COMMON PRE-BOARD EXAMINATION 2022-23

Subject: PHYSICS (042)

MARKING SCHEME

Date:

General Instructions:

1) There are 35 questions in all. All questions are compulsory
(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
(3) Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
(4) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

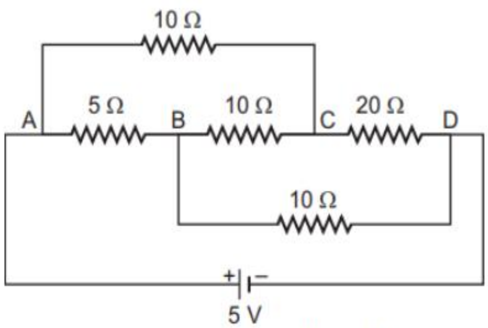
SI. NO.	SECTION – A	Marks
1.	c) $4\pi/\varepsilon_0$	1
2.	b) σ/ε_0	1
3.	c) Semiconductor	1
4.	a) 1Ω	1
5.	c) 4B	1
6.	c) 11 cm	1
7.	a) Diamagnetic	1
8.	d) 0	1
9.	b) π V	1
10.	c) 1:1	1
11.	b) wavelength and constant phase difference	1
12.	d) D	1
13.	b) 3	1
14.	c) Charge independent	1
15.	d) All of the above	1
16.	a) Both A and R are true and R is the correct explanation of A	1
17.	c) A is true but R is false	1
18.	a) Both A and R are true and R is the correct explanation of A	1

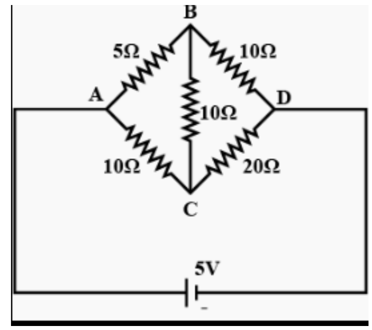
SECTION – B

19. In case of balanced Wheatstone bridge, no current flows through the resistor 10Ω between points B and C. 2

The resistance of arm ACD, $R_{S1} = 10 + 20 = 30\Omega$

The resistance of arm ABD, $R_{S2} = 5 + 10 = 15\Omega$





Equivalent resistance $R_{eq} = \frac{R_{S_1} \times R_{S_2}}{R_{S_1} + R_{S_2}}$

$= \frac{30 \times 15}{30 + 15} = \frac{30 \times 15}{45}$

$= 10\Omega$

Current drawn from the source,

$I = \frac{V}{R_{eq}} = \frac{5}{10} = \frac{1}{2} A = 0 \cdot 5A$

20. a) When the axis of magnetic moment m makes an angle θ with the direction of magnetic field B, then torque on magnet is given by, $r = mB \sin\theta$ and potential energy $U = -mB \cos\theta$. The magnet will be in stable equilibrium if $r = 0$ *and* U is minimum. It will be so if the magnetic moment of magnet acts in the direction of magnetic field i. e. $\theta = 0^0$. 2

b) The magnet will be in unstable equilibrium if $r = 0$ *and* U is maximum. It will be so if the magnetic moment of magnet acts opposite direction to that of magnetic field i. e. $\theta = 180^0$.

21. given L = 10 cm = 0.1 m, B = 0.25 T, v = 20 m s^{-1} 2

(a)$\varepsilon = BLv = 0.25 \times 0.1 \times 20 = 0.5V$

(b) $l = \varepsilon/R = 0.5/4 = 0.125$ A

22. (a) (i) Radar: Microwaves are used in radar systems. Microwaves are electromagnetic waves of frequency range 1 GHz to 300 GHz or 3×10^{11} to 1×10^9 Hz. (ii) Eye surgery: Ultraviolet rays are used in eye surgery. Ultraviolet rays are electromagnetic waves of frequency range 8×10^{14} to 5×10^{17} Hz. 2

23. Fringe width is inversely proportional to the slit width and Intensity is directly proportional to square of the slit width. 2

Fringe size becomes half;

Intensity becomes 4 times. (can write respective formula to justify)

24. Binding energy of nucleus with mass number 240, 2

$(E_{BN})_1 = 240 \times 7.6$ MeV............ (i)

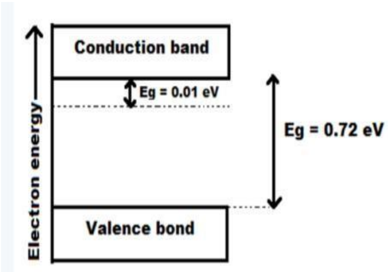
Binding energy of two fragments

$(E_{BN})_2 = 2 \times 120 \times 8.5$ MeV… .... (ii)

Energy released = $(E_{BN})_2 - (E_{BN})_1$

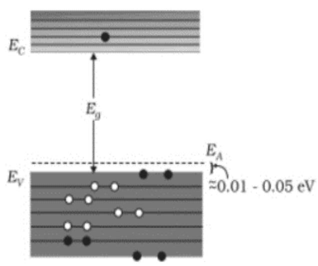
$= (2 \times 120 \times 8.5) - (240 \times 7.6)$
$= 216$ MeV

25. 2



n type semiconductor – electrons are majority charge carriers

(OR)

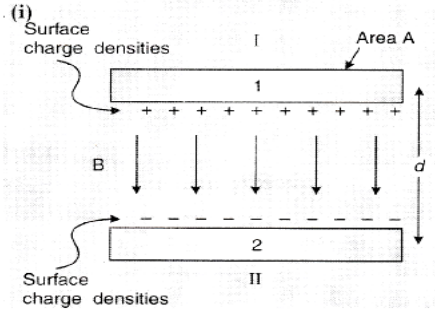


p type semiconductor – holes are majority charge carriers.

SECTION – C

26. 3

(i)



Electric field between the plates of capacitor

$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}$$

$$\therefore \quad V = Ed = \frac{Qd}{A\varepsilon_0}$$

$$\text{Capacitance,} \quad C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d}$$

(ii) When the two charged spherical conductors are connected by a conducting wire they acquire the same potential.

$$i.e. \quad \frac{Kq_1}{R_1} = \frac{Kq_2}{R_2} \Rightarrow \frac{q_1}{q_2} = \frac{R_1}{R_2}$$

Hence, ratio of surface charge densities,

$$\frac{\sigma_1}{\sigma_2} = \frac{q_1/4\pi R_1^2}{q_2/4\pi R_2^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{q_1 R_2^2}{q_2 R_1^2}$$

$$\frac{\sigma_1}{\sigma_2} = \frac{R_1}{R_2} \times \frac{R_2^2}{R_1^2} = \frac{R_2}{R_1}$$

(OR)

Step 2: Deriving an expression for electric field due to infinite plane sheet

Consider an infinite plane sheet of positive charge with charge density σ as shown in the attached figure. Electric field lines will be directed orthogonal and away from the sheet of charge. Hence, a cylindrical closed surface with its base parallel to the sheet of paper as shown in the figure is a good choice of Gaussian surface.

For the curved surface electric field is orthogonal to the surface area vector. Hence, flux linked to curved surface is zero.

$\phi_s = 0$

For the plane surface, applying Gauss's Law, we get:

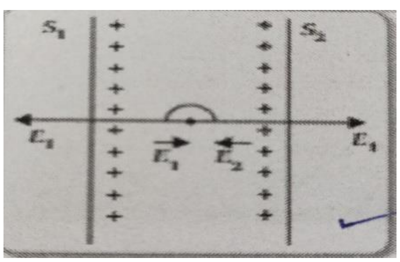
$$\phi_s + \phi_b = \frac{Q_{enclosed}}{\varepsilon_o}$$

$$EA + EA = \frac{Q_{enclosed}}{\varepsilon_o}$$

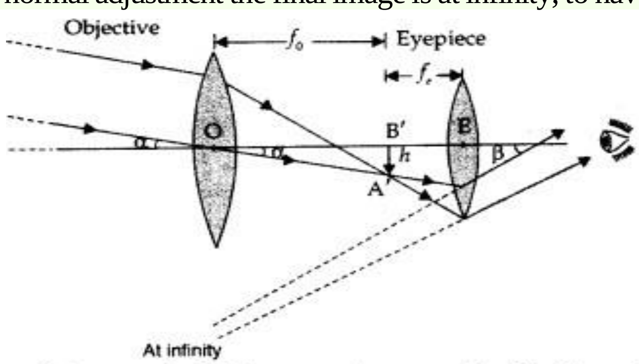
But Q = σA by definition of surface charge density

$$\Rightarrow \boxed{E = \frac{\sigma}{2\varepsilon_o}}$$

And the electric field between the plates is zero. E = 0



27. In normal adjustment the final image is at infinity, to have large magnifying power fo must be as large as practically possible while fe has to be kept small. The magnifying power is the minimum and its field of view is small. 3



Astronomical telescope in normal adjustment

Magnifying power $m = -\frac{f_o}{f_e}$

(a) Total internal reflection is defined as the phenomenon of reflection of light into a denser medium from an interface of this denser medium and a rarer medium. The conditions for total internal reflection: **(OR)**

(i) Incident light ray should travel from a denser medium to a rarer medium.

(ii) Angle of incidence, i, should be greater than the critical angle, C, for pair of media in contact.

Critical angle is defined as the angle of incidence in denser medium to which angle of refraction is 90° in the rarer medium.

Relation between critical angle of incidence and refraction index of the medium:
Consider angle of incidence is equal to the critical angle, that is,

i = c

Then, the angle of refraction is r = 90°. Applying Snell's law, we have

$$\mu_d \sin C = \mu_r \sin r$$

where μ_d is refractive index of denser medium and μ_r is refractive index of rarer medium. Therefore,

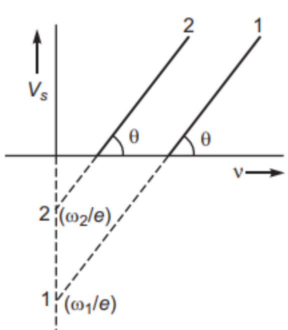
$$\frac{\mu_d}{\mu_r} = \frac{\sin r}{\sin C} = \frac{\sin 90^\circ}{\sin C}$$

$$\Rightarrow \mu = \frac{\mu_d}{\mu_r} = \frac{1}{\sin C}$$

$$\Rightarrow \mu = \frac{1}{\sin C}$$

This is the required relation between critical angle of incidence and refractive index of medium.

28. The graph of stopping potential V_s and frequency (v) for two metals 1 and 2 is shown in fig. 3



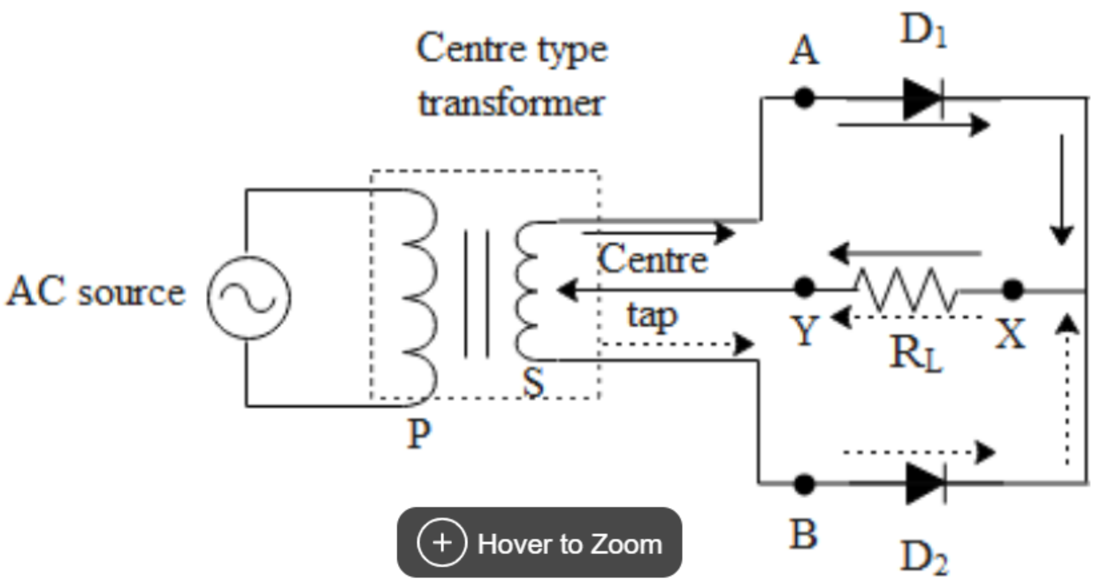
(i) Slope of graph tan θ = h/e and depends on h and e.

(ii) Intersect of lines depend on the work function.

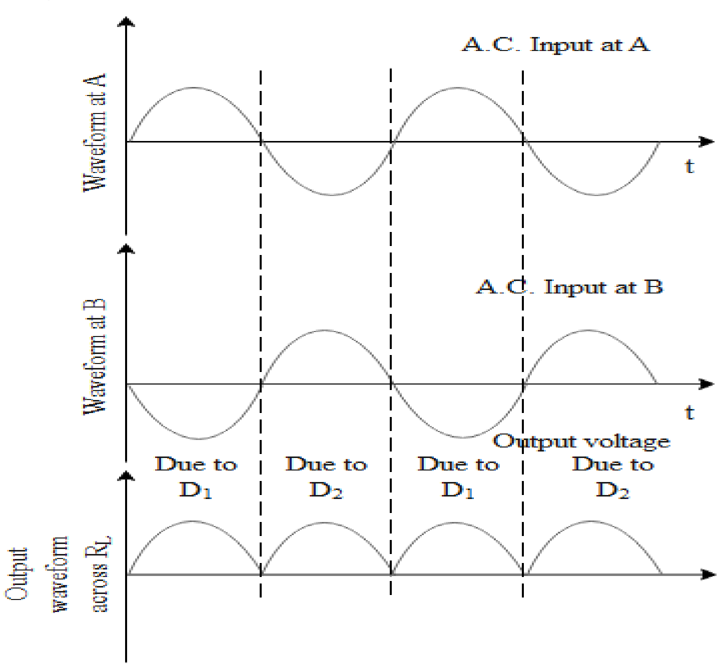
29. (a) As $1/\lambda = R * 1/3^2 - 1/\text{infinite} = R/9$ so we get $\lambda = 9/R = 8.2 \times 10^{-7}$ m 1 ½

(b) $1/\lambda = R * 1/1^2 - 1/2^2 = (3/4)R$ so we get $\lambda = 4/3R = 1.2 \times 10^{-7}$ m 1 ½

30. 3



A simple full way rectifier consists of two transformers mutually inducted and two diodes which filter the negative cycle of alternating current. At any instant the voltage at A(input voltage of diode 1) and end B (input voltage of diode 2) of the secondary with respect to the centre tap will be out of phase. Suppose during a positive half cycle of Ac input, the end A is positive and end B is negative with respect to the centre tap. Then diode 1 gets forward biased(allows the flow of current) and diode 2 gets reversed biased(does not allow the flow of current). Hence the current flows through the diode 1 towards the centre tap along the path AXY as shown in the above diagram. Similarly, during the negative half cycle of Ac input the end B becomes positive and end A becomes negative. Hence diode 1 gets reversed biased and diode 2 gets forward biased resulting in the current to flow from diode 2 to the centre tap along the path BXY as shown in the above diagram. As during both the half cycles the input a.c. the current through the load resistor will flow from X to Y and will keep on pulsating. Given below is the waveform for the full wave rectifier indicating inputs of AC and the output voltage.



SECTION – D

31. Biot-Savart's law : Magnetic field at an axial point P due to a current element of the ring $dB = \frac{\mu_o}{4\pi}\frac{i(\vec{dl}\times\hat{r})}{r^2}$ 5

where $r = \sqrt{R^2 + x^2}$

$\therefore$ We get $B = \frac{\mu_o}{4\pi}\frac{idl}{(R^2 + x^2)}$

We resolve dB into vertical and horizontal components. Now all the vertical components cancel out each other and so only the horizontal components survive which results in the net magnetic field at P in the horizontal direction.

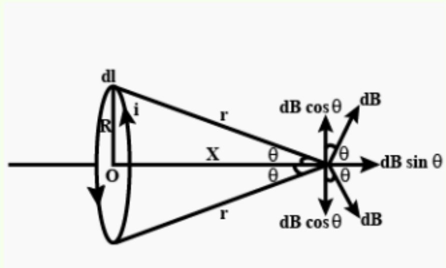
Net magnetic field $B = \int dB \sin\theta$

$$B = \int \frac{\mu_o idl}{4\pi(R^2 + x^2)}\frac{R}{(R^2 + x^2)^{1/2}}$$

$$\text{Or } B = \frac{\mu_o iR}{4\pi(R^2 + x^2)^{3/2}}\int dl$$

$$\text{Or } B = \frac{\mu_o iR}{4\pi(R^2 + x^2)^{3/2}}(2\pi R)$$

$$\Rightarrow \ B = \frac{\mu_o iR^2}{2(R^2 + x^2)^{3/2}}$$



Maxwell's Right-Hand Thumb Rule can be used to determine the direction of magnetic field lines around a current-carrying conductor. It states that, if the thumb of the right hand represents the direction of the current flow, the rest of the curled fingers determine the direction of the magnetic field around it.

Direction of magnetic field along APB is in clockwise direction and direction of magnetic field along AQB is in anti-clockwise direction. That is, magnetic fields at the point C will be equal and opposite. Hence, net magnetic field at C is zero.

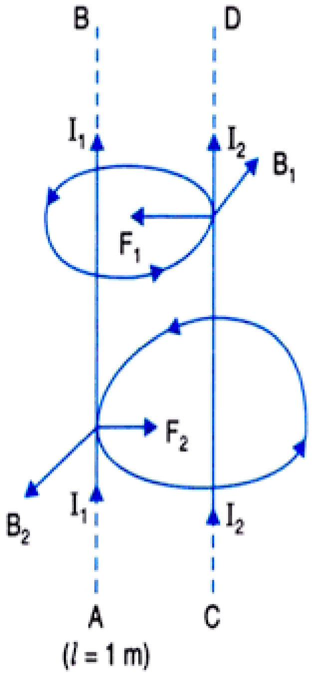
(OR)

As the current-carrying wire 2 lies in magnetic field produced by wire 1, the unit length of wire 2 will experience a force, which is given by

$$F = B_1 I_2 \times 1 = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d}$$

According to Fleming's left-hand rule, the force on wire 2 acts in the plane of paper perpendicular to wire 2, directed towards wire 1. Similarly, wire 1 also experiences the same force towards wire 2.
Thus, both the conducting wires attract each other with the same force F.

Thus, one ampere can be defined as the amount of current flowing through two parallel conductors (in the same direction or opposite directions) placed at a distance of one metre in a free space, and both the wires attract or repel each other with a force of 2×10^{-7} Nm^{-1} per metre of their lengths.



32. Correct graphs 5

Correct phasor diagram

in device X:

Current lags behind the voltage by $\frac{\pi}{2}$

X is an inductor

In device Y:

Current in phase with the applied voltage

Y is resistor

We are given that

$0.25=220/X_L$

$X_L=880\Omega$

Also $0.25=220/R$

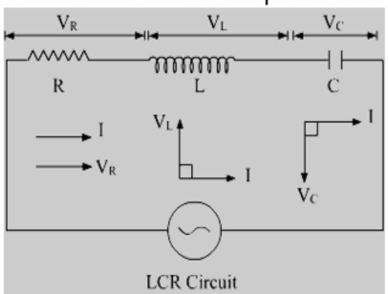
$R=880\Omega$

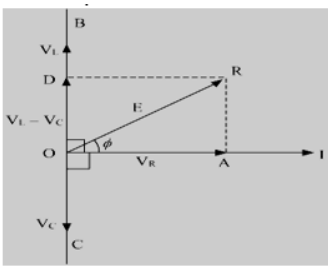
For the series combination of X and Y

Equivalent impedance = $\sqrt{X_L^2 + R^2} = 880\sqrt{2}\Omega$

Current flowing = $220/880\sqrt{2}$ = 0.177 A

Let an alternating Emf $E = E_0 \sin\omega t$ is applied to a series combination of inductor L, capacitor C and resistance R. Since all three of them are connected in series the current through them is same. But the voltage across each element has a different phase relation with current.





In the phases diagram,

V_L and V_C are opposite to each other. If $V_L > V_C$ then resultant $(V_L - V_C)$ is represent by OD. OR represent the resultant of V_R and $(V_L - V_C)$. It is equal to the applied Emf E.

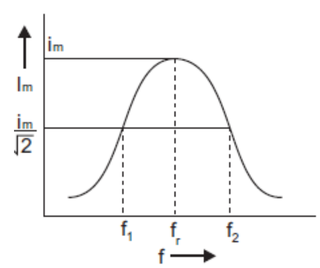
$$E^2 = V_R^2 + (V_L - V_C)^2$$

$$E^2 = I^2 + \left[R^2 + (X_L - X_C)^2\right]$$

$$\text{or } I = \frac{E}{\sqrt{R^2 + (X_2 - X_C)^2}}$$

The term $\sqrt{R^2 + (X_2 - X_C)^2}$ is called impedance Z of the LCR circuit.

$$Z = \sqrt{R^2 + (X_2 - X_C)^2} = \sqrt{R^2 + \left(L\omega - \frac{1}{c\omega}\right)^2}$$



Emf leads current by a phase angle ϕ

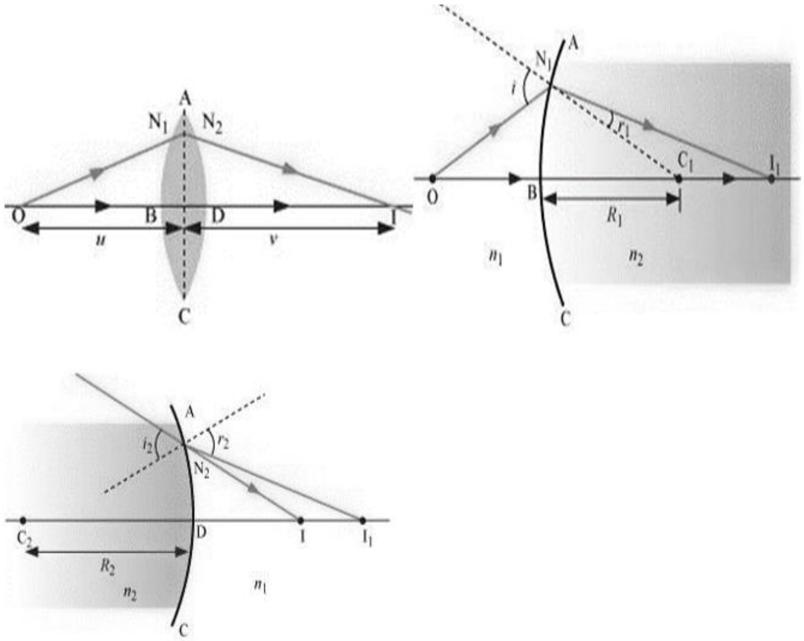
$$\tan\phi = \frac{V_L - V_C}{R} = \frac{X_L - X_C}{R} = \frac{L\omega - \frac{1}{c\omega}}{R}$$

When resonance takes place

$$\omega L = \frac{1}{\omega c}$$

Impedance of circuit becomes equal to R. Current becomes maximum and is equal to E/R

33. 5



In the given figure, image is I and object is denoted as O.
The centre of curvature is C.

The rays are incident from a medium of refractive index n_1 to another of refractive index n_2.
We consider NM to be perpendicular to the principal axis.

$$\tan \angle NOM = \frac{MN}{OM}$$

$$\tan \angle NCM = \frac{MN}{MC}$$

$$\tan \angle NIM = \frac{MN}{MI}$$

For ΔNOC, *i* is the exterior angle.
Therefore, *i* = ∠NOM + ∠NCM

$$i = \frac{MN}{OM} + \frac{MN}{MC}$$

Similarly,
r = ∠NCM − ∠NIM

i.e., $r = \frac{MN}{MC} - \frac{MN}{MI}$

According to Snell's law,

$$n_1 \sin i = n_2 \sin r$$

For small angles,

$$n_i i = n_2 r$$

Substituting *i* and *r*, we obtain

$$\frac{n_1}{OM} + \frac{n_2}{MI} = \frac{n_2 - n_1}{MC}$$

Where, OM, MI, and MC are the distances
OM = −*u*
MC = +*R*
MI = *v*

Substituting these, we obtain

$$\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R} \qquad ...(i)$$

Applying equation (i) to lens ABCD, we obtain for surface ABC,

$$\frac{n_1}{\mathrm{OB}}+\frac{n_2}{\mathrm{BI}_1}=\frac{n_2-n_1}{\mathrm{BC}_1} \qquad ...(ii)$$

For surface ADC, we obtain

$$\frac{-n_2}{\mathrm{DI}_1}+\frac{n_1}{\mathrm{DI}}=\frac{n_2 n_1}{\mathrm{DC}_2} \qquad ...(iii)$$

For a thin lens,

$BI_1 = DI_1$

Adding (ii) and (iii), we obtain

$$\frac{n_1}{\mathrm{OB}}+\frac{n_1}{\mathrm{DI}}=\left(n_2-n_1\right)\left[\frac{1}{\mathrm{BC}_1}+\frac{1}{\mathrm{DC}_2}\right]$$

Suppose object is at infinity and DI = *f*, then

$$\frac{n_1}{f}=(n_2-n_1)\left[\frac{1}{\mathrm{BC}_1}+\frac{1}{\mathrm{DC}_2}\right]$$

Using sign convention,

$BC_1 = +R_2$

$DC_2 = -R_2$

We obtain:

$$\frac{1}{f}=(n_{21}-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

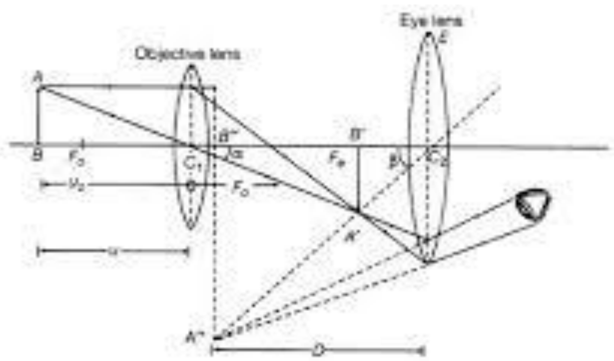
$$n_{21}=\frac{n_2}{n_1}$$

n_{21} → Refractive index of medium 2 with respect to medium 1

This is known as lens maker's formula.

(OR)

(a)



Magnifying power of a compound microscope

$$M=-\frac{L}{f_o}\left(1+\frac{D}{f_e}\right)$$

where, L = length of telescope
f_o = focal length of objective and
f_e = focal length of eye lens **(1)**

(b)

$u_o = -6$cm

Magnifying power of microscope

$$M = -\frac{|v_o|}{|u_o|}\left(1+\frac{D}{f_e}\right)$$

From lens formula $\frac{1}{f_o} = \frac{1}{v_o} - \frac{1}{u_o}$

$$= \frac{1}{v_o} = \frac{1}{f_o} + \frac{1}{u_o} = \frac{1}{4} - \frac{1}{6} = \frac{3-2}{12}$$

$$\Rightarrow \quad v_o = 12 \text{ cm}$$

$$\therefore \; m = -\frac{12}{6}\left(1+\frac{25}{10}\right) = -2 \times 3.5 = -7$$

Negative sign shows that the image is inverted.

Length of microscope L = $|v_0| + |u_e|$

For eye lens $\frac{1}{f_e} = \frac{1}{v_e} - \frac{1}{u_e}$

$$= \frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = -\frac{1}{25} - \frac{1}{10} \qquad (v_e = D = -25 \text{ cm}, u_e = ?)$$

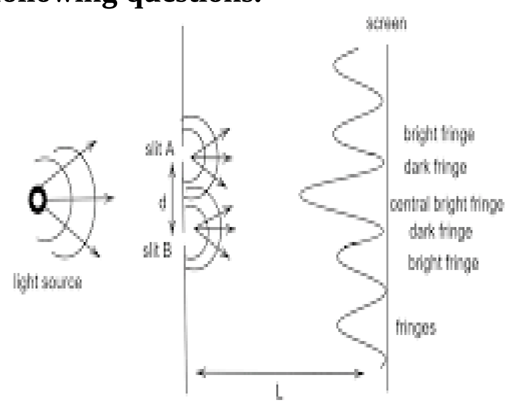
$$\Rightarrow \quad u_e = -\frac{50}{7}(\text{cm}) = -7 \cdot 14$$

$$\therefore \; L = |v_o| + |u_e| = 12 + 7 \cdot 14 = 19 \cdot 14 \text{ cm}$$

SECTION - E

34. **Read the following passage and answer the following questions.** 4

Interference of visible light is not easy to observe because of the short wavelength (400nm- 700nm).To maintain a stable interference pattern individual waves must maintain a constant phase relationship with one another. Light waves whose phase difference is either zero or constant are known as coherent waves. Sources of such light are called coherent waves.
Constructive interference (p=nλ) produces a bright band and destructive interference (p = (n+1/2) λ) produces a dark band.



Young's double slit experiment

(a) For a destructive interference what is the phase difference between the 2 superimposing waves.

Ans: (2n-1)π

(b) In Young's double slit experiment, if the source of yellow light is replaced by red light how do the fringe width changes.

Ans:

Fringe width $(\beta) = \frac{D\lambda}{d} \Rightarrow \beta \propto \lambda$

As $\lambda_{red} > \lambda_{yellow}$, hence fringe width will increase

(c) What will happen if the phase difference between the sources doesn't maintain a constant phase difference?

Ans:

The interference term includes cos Φ whose average over the whole cycle is Zero. Hence for the interference term to be sustained the phase difference should be 0 or constant over the time period.

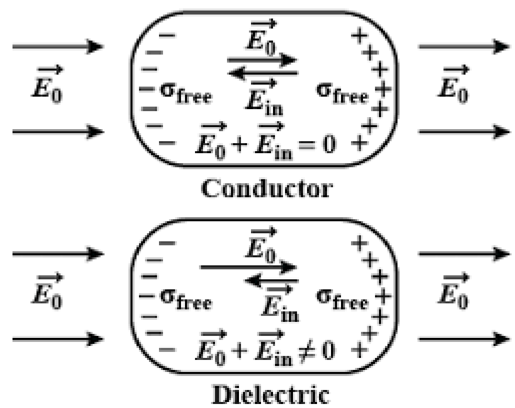
(OR)

(c) In a double slit experiment, the distance between slits is increased 10 times whereas their distance from screen is halved, then what is the fringe width.

Ans:

Fringe width becomes 1/20 times the original width.

35. Dielectric with polar molecules also develops a net dipole moment in an external field, but for a different reason. In the absence of any external field, the different permanent dipoles are oriented randomly due to thermal agitation, so the total dipole moment is zero. 4



When an external field is applied, the individual dipole moments tend to align with the field. When summed overall the molecules, there is then a net dipole moment in the direction of the external field, i.e., the dielectric is polarised.

The extent of polarisation depends on the relative strength of two factors: the dipole potential energy in the external field tending to align the dipoles mutually opposite with the field and thermal energy tending to disrupt the alignment. There may be, in addition, the 'induced dipole moment' effect as for non-polar molecules, but generally the alignment effect is more important for polar molecules. Thus, in either case, whether polar or non-polar, a dielectric develops a net dipole moment in the presence of an external field. The dipole moment per unit volume is called polarization.

(a) What happens when dielectric is kept in external electric field.

Ans: When a dielectric is placed in an electric field, it gets polarised. The electric field in a polarised material is less than the applied field.

(b) State the two factors that affect polarization.

Ans: The strength of the external field and the thermal energy that breaks this alignment.

(c) Calculate the polarisation vector of the material which has 100 dipoles per unit volume in a volume of 2 units.

Ans: Polarisation vector P = N x p, where N = 100 and p = 2. On substituting we get P = 200 units.

(OR)

(c) State any two differences between polar molecules and non-polar molecules

Ans:

S.No	*Polar molecules*	*Non - Polar molecules*
1.	These molecules have permanent dipole moment even in the absence of on applied field.	These molecules do not have permanent dipole moment
2.	The polarization of polar molecules is highly temperature dependent.	The polarization in these type of molecules is independent of temperature.
3.	There is absorption or emission in the infrared range for these molecules ***Example:*** H_2O, HC1, CO	There is no absorption of emission in infrared range for these molecules ***Example:*** O_2, H_2, N_2