E at a point on the axis of the ring. Hence show that for points at large distance from the ring, it behaves like a point charge. **[3]**

Ans.



As the total charge q is uniformly distributed, the charge dq on the element dl is

$$dq = \frac{q}{2\pi a}.dl$$

∴ the magnitude of the electric field produced by the element dl at the axial point P is

$$dE = k.\frac{dq}{r^2} = \frac{kq}{2\pi a}\cdot\frac{dl}{r^2}$$

The electric field dE has two components.

(i) the axial components $dE\cos\theta$ and

(ii) the perpendicular component $dE\sin\theta$

Since the perpendicular component of any two diametrically opposite elements are equal and opposite, they cancel out in pairs. Only the axial components will add up to produce the resultant field.

E at point P is given by

$$E = \int_0^{2\pi a} dE\cos\theta \qquad [\because \text{ only the axial components contribute towards E}]$$

$$= \int_0^{2\pi a} \frac{kq}{2\pi a}\cdot\frac{dl}{r^2}\cdot\frac{x}{r} = \frac{kqx}{2\pi a}\cdot\frac{1}{r^3}\int_0^{2\pi a} dl \qquad \left[\because \cos\theta = \frac{x}{r}\right]$$

$$= \frac{kqx}{2\pi a}\cdot\frac{1}{r^3}\,(l)_0^{2\pi a}$$

$$= \frac{kqx}{2\pi a}\cdot\frac{1}{(x^2+a^2)^{3/2}}\cdot 2\pi a \qquad \left[\because r^2 = x^2 + a^2\right]$$

$$E = \frac{kqx}{(x^2+a^2)^{3/2}} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{qx}{(x^2+a^2)^{3/2}}$$

If x >> a, then $x^2 + a^2 \simeq x^2$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{qx}{(x^2)^{3/2}}$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$$

This expression is similar to electric field due to point charge.

12. Write three characteristic features in photoelectric effect which cannot be explained on the basis of wave throry of light, but can be explained only using Einstein's equation. **[3]**

Ans. (i) Existance of threshold frequency: According to wave theory, there should not exist any threshold frequency but Einstein's theory explains the ejxistance of threshold frequency.

(ii) Dependence of kinetic energy on frequency of incident light: According to wave theory, the maximum kinetic energy of emitted electrons should depend on intensity of incident light and not on frequency where as Einstein's equation explains that it depends on frequency and not on intensity.

(iii) Instantaneous emission of electrons: According to wave theory there should be time lag between emission of electrons and incident of light where as Einstein's equation explains why there is no time lag between incident of light and emission of electrons.

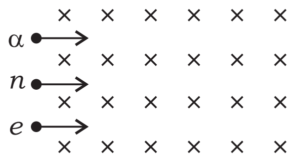
13. (a) Write the expression for the magnetic force acting on a charged particle moving with velocity v in the presence of magnetic field B.

Ans. (a) A charge particle having charge q is moving with velocity 'V' in a magnetic field of field strength 'B' then the force acting on it is given by the formula

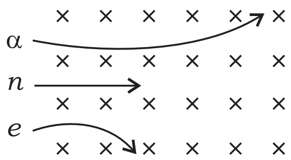
$\vec{F} = q(\vec{V} \times \vec{B})$ & $F = qvB\sin\theta$ (where θ is angle between velocity vector & magnetic field)

Direction of force is given by the cross product of velocity & magnetic field

(b) A neutron, an electron and an alpha particle moving with equal velcoities, enter a uniform magnetic field going into the plane of the paper as shown. Trace their paths in the field and justify your answer.



Ans. (b)



α particle will trace circular path in anti-clockwise sense as it's deviation will be in the direction of $(\vec{v} \times \vec{B})$, neutron will pass without any deviation as magnetic field does not exert force on neutral particle.

Electron will trace circular path in clockwise sense as it's deviation will be in the direction opposite to $(\vec{v} \times \vec{B})$ with a smaller radius due to larger charge/mass ratio as $r = \frac{mv}{qB}$.

14. (i) Define mutual inductance. **[3]**

Ans. (i) Mutual induction is the phenomenon of production of induced emf in one coil due to change of current in the neighbouring coil.

(ii) A pair of adjacent coils has a mutual inductance of 1.5 H. If the current in one coil changes from 0 to 20 A in 0.5s, what is the change of flux linkage with the other coil?

Ans. (ii) M = 1.5 H

$I_i = 0A$

$I_f = 20A$

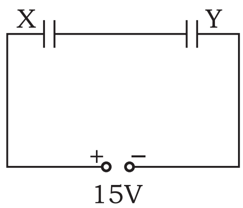
dI = 20A

dΦ = MdI

= 1.5 × 20

= 30 weber

15. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric medium of $\varepsilon_r = 4$.



(i) Calculate capacitance of each capacitor if equivalent capacitance of the combination is 4 μF.

(ii) Calculate the potential difference between the plates of X and Y.

(iii) Estimate the ratio of electrostatic energy stored in X and Y.

Ans. (i) Lets capacitance of X be C_1 and capacitance of Y be C_2.

$$C_1 = \frac{\epsilon_0 A}{d}$$

$$C_2 = \frac{\epsilon_r \epsilon_0 A}{d}$$

$$\frac{C_1}{C_2} = \frac{1}{\epsilon_r} \Rightarrow C_2 = \epsilon_r C_1$$

$C_1 = C$

$C_2 = 4C \quad \{\because \epsilon_r = 4\}$

Since two capacitance are connected in series so, equivalent capacitance will be

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$$

$$4\mu F = \frac{C \times 4C}{C + 4C}$$

$$\Rightarrow C = 5\mu F$$

So, $C_1 = 5\mu F$ & $C_2 = 20\mu F$

(ii) $C_{eq} V_{net} = Q_{total}$

$4\mu F \times 15V = Q_{total}$

$Q_{total} = 60\ \mu C$

Since in series configuration charge on each capacitor is equal

Hence $Q_1 = Q_2 = Q_{total} = 60\mu C$

Using Q = CV

$$V_1 = \frac{Q_1}{C_1} = \frac{60\mu C}{5\mu F} = 12V$$

$$V_2 = \frac{Q_2}{C_2} = \frac{60\mu C}{20\mu F} = 3V$$

(iii) $$U_1 = \frac{1}{2}\frac{Q_1^2}{C_1} = \frac{1}{2}\frac{(60\mu C)^2}{5\mu F} = 360\,\mu J$$

$$U_2 = \frac{1}{2}\frac{Q_2^2}{C_2} = \frac{1}{2}\frac{(60\mu C)^2}{20\mu F} = 90\,\mu J$$

$$\frac{U_1}{U_2} = \frac{4}{1} \Rightarrow U_1 : U_2 :: 4 : 1$$

16. Two long straight parallel conductors carry steady current I_1 and I_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set up in one produces an attractive force on the other. Obtain the expression for this force. Hence define one ampere. **[3]**

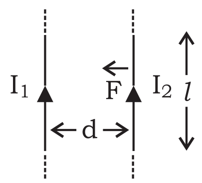
Ans. Magnetic field produced on the wire (carrying current I_2) due to I_1 will be

$$B = \frac{\mu_0 I_1}{2\pi d}$$

Force acting at l length is

$F = I_2 l B$

$$F = \frac{\mu_0 I_1 I_2 l}{2\pi d} \quad \text{towards } I_1$$



$\Rightarrow$ Attractive force between wires.

If $l = 1$ m, d = 1 m $I_1 = I_2 = I$ & F = 2×10^{-7} N

$\Rightarrow$ I = 1A

So one ampere is defined as the current, which when maintained in two parallel infinite length conductors, held at a separation of one metre will produce of a force of 2×10^{-7} N per meter of each conductor

17. How are EM wave produced by oscillating charges? **[3]**

Draw a sketch of linearly polarized EM waves propagating in the Z-direction. Indicate the directions of the oscillating electric and magnetic fields.

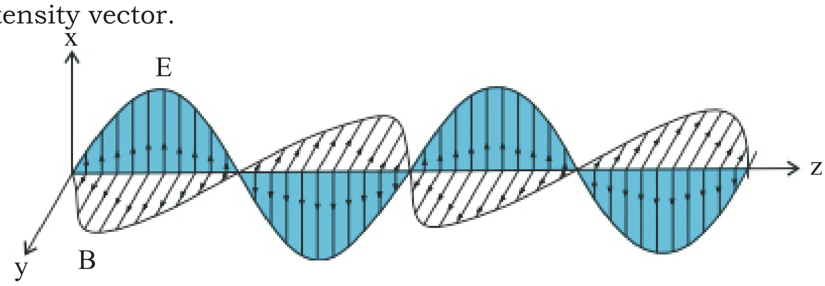
OR

Write Maxwell's generalization of Ampere's Circuital Law. Show that in the process of charging a capacitor, the current produced within the plates of the capacitor is

$$i = \varepsilon_0 \frac{d\Phi_E}{dt}$$

where Φ_E is the electric flux produced during charging of the capacitor plates.

Ans. These waves are constituted by varying or oscillating electric and magnetic fields. The electric and magnetic fields are perpendicular to each other and are also perpendicular to the direction of propagation of the wave. E is the envelope of electric intensity vector and B is the envelope of magnetic intensity vector.



OR

Ans. Correction in Ampere's circuital law (Modified ampere's law): Maxwell removed the problem of current continuity and inconsistency observed in Ampere's circuital law by introducing the concept of displacement current. Displacement current arises due to change in electric flux with time and is given by $i_d = \varepsilon_0 \frac{d\phi_E}{dt}$.

Electric Flux through the loop

$$\phi_E = EA = \frac{\sigma}{\varepsilon_0} A = \frac{Q}{A}\frac{A}{\varepsilon_0} = \frac{Q}{\varepsilon_0}$$ (Q = Charge on either plates)

$$\phi_E = \frac{Q}{\varepsilon_0}$$

$$\frac{d\phi_E}{dt} = \frac{1}{\varepsilon_0}\frac{dQ}{dt}$$

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

$\frac{dQ}{dt}$ is called conduction current which is equal to $\varepsilon_0 \frac{d\phi_E}{dt}$ which is displacement current. Hence, $i_c = i_d$.

Generalization of Ampere's circuital law is:

$$\oint \vec{B} . d\vec{l} = \mu_0 (i_c + i_d)$$

Conduction current is because of flow of charges but displacement current is not because of flow of charges but because of change in electric flux.

18. (a) Explain any two factors which justify the need of modulating a low frequency signal. **[3]**

(b) Write two advantages of frequency modulation over amplitude modulation.

Ans. (a) (i) Size of Antenna: The size of antenna required will be of order of $\lambda/4$. When frequnecy is small, the height of antenna will be large, so audio frequency signal should be modulated over a high frequency carrier wave.

(ii) Effective power radiated by an Antenna: As power radiated $\propto \frac{1}{\lambda^2}$, hence when frequency is increased then the power radiated will be more.

Ans. (b) Advantage of frequency modulation over amplitude modulation:

(i) Noise can be reduced

(ii) Transmission efficiency is more.

19. (*i*) Write the functions of three segments of transistor. **[3]**

Ans. (i) Three segments of transisitor are

(*i*) Emitter (*ii*) Base

(*iii*) Collector

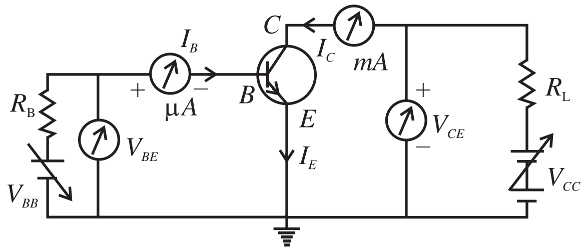
Emitter : It is of moderate size and heavily doped, it supplies a large number of majority carriers which flow through the transistor

Base : It is very thin and lightly doped and it separates emitter and collector region of transstor and controls the flow of charge carriers.

Collector : This segment is moderately doped and larger in size as compared to emitter.It collects a mojor portion of majority carriers supplied by the emitter.

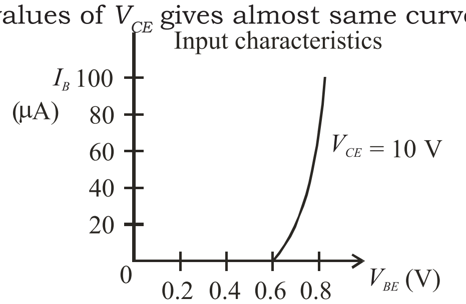
(*ii*) Draw the circuit diagram for studying the input and output characteristics of n-p-n transistor in common emitter configuration. Using the circuit, explain how input, output characteristics are obtained.

Ans. (*ii*)



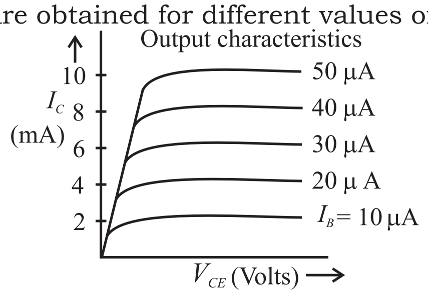
Circuit to study characteristic of a transistor

For input characteristics, base current I_B vs base-emitter voltage V_{BE} is plotted while collector base voltage V_{CE} is kept constant. V_{CE} is kept large 3 V to 20 V. Input characteristics for various values of V_{CE} gives almost same curves.



$V_{BE} \cong 0.7$ V,

Output characterestics is obtained by varying I_C with V_{CE} keeping I_B constant. Different curves are obtained for different values of I_B.



20. **(a)** Calculate the distance of an object of height h from a concave mirror of radius of curvature 20 cm, so as to obtain a real image of magnification 2. Find the location of image also.**[3]**

Ans. (a) Given,

Height of object = h_0
radius of curvature = 20 cm
magnification, m = 2
object distance, u = ?
image distance, v = ?

magnification, $m = \left|\frac{v}{u}\right| = \frac{h_I}{h_0}$

$$2 = \frac{v}{u}$$

$v = 2u$ ...(*i*)

Using mirror formula,

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{-2u} - \frac{1}{u} = -\frac{2}{20}$$

$$\frac{+3}{2u} = \frac{+2}{20}$$

$$u = \frac{60}{4} = 15 \text{ cm}$$

Puting in (*i*)
$v = 2 \times 15$ cm
= 30 cm in front of mirror

$$\frac{h_I}{h_0} = \left|\frac{v}{u}\right|$$

$$\frac{h_I}{h_0} = \left|\frac{2u}{u}\right|$$

Height of image,
$h_1 = 2h_0$.

(b) Using mirror formula, explain why does a convex mirror always produce a virtual image.

Ans. (b) For convex mirror,
f = + ve (always)
mirror formula

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{u}$$

as, u = – ve (for real object)

$$\frac{1}{v} = \frac{1}{f} - \left(\frac{1}{-u}\right)$$

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

⇒ v = + ve
hence, it will form virtual image.

21. (i) State Bohr's quantization condition for defining stationary orbits. How does de Broglie hypothesis explain the stationary orbits? **[3]**

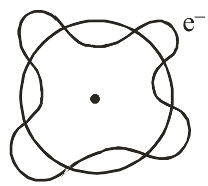
Ans. (i) **Quantization condition:** Of all the possible circular orbits allowed by the classical theory, the electrons are permitted to circulate only in those orbits in which the angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$; h being Planck's constant. Therefore, for any permitted orbit,

$$L = mvr = \frac{nh}{2\pi}; \quad n = 1, 2, 3, \ldots$$

where L, m and v are the angular momentum, mass and speed of the electron, r is the radius of the permitted orbit and n is positive integer called principal quantum number. The above equation is Bohr's famous quantum condition.

When an electron of mass m is confined to move on a line of length l with velocity v, the de Broglie wavelength λ associated with electron is

$$\lambda = \frac{h}{mv} = \frac{h}{p} \text{ or } p = \text{linear momentum}$$



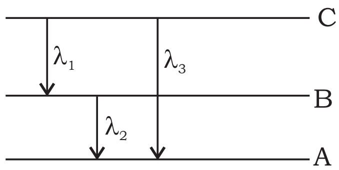
$$\Rightarrow p = \frac{h}{\lambda} = \frac{h}{2l/n} = \frac{nh}{2l}$$

When electron revolves in a circular orbit of radius 'r' then $2l = 2\pi r$.

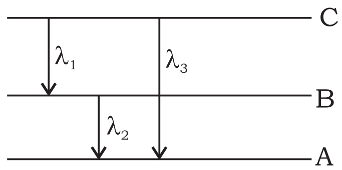
$$\therefore \; p = \frac{nh}{2\pi r} \quad or \quad p \times r = \frac{nh}{2\pi} \text{ or angular momentum } |\vec{L}| = p \times r \text{ is integral multiple of } h/2\pi$$

which is Bohr's quantisation of angular momentum.

(ii) Find the relation between the three wavelengths λ_1, λ_2, λ_2 from the energy level diagram shown below.



Ans. (ii) $E_{CB} = \frac{hc}{\lambda_1}$



$E_{BA} = \frac{hc}{\lambda_2}$

$E_{CA} = \frac{hc}{\lambda_3}$

where,

E_{CB} – Energy gap between level B and C.

E_{BA} – Energy gap between level A and B

E_{CA} – Energy gap between level A and C.

$$E_{CA} = E_{CB} + E_{BA}$$

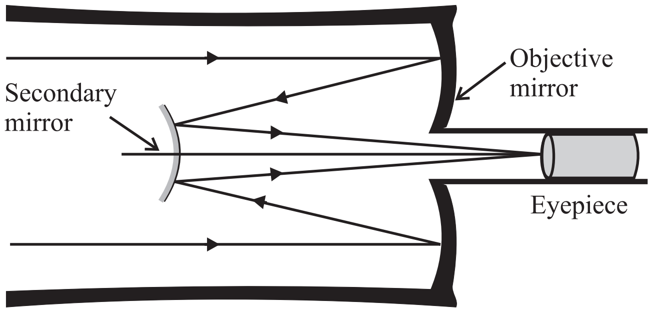
$$\frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\frac{1}{\lambda_3} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

$$\boxed{\lambda_3 = \frac{\lambda_1 \lambda_2}{\lambda_1 + \lambda_2}}$$

22. Draw a schematic ray diagram of reflecting telescope showing how rays coming from a distant object are received at the eye-piece. Write its two important advantages over a refracting telescope. **[3]**

Ans. The reflecting telescope makes use of a concave mirror as objective. The rays of light coming from distant object are incident on the objective (parabolic reflector). After reflection the rays of light meet at a point where another convex mirror is placed. This mirror focusses light inside the telescope tube. The final image is seen through the eyepiece. The images produced by the reflecting telescope is very bright and its resolving power is high.



Advantages

(i) The resolving power (the ability to observe two objects distinctly) is high, due to the large diameter of the objective.

(ii) There is no chromatic aberration as the objective is a mirror.

23. Meeta's father was driving her to the school. At the traffic signal she noticed that each traffic light was made of many tiny lights instead of a single bulb. When Meeta asked this question to her father, he explained the reason for this.

Answer the following questions based on above information:

(*i*) What were the values displayed by Meeta and her father?

(*ii*) What answer did Meeta's father give?

(*iii*) What are the tiny lights in traffic signals called and how do these operate?

Ans. (i) Awareness for energy conservation, power saving and knowledge about traffic rules.

(ii) Meeta's father said that these are LED light which consume less power and high reliability.

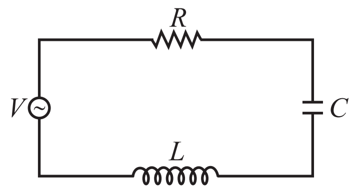
(iii) The tiny lights in traffic signols are LIGHT EMITTING DIODE.

These are operated by connecting the P–N Junction diode in forward biased condition.

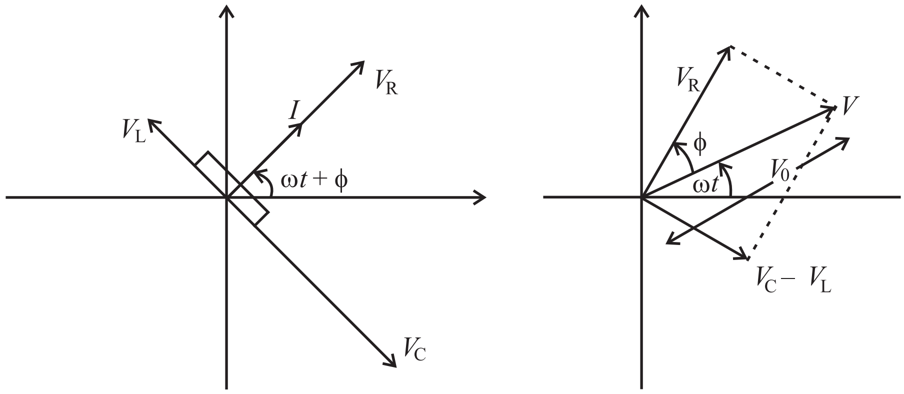
Section – E

24. (*i*) An a.c. source of voltage $V = V_0 \sin \omega t$ is connected to a series combination of L, C and R. Use the phase diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit in this condition called?

Ans. (i) Let a series *LCR* circuit is connected to an ac source *V* (Fig.). We take the voltage of the source to be $V = V_0 \sin \omega t$.



The AC current in each element is the same at any time, having the same amplitude and phase. It is given by, $I = I_0 \sin (\omega t + \phi)$.



Phasor diagram for LCR circuit

Let V_L, V_R, V_C and V represent the voltage across the inductor, resistor, capacitor and the source respectively.

$\therefore$ $V_C > V_L$

$\therefore$ $V_0^2 = V_R^2 + (V_C - V_L)^2$

$V_0^2 = (I_0R)^2 + (I_0X_C - I_0X_L)^2$

$V_0^2 = I_0^2 [R^2 + (X_C - X_L)^2]$

and, $I_0 = \dfrac{V_0}{\sqrt{R^2 + (X_C - X_L)^2}}$ $\Rightarrow$ $I_0 = \dfrac{V_0}{Z}$

where $Z = \sqrt{R^2 + (X_C - X_L)^2}$, it is called the impedance in an AC circuit

Condition: The current will be in phase with the voltage at resonance condition.

At Resonance condition

$X_L = X_C$

$\omega L = \dfrac{1}{\omega C}$

$\omega = \dfrac{1}{\sqrt{LC}}$

$2\pi\nu = \dfrac{1}{\sqrt{LC}}$

$\nu = \dfrac{1}{2\pi\sqrt{LC}}$

(ii) In a series LR circuit $X_L = R$ and power factor of the circuit is P_1. When capacitor with capacitance C such that $X_L = X_C$ is put in series, the power factor becomes P_2. Calculate P_1/P_2.

Ans. (ii) As $\cos\phi = \dfrac{R}{Z}$

In L.R. Circuit

$P_1 = \cos\phi = \dfrac{R}{\sqrt{R^2 + X_L^2}} = \dfrac{R}{\sqrt{2R^2}}$ $[\because X_L = R]$

$P_1 = \dfrac{1}{\sqrt{2}}$

In LCR when $X_L = X_C$

$P_2 = \dfrac{R}{\sqrt{R^2 + (X_L - X_C)^2}} = \dfrac{R}{R} = 1$ $[\because X_L = X_C]$

$\therefore$ $\boxed{\dfrac{P_1}{P_2} = \dfrac{1}{\sqrt{2}}}$

OR

(i) Write the function of a transformer. State its principle of working with the help of a diagram. Mention various every losses in this device.

(ii) The primary coil of an ideal step up transformer has 100 turns and transformation ratio is also 100. The input voltage and power are respectively 220 V and 1100 W. Calculate

(a) number of turns in secondary

(b) current in primary

(c) voltage across secondary

(d) current in secondary

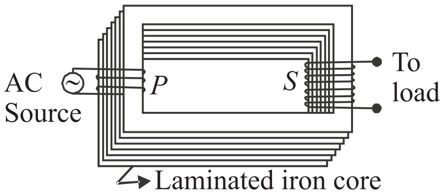
(e) power in secondary

Ans. (i) A transformer is an electrical device for converting an alternating current at low voltage into that at high voltage or vice versa.

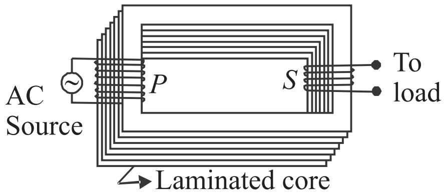
- ❖ If it increases the input ac voltage, it is called step up transformer.
- ❖ If it decreases the input ac voltage, it is called step down transformer.

Principle

It works on the principle of mutual induction i.e., when a changing current is passed through one of the two inductively coupled coils, an induced emf is set up in the other coil.



Step-up transformer



Step-down transformer

Working – Theory

As the AC flows through the primary (See Fig.), it generate an alternating magnetic flux in the core which passes through the secondary coil.

Let N_1 = No. of turns in primary coils

N_2 = No. of turns in secondary coils

This changing flux set up an induced emf in the secondary, also a self induced emf in the primary.

If there is no leakage of magnetic flux, then flux linked with each turn of the primary will be equal to that linked with each of the secondary. According to faraday's law of induction,

Induced emf in the primary coil, $\varepsilon_1 = -N_1 \frac{d\phi}{dt}$

Induced emf in the secondary coil, $\varepsilon_2 = -N_2 \frac{d\phi}{dt}$

Where, $\frac{d\phi}{dt}$ = Rate of change of magnetic flux associated with each turn.

ϕ = magnetic flux linked with each turn of the primary or secondary at any instant.

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{N_2}{N_1}$$

Energy losses in transformer

- ❖ **Copper loss.** Some energy is lost due to the heating of copper wires used in the primary and secondary windings. This power loss ($P = I^2R$) can be minimised by using thick copper wires of low resistance.
- ❖ **Eddy current loss.** The alternating magnetic flux induces eddy currents in the iron core which leads to some energy loss in the form of heat. This loss can be reduced by using laminated iron core.
- ❖ **Hysteresis loss.** The alternating current carries the iron core through cycles of magnetisation and demagnetisation. Work is done in each of these cycles and is lost as heat. This is called hysteresis loss and can be minimised by using core material having narrow hysteresis loop.
- ❖ **Flux leakage.** The magnetic flux produced by the primary may not fully pass through the

secondary. Some of the flux may leak into air. This loss can be minimised by winding the primary and secondary coils over one another.

Ans. (ii) Given $N_1 = 100$

$K = 100$

$V_1 = 220$ V

$P_1 = 1100$ W

(a) As $K = \dfrac{N_2}{N_1}$

$N_2 = KN_1 = 100 \times 100$

$N_2 = 10000$

(b) $P_1 = V_1 I_1$

$I_1 = \dfrac{P_1}{V_1} = \dfrac{1100}{220} = 5A$

(c) $\dfrac{V_2}{V_1} = K$

$V_2 = KV_1$; $V_2 = 100 \times 220$

$V_2 = 22000$ V

(d) $\dfrac{I_1}{I_2} = K$

$I_2 = \dfrac{I_1}{K} = \dfrac{5}{100}$

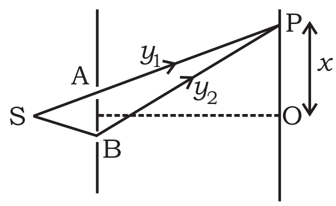
$\boxed{I_2 = 0.05\text{ A}}$

(e) $P_2 = V_2 I_2$

$P_2 = 22000 \times \dfrac{5}{100}$; $P_2 = 1100$ W

25. (*i*) In Young's double slit experiment, deduce the condition for (a) constructive, and (b) destructive interference at a point on the screen. Draw a graph showing variation of intensity in the interference pattern against position 'x' on the screen.

Ans. (i) Let the two waves arising from the slits A and B have the amplitudes a and b and the phase difference ϕ



Such that $y_1 = a \sin \omega t$ and $y_2 = b \sin (\omega t + \phi)$.

The resultant displacement is given as

$y = y_1 + y_2$

$y = a \sin \omega t + b \sin (\omega t + \phi)$

$y = a \sin \omega t + b \sin \omega t \cos \phi + b \cos \omega t \sin \phi$

$y = (a + b \cos \phi) \sin \omega t + b \sin \phi \cos \omega t$ ... (i)

Let $a + b \cos \phi = A \cos \delta$ ... (ii)

and $b \sin \phi = A \sin \delta$ ... (iii)

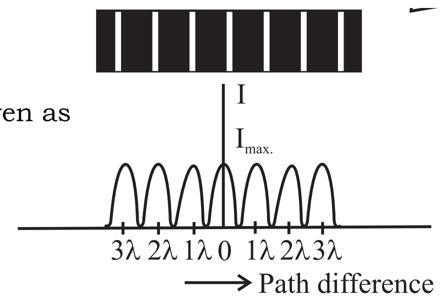
Hence, $y = A \sin \omega t \cos \delta + A \cos \omega t \sin \delta$

$y = A \sin (\omega t + \delta)$ ... (iv)

where the amplitude A of the resultant wave can be given as

$$A = \sqrt{a^2 + b^2 + 2ab\cos\phi} \quad \text{... (v)}$$

$$\text{and } \tan\delta = \frac{b\sin\phi}{a + b\cos\phi} \quad \text{... (vi)}$$



(a) **Constructive Interference:** Intensity $I \propto A^2$ and for A to be maximum

$\cos \phi = 1$

or $\cos \phi = \cos 2n\pi$, $n = 0, 1, 2, 3, \ldots$

$\phi = 2n\pi$ ... (i)

and path difference $\Delta x = n\lambda$ ... (ii)

$A_{max} = a + b$

$I \to I_{max} = k\,(a + b)^2$

(b) **Destructive Interference:** For I to be minima

$\cos \phi = -1$

phase difference $\Delta\phi = (2n + 1)\pi$

and path difference $\Delta x = (2n+1)\frac{\lambda}{2}$

$A_{min} = a - b$

$I \to I_{min} = k\,(a - b)^2$

Graph showing interference pattern against position 'x' on the screen.

(ii) Compare the interference pattern observed in Young's double slit experiment with single slit diffraction pattern, pointing out three distinguishing features.

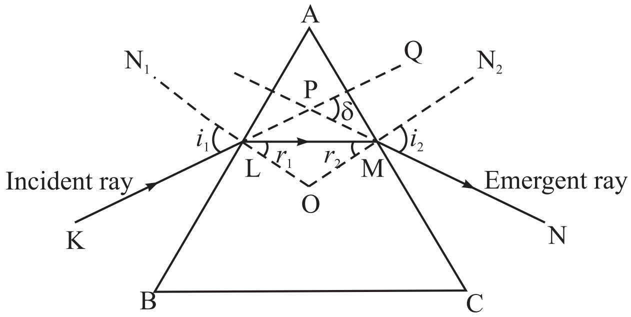
Ans. (ii) Compare of Interference pattern observed in Young's double slits and single slits diffraction:

S.No.	Interference	Diffraction
1.	Interference is the result of superposition of secondary waves starting from two different wavefronts origentating from two coherent sources.	Diffraction is the result of superposition of secondary waves starting from diffrent part of same wavefront.
2.	All bright and dark fringe are of equal width.	The width of central bright fringe is twice the width of any secondary maximum.
3.	All bright fringes are of same intensity.	Intensity of bright fringes decreases as we more away from central bright fringe on eighter side.

OR

(i) Plot a graph to show variation of the angle of deviation as a function of angle of incidence for light passing through a prism. Derive an expression for refractive index of the prism in terms of angle of minimum deviation and angle of prism.

Ans. (i) It is a transparent medium having two planes and non-parallel refracting surfaces inclined to each other and three surfaces are not participating in refraction.



It is the angle through which the incident ray is deviated on passing through a prism (i.e. angle between the incident and emergent ray). It is denoted by δ.

Calculation of Angle of Deviation

In ΔPLM,

$\delta = \angle PLM + \angle PML$

$\delta = (i_1 - r_1) + (i_2 - r_2)$

$\delta = (i_1 + i_2) - (r_1 + r_2)$ ... (1)

In ΔOLM,

$\angle O + r_1 + r_2 = 180°$ ... (2)

In quadrilateral ALOM,

As $\angle L + \angle M = 180°$ ($\because$ each angle is 90°)

$\therefore$ $A + \angle O = 180°$ ($\because$ sum of four angles of a quad. = 360°)

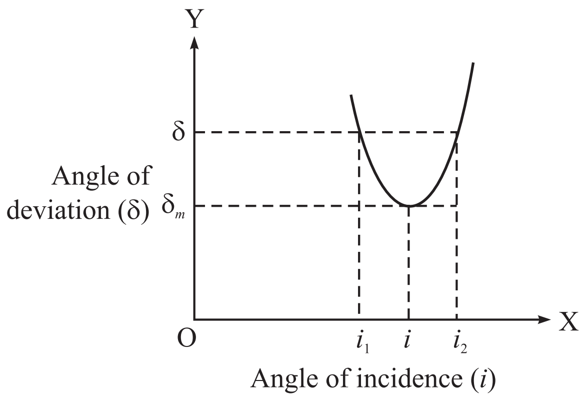
Using eq. (2),

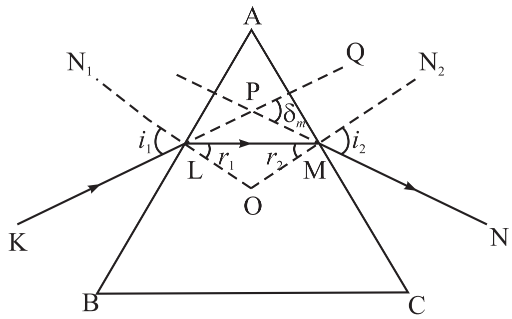
$\angle O + r_1 + r_2 = A + \angle O$

$r_1 + r_2 = A$ ...(3)

Put in (1),

$\delta = (i_1 + i_2) - A$ ...(4)





$\therefore\ r = \frac{A}{2}$

From (4)

$\delta_m = i + i - A$(δ_m : angle of minimum deviation)

$A + \delta_m = 2i$

$i = \frac{A+\delta_m}{2}$

If μ is refractive index of the material of the prism, then according to Snell's law,

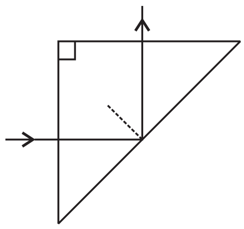
$\mu = \frac{\sin i}{\sin r}$

$$\boxed{\mu = \frac{\sin(A+\delta_m)/2}{\sin A/2}}$$ ...(6)

(ii) What is dispersion of light ? What is its cause?

Ans. (ii) **Dispersion of Light:** These colors are often observed as light passes through a triangular prism upon passing through the prism, the white light is separated into its component colors– red, orange, yellow, green, blue and violet. The separation of visible light into its different colors is known as **dispersion**. Dispersion occurs because for different colour of light a transparent medium will have different reflective indices (μ).

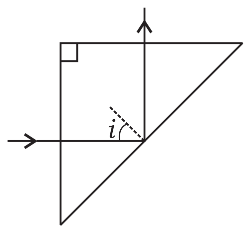
(iii) A ray of light incident normally on one face of a right isosceles prism is totally reflected as shown in fig. What must be the minimum value of refractive index of glass ? Give relevant calculations.



Ans. (iii) For T.I.R.

$i > Q_C$

$\sin i > \sin Q_c$



$$\sin 45° > \frac{1}{\mu}$$

$$\frac{1}{\sqrt{2}} > \frac{1}{\mu}$$

$$\mu > \sqrt{2}$$

$$\boxed{\mu_{min} = \sqrt{2}}$$

26. (i) Define the term drift velocity.

Ans. (i) Drift velocity is defined as the average velocity with which the electrons are drifted towards positive terminal under the effect of applied electric field.

Thermal velocities are randomly distributed and average thermal velocity is zero.

$$\frac{\vec{u_1} + \vec{u_2} + ...+ \vec{u_N}}{N} = 0$$

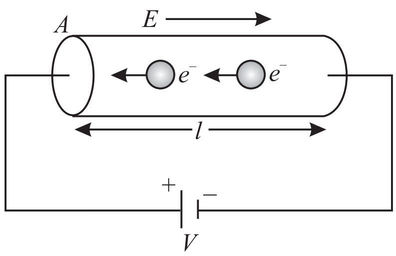
$$v_d = -\frac{eE\tau}{m}$$

(ii) On the basis of electron drift, derive an expression for resistivity of a conductor in terms of number density of free electrons and relaxation time. On what factors does resistivity of a conductor depend?

Ans. (ii) We know that the current flowing through the conductor is

$I = nAev_d$ and

$$\therefore\ I = neA\left(-\frac{eE\tau}{m}\right)$$



Using $E = -\frac{V}{l}$

$$I = neA\left(\frac{eV}{ml}\right)\tau = \left(\frac{ne^2A\tau}{ml}\right)V = \frac{1}{R}V$$

$I \propto V \rightarrow$ which is ohm's law.

where $R = \frac{ml}{nAe^2\tau}$

is a constant for a particular conductor at a particular temperature and is called the resistance of the conductor.

$$R = \left(\frac{m}{ne^2\tau}\right)\frac{l}{A} = \frac{\rho l}{A}$$

$$\Rightarrow \quad \rho = \left(\frac{m}{ne^2\tau}\right)$$

Where ρ is the specific resistance or resistivity of the material of the wire. It depends on number of free electrons per unit volume and temperature.

(iii) Why alloys like constantan and manganin are used for making standard resistors?

Ans. (iii) They are used to make standard resistors because:

(a) they have high value of resistivity

(b) temperature coefficient of resistance is less

(c) they are least affected by temperature.

OR

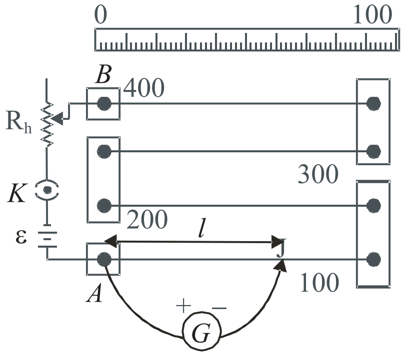
(i) State the principle of working of a potentiometer.

Ans. (i) Principle of Potentiometer: The basic Principle of potentiometer is that when a constent current flows through a wire of uniform cross-section area and composition the potential drop across any length of the wire is directly porportional to that length.

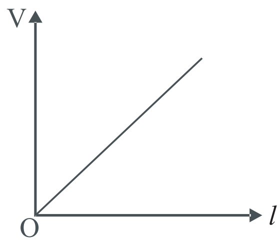
A potentiometer is a device used to measure an unknown emf or potential difference and internal resistance of a cell accurately.

Construction

1. A potentiometer consists of a long uniform cross-section of wire generally made of manganin or constantan.
2. Usually, 1m long separate pieces of wire are fixed on a wooden board parallel to each other.
3. The wires are joined in series by thick copper strips.
4. The ends *A* & *B* are connected to a battery (called driving cell), a plug key and a rheostat (See Fig.).
5. A jockey *J* is provided with the help of which contact can be made at any point on the wire.
6. This circuit sends a constant current *I* through the wire *AB*.



Construction of a potentiometer



Potential Vs Length of Difference

Principle

When a constant current flows through a wire of uniform cross sectional area and composition the potential drop across any length of the wire is directly proportional to that length.

Let V be the potential difference across the portion of the wire of length l whose resistance is R.

By Ohm's Law,

$$V = IR = I \cdot \frac{\rho l}{A}$$

Where ρ = resistivity of wire

A = Area of cross section

$$V = \frac{I\rho l}{A}$$

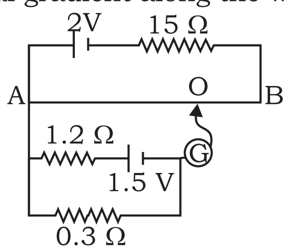
$V = Kl$ (if I, A & ρ are constants)

$V \propto l$

Where $K = \dfrac{I\rho}{A}$

⇒ Here $\dfrac{V}{l} = K =$ Potential gradient, i.e., potential per unit length of wire.

(ii) In the following potentiometer circuit AB is a uniform wire of length 1 m and resistance 10 Ω. Calculate the potential gradient along the wire and balance length AO (= l).



Ans. (ii) (a) Total reistence of the Primery Circuit

= 15 + 10 = 25Ω emf = 2V

∴ Current in the wire AB

$I = \frac{2}{25} = 0.08$ A

P.D. Across the wire AB
= Current × resistance of wire AB
= 0.08 × 10 = 0.8 V
Potential gradient

$= \frac{\text{P.D.}}{\text{length}} = \frac{0.8}{100} = 0.008 \text{ V cm}^{-1}$

(b) Resistance of secondary circuit
= 1.2 + 0.3 = 1.5 Ω
e.m.f. = 15 V

Current in the secondary circuit = $\frac{1.5}{1.5} = 1.0$ A
The same is the current in 0.3 Ω resistor
P.D. between points A and O
= P.D. across 0.3 Ω resistor in the zero-deflection condition
= Current × resistance
= 1.0 × 0.3 = 0.3 V

Length AO = $\frac{\text{Potential difference}}{\text{Potential gradient}}$

$= \frac{0.3 \text{ V}}{0.008 \text{ V cm}^{-1}} = 37.5 \text{ cm}$

*****