CBSE Class 12 Physics
Sample Paper - 07(2019-20)

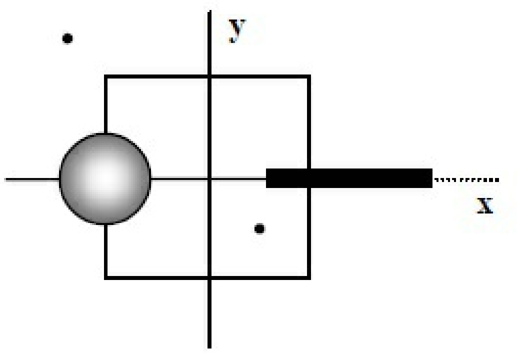
Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

i. All questions are compulsory. There are 37 questions in all.
ii. This question paper has four sections: Section A, Section B, Section C and Section D.
iii. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
iv. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.

Section A

1. A disk of radius a/4 having a uniformly distributed charge 6C is placed in the x-y plane with its centre at (−a/2, 0, 0). A rod of length a carrying a uniformly distributed charge 8C is placed on the x-axis from x = a/4 to x = 5a/4. Two point charges −7C and 3C are placed at (a/4, −a/4, 0) and (−3a/4, 3a/4, 0), respectively. Consider a cubical surface formed by six surfaces.$x = \pm a/2, y = \pm a/2, z = \pm a/2$ The electric flux through this cubical surface is



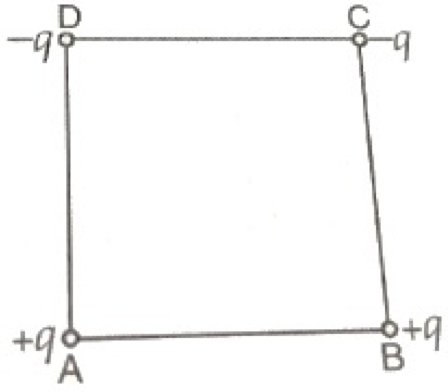
a. $\frac{12C}{\epsilon_0}$

b. $-\frac{2C}{\epsilon_0}$

c. $\frac{10C}{\epsilon_0}$

d. $\frac{2C}{\epsilon_0}$

2. The charges are placed on the vertices of a square as shown the figure. Let $\vec{E}$ be the electric field and V, the potential at the centre. If the charges at the points A and B are interchanged with those at D and C respectively, then



a. $\vec{E}$ and V remain unchanged.

b. $\vec{E}$ changes, but V remains unchanged.

c. Both $\vec{E}$ and V change.

d. $\vec{E}$ remains unchanged, but V changes.

3. If the length of the filament of a heater is reduced by 10% the power of the heater will ___________

a. increase by about 19%

b. Increase by about 11%

c. Increase by about 9%

d. decrease by about 29%

4. An ammeter together with an unknown resistance in series is connected across two identical batteries each of emf 1.5 V. When the batteries are connected in series, the galvanometer records a current of 1A and when the batteries are in parallel, the current is 0.6A. Then the internal resistance of the battery is

a. $\frac{1}{3}\Omega$

b. $\frac{1}{4}\Omega$

c. $\frac{1}{5}\Omega$

d. $\frac{1}{2}\Omega$

5. The magnetic field due to a current carrying circular loop of radius 3 cm at a point on the axis at a distance of 4 cm from the centre is 54 μT. what will be its value at the centre of the loop?

a. 125μ T

b. 75 μ T

c. 150μ T

d. 250 μ T

6. If I_0 is the intensity after the first Polaroid the intensity emerging from the second Polaroid kept at an angle θ to the first is given by

a. $2I_0\cos^2\theta$

b. $I_0\cos^2\theta$

c. $I_0\cos\theta$

d. $I_0\cos^2\theta/2$

7. Two slits are made one millimetre apart and the screen is placed one metre away. What is the fringe separation when bluegreen light of wavelength 500 nm is used?

a. 0.65 mm

b. 0.56 mm

c. 0.6 mm

d. 0.5 mm

8. A fish at a depth of 12 cm in water is viewed by an observer on the bank of a lake. Through what height is the image of fish raised? (u = 4/3)

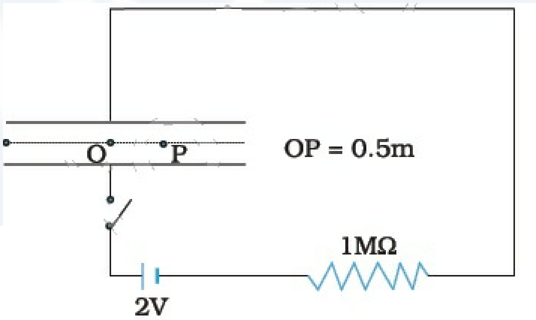
a. 9 cm

b. 3 cm

c. 12 cm

d. 3.8 cm

9. A parallel plate capacitor with circular plates of radius 1 m has a capacitance of 1 nF. At t = 0, it is connected for charging in series with a resistor R = 1 MΩ across a 2V battery. Calculate the magnetic field at a point P, halfway between the centre and the periphery of the plates, after t = 10^{-3} s. (The charge on the capacitor at time t is q (t) = CV [1 – exp (–t$/\tau$)], where the time constant τ is equal to CR.)



a. 0.68 $\times 10^{-13}$T Hz

b. 0.64 $\times 10^{-13}$T

c. 0.74 $\times 10^{-13}$T

d. 0.54 $\times 10^{-13}$T

10. A drop of radius one micron carries a charge of 4 electrons. If the density of oil is 2g/cc, the electric field required to balance it is

a. 14.83 $\times 10^{4}$ V/m

b. 12.83×10^4 V/m

c. 13.83×10^4 V/m

d. 12.03×10^4 V/m

11. Fill in the blanks:

    The lines joining the places of equal dip or inclination are called ________ lines.

12. Fill in the blanks:

    The magnetic force required to demagnetize the material is ________.

13. Fill in the blanks:

    The SI unit of magnetic induction is ________.

    OR

    Fill in the blanks:

    When a glass rod of length l moves with velocity v perpendicular to a uniform magnetic field B, the induced emf in the glass rod is ________.

14. Fill in the blanks:

    ________ are the nuclides which contain the same number of neutrons.

15. Fill in the blanks:

    The angle of incidence when a ray of light falls normally on a mirror is ________.

16. Two nuclei have mass numbers in the ratio 1: 2. What is the ratio of their nuclear densities?

17. A radioactive material has a half life of 1 minute. If one of the nuclei decays now, when will the next one decay?

18. How does the length of a dipole antenna vary with the increase in the frequency of the carrier wave?

19. Show graphically, the variation of de-Broglie wavelength(λ) with the potential (V) through which an electron is accelerated from rest.

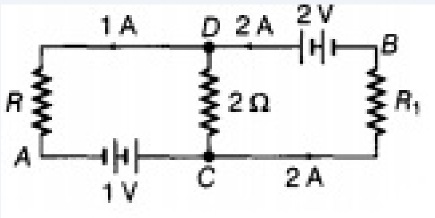
20. How does the energy gap in an intrinsic semiconductor change, when doped with a trivalent impurity?

OR

How does the length of a dipole antenna vary with the increase in the frequency of the carrier wave?

Section B

21. In the given circuit, assuming point A to be at zero potential, use Kirchhoff's rules to determine the potential at point B.



22. A capacitor (C) and resistor (R) are connected in series with an ac source of voltage of frequency 50 Hz. The potential difference across C and R are respectively 120 V and 90 V, and the current in the circuit is 3 A. Calculate:
    i. the impedance of the circuit.
    ii. the value of the inductance, which when connected in series with C and R will make the power factor of the circuit unity.

23. An electron is accelerated through a potential difference of 100 V. What is the de-Broglie wavelength associated with it? To which part of the electromagnetic spectrum does this value of wavelength correspond?

24. A capacitor of capacitance *C* is being charged by connecting it across a DC source along with an ammeter. Will the ammeter show a momentary deflection during the process of charging? If so, how would you explain this momentary deflection and the resulting continuity of current in the circuit? Write the expression for the current inside the capacitor.

25. An electron in the ground state of hydrogen atom is revolving in anti-clockwise direction in a circular orbit. The atom is placed normal to the electron orbit makes an angle of 30^{o} in the magnetic field. Find the torque experienced by the orbiting electron.

26. A hydrogen atom in the ground state is excited by an electron beam of 12.5 eV energy. Find out the maximum number of lines emitted by the atom from its excited state.

OR

State Bohr postulate of hydrogen atom that gives the relationship for the frequency of emitted photon in a transition.a

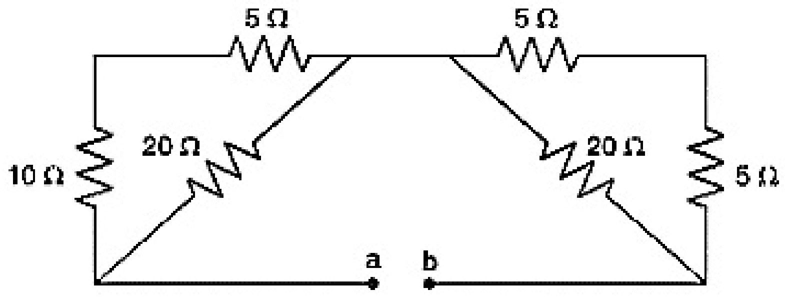
27. Distinguish between a metal and an insulator on the basis of energy band diagram.

OR

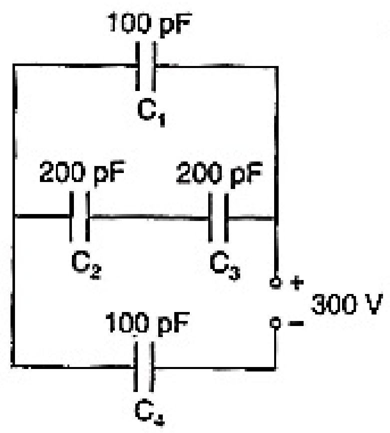
For a common base amplifier, if the values of voltage gain and resistance gain are 2800 and 3000 respectively, find the current gain and power gain of this amplifier.

Section C

28. Find the equivalent resistance of the circuit given across ab.



29. Obtain the equivalent capacitance of the network in figure. For a 300 V supply, determine the charge and voltage across each capacitor.



30. Derive an expression for the average power consumed in a series LCR circuit connected to a.c. source in which phase difference between the voltage and the current in the circuit is ϕ.

31. What is intensity of electromagnetic wave? Give its relation in terms of electric field E and magnetic field B.

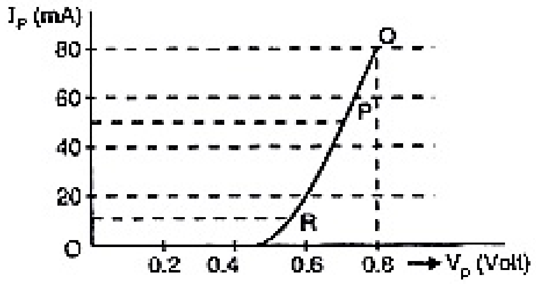
32. A plane wavefront propagating in a medium of refractive index μ_1 is incident on a plane surface making an angle of incidence i and enters into another medium of refractive index μ_2(μ_2 >μ_1). Use Huygens' construction of secondary wavelets to trace the propagation of the refracted wavefront. Hence, verify Snell's law of refraction.

OR

Define the term wavefront. State Huygen's principle. Consider a plane wavefront incident on a thin convex lens. Draw a proper diagram to show how the incident wavefront traverses through the lens and after refraction focusses on the focal point of the lens, giving the shape of the emergent wavefront.

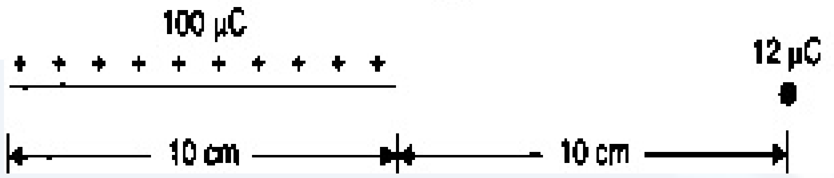
33. (a) Using the Bohr's model calculate the speed of the electron in a hydrogen atom in the n = 1, 2 and 3 levels.
(b) Calculate the orbital period in each of these levels.

34. The characteristics curve of a diode is shown in the above figure. Determine the d.c. and a.c. resistance around point.



Section D

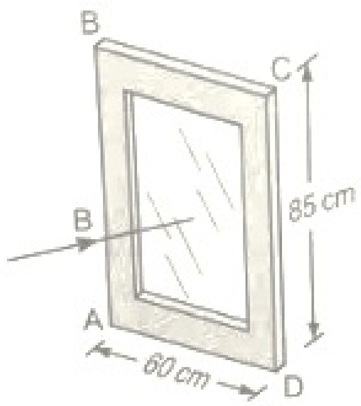
35. a. State coulomb's law of force in electrostatics. Express it in vector form.
    b. A $12\mu C$ charge is placed at the distance of 10 cm from a linear charge of $100\mu C$ uniformly distributed once the length of 10 cm as shown in figure. Find the force on $12\mu C$ charge.



OR

a. Deduce the expression for the energy stored in a charged capacitor
b. Show that the effective capacitance C of a series combination of three capacitors C_1, C_2 and C_3 is given by $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$.

36. The aluminium frame ABCD of a window measures 85cm $\times$ 60cm, as illustrated in fig.



The window is hinged along the edge AB. When the window is closed, the horizontal component of the earth's magnetic field of flux density 1.8 $\times$ 10^{-4}T, is normal to the window.

i. Calculate the magnetic flux through the window.

ii. The window is now opened in a time of 0.20s. When open, the plane of the window is parallel to the earth's magnetic field. For the opening of the window, state the change in flux through the window and calculate the average e.m.f. induced in side CD of the frame.
iii. Suggest, with a reason, whether the e.m.f. calculated in (ii) gives rise to a current in the frame ABCD.

OR

A circular coil of 20 turns and radius 10 cm is placed in a uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in the coil is 5.0 A, what is the

a. total torque on the coil,
b. total force on the coil,
c. average force on each electron in the coil due to the magnetic field?

37. a. Draw the ray diagram showing the refraction of light through a glass prism and hence obtain the relation between the refractive index μ of the prism, angle of prism and angle of minimum deviation.
b. Determine the value of the angle of incidence for a ray of light travelling from a medium of refractive index $\mu_1 = \sqrt{2}$ into the medium of refractive index μ_2 = 1, so that it just grazes along the surface of separation.

OR

With the help of ray diagram, show the formation of image of a point object by refraction of light at a spherical surface separating two media of refractive indices n_1 and n_2 ($n_2 > n_1$)respectively. Using this diagram, derive the relation.
$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ Write the sign conventions used. What happens to the focal length of convex lens when it is immersed in water?

Answer

Section A

1. (b) $-\frac{2C}{\epsilon_0}$ **Explanation:** Electric flux through a surface is given by $\phi = \frac{q}{\epsilon_0}$
   Where q = net charge enclosed inside the surface Since half the disc lies inside the surface and one fourth of rod lies inside the surface, point charge -7C lies inside the surface and point charge 3C lies outside the surface So the net charge enclosed by the surface is $= \frac{6C}{2} + \frac{8C}{4} - 7C + 0 = -2C$
   So $\phi = \frac{-2C}{\epsilon_0}$
2. (b) $\vec{E}$ changes, but V remains unchanged. **Explanation:** $\vec{E}$ changes, but V remains unchanged.
3. (b) Increase by about 11%
   Explanation: The power is related to resistance as, $P \propto \frac{1}{R}$
   $\frac{P_2}{P_1} = \frac{R_1}{R_2}$
   also, $R \propto L$
   $\therefore \frac{P_2}{P_1} = \frac{L_1}{L_2}$
   $\frac{P_2}{P_1} = \frac{L}{0.9L}$
   $\Rightarrow P_2 \approx 0.11P_1$
   So Power increases by 11%.
4. (a) $\frac{1}{3}\Omega$ **Explanation:** When the batteries are in series, the internal resistances are in series. Both e m f and the internal resistances add up. $I = \frac{E}{(r+R)}$
   $1 = \frac{3}{(2r+R)} \ldots . (i)$
   $0.6 = \frac{1.5}{\left(\frac{r}{2} + R\right)} \ldots . (ii)$ from equation (i) and (ii) $r = \frac{1}{3}\Omega$
5. (c) 150μ T
   Explanation: The magnetic field at the centre of a coil of radius R and number of turns N , carrying a current I is $B_0 = \frac{\mu_0 NI}{2R}$. At a point distance x from the coil, the field is $B_x = \frac{\mu_0 NIR^2}{2(R^2+x^2)^{\frac{3}{2}}}$

$$\frac{B_0}{B_x} = \frac{(R^2+x^2)^{\frac{3}{2}}}{R^3} = \frac{(3^2+4^2)^{\frac{3}{2}}}{3^3} = \left(\frac{5}{3}\right)^3.$$

$$B_0 = \left(\frac{5}{3}\right)^3 \times 54\mu T = 150\mu T$$

6. (b) $I_0 \cos^2\theta$ **Explanation:** As per malus law when a beam of completely plane polarised light i passed through the analyser the intensity of transmitted light varies directly as the square of cosine of angle between the plane of polariser and analyser.
7. (d) 0.5 mm

   Explanation: as per the relation of fringe width $w = \frac{\lambda D}{d}$

   500×10^{-6} = 0.5mm
8. (b) 3 cm

   Explanation: Apparent depth = (Real depth)/refractive index shift = real depth - apparent depth

   $$= R.D.\left(1 - \frac{1}{\mu}\right) = 12\left(1 - \frac{1}{\frac{4}{3}}\right) = 12\left(1 - \frac{3}{4}\right) = \frac{12}{4} = 3cm.$$
9. (c) 0.74 $\times 10^{-13}$T **Explanation:** The time constant of the CR circuit is τ = CR = 10^{-3} s. Then, we have q(t) = CV [1 – exp (–t/τ)] = 2 $\times$ 10^{-9} [1 – exp (–t/10^{-3})] The electric field in between the plates at time t is $E = \frac{q(t)}{\epsilon_o A} = \frac{q}{\pi\epsilon_o}$

   Consider now a circular loop of radius (1/2) m parallel to the plates passing through P. The magnetic field B at all points on the loop is along the loop and of the same value. The flux through this loop, Φ_E = E × area of the loop

   $$= e \times \pi \times \left(\frac{1}{2}\right)^2 = \frac{\pi E}{4} = \frac{q}{4\epsilon_o}$$

   The displacement current, $i_d = \epsilon_o \frac{d\phi}{dt} = \frac{1}{4}\frac{dq}{dt} = 0.5 \times 10^{-6} exp(-1)$ at t = 10^{-3} s.

   Now, applying Ampere-Maxwell law to the loop, we get

   $$B \times 2\pi \times \left(\frac{1}{2}\right) = \mu_o(i_c + i_d) = \mu_o(0 + i_d)$$
   $$= .5 \times 10^{-6}\mu_o exp(-1)$$

   or B = 0.74 x 10^{-13}T.
10. (b) 12.83 $\times 10^4$ V/m **Explanation:** F_e = mg 4eE = density $\times$ volume $\times$ g = d $\times$ $\frac{4}{3}$ $\times$ π $\times r^3 \times$ g

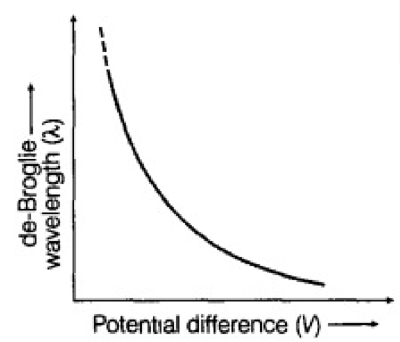
    d = 2g/cc = 2000 kg/m^3; r = 10^{-6} m

    4 $\times$ 1.6 $\times$ 10^{-19} $\times$ E = 2 $\times$ 10^3 $\times$ $\frac{4}{3}$ $\times$ 3.14 $\times$ 10^{-18} $\times$ 9.8

    E = (2 $\times$ 10^3 $\times$ $\frac{4}{3}$ $\times$ 3.14 $\times$ 10^{-18} $\times$ 9.8) / (4 $\times$ 1.6 $\times$ 10^{-19}) = 12.83 $\times$ 10^4 V/m

11. Isoclinical
12. Coercivity
13. Tesla

OR

Zero
14. Isotones
15. Zero degree
16. Nuclear density of any nucleus is independent of its mass number and given as
$\rho = \frac{3m}{4\pi R_0^3}$
Thus, the density of nucleus is constant where, m = average mass of single nucleon which is constant i.e roughly 1.67×10^{-27} kg
17. The next nucleus can decay any time.
18. With an increase in frequency, the length of a dipole decreases.
19. Relation between momentum and energy is
$\Rightarrow \quad p = \sqrt{2mK} = \sqrt{2meV}$
$\therefore$ de-Broglie wavelength
$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}} \Rightarrow \lambda \propto \frac{1}{\sqrt{V}}$
$\Rightarrow \quad V \cdot \lambda^2$ = constant


20. The value of the energy gap becomes more when an intrinsic semiconductor is doped with a trivalent impurity.

OR

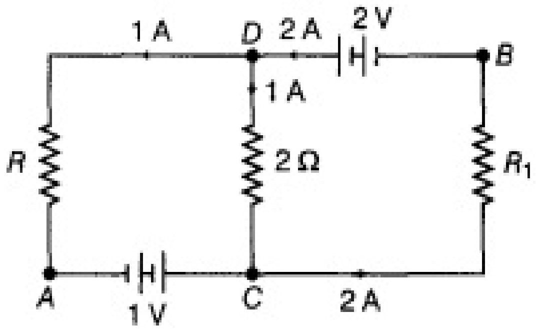
With an increase in frequency, the length of a dipole decreases.

Section B

21. By applying Kirchhoff's first law at D,

$I_{DC} + 1 = 2$

$I_{DC} = 1A$



Along ACDBA, $V_A + 1 V + 1 \times 2 - 2 = V_B$

But $V_A = 0$, $V_B = 1 + 2 - 2 = 1V$

$\therefore V_B = 1 V$

22. i. Impedence for RC circuit,

$Z = \sqrt{R^2 + X_c^2}$

$R = \frac{V_R}{I_R} = \frac{90}{3} = 30\ \Omega$

$X_c = \frac{V_c}{I_c} = \frac{120}{3} = 40\ \Omega$

Therefore, $Z = \sqrt{(30)^2 + (40)^2} = 50\ \Omega$

ii. At unity power factor, $X_L = X_c$

$\omega L = 40$

Thus, $L = \frac{40}{\omega} = \frac{40}{2\pi f} = \frac{40}{2\times 50\pi} = \frac{2}{5\pi} = 0.13$ H

23. Given, V = 100 V. Wavelength of accelerated electron beam from de-Broglie equation

$\lambda = \frac{12.27}{\sqrt{V}} \overset{o}{A}$

For V = 100 V $\Rightarrow \lambda = 1.227 \overset{o}{A}$

This wavelength belongs to the X-ray part of electromagnetic radiation.

24. Yes, the ammeter will show the momentary deflection.

This momentary deflection occurs due to the fact that the conducting current flows through connecting wires during the charging of capacitor. This leads to deposition of charge at two plates and hence, varying electric field of increasing nature is produced between the plates which in turn produces displacement current in space between two plates, which maintains the continuity with the conduction current. Expression for the current $I = \epsilon_0 \frac{d\phi_E}{dt}$, where $\frac{d\phi_E}{dt}$ is the rate of change of electric flux with time.

25. Magnetic moment associated with electron is given by,

M = $\frac{eh}{4\pi m_e}$

and torque, $\tau = MB\sin\theta$

Here, $\theta = 30^\circ$

$\tau = \frac{eh}{4\pi m_e}B \times \sin 30^\circ = \frac{eh}{4\pi m_e}B \times \frac{1}{2}$

$\tau = \frac{ehB}{8\pi m_e}$

where h is Planck's constant, m_e is electron mass, B is the magnetic field.

26. Energy in ground state, E_1 = - 13.6eV

Energy supplied = 12.5eV

Energy in excited state = - 13.6 + 12.5 = - 1.1eV

But, E_n = $\frac{-13.6}{n^2}$ = - 1.1 $\Rightarrow n^2$= 12.3 $\Rightarrow$ n=3.5

Hence, n = 3

Maximum number of lines = 3

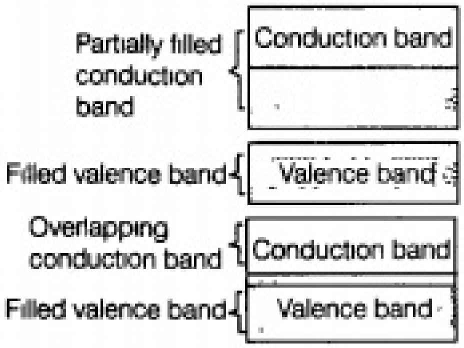
OR

Frequency condition: An atom can emit or absorb radiation in the form of discrete energy photons only when an electron Jumps from a higher to a lower orbit or from a lower to a higher orbit, respectively.

hv = E_t - E_f

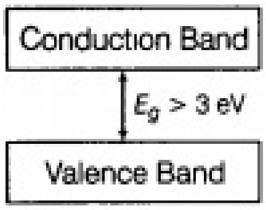
where, v is frequency of radiation emitted, E_t and E_f are the energies associated with stationary orbits of principal quantum numbers n_t and n_f respectively (where $n_t > n_f$)

27. **Metal:** For metals, the valence band is completely filled and the conduction band overlaps with balance band so it is always partially filled as shown in figure.



Metals can conduct electricity even at low electric field.

Insulators: For insulator, the forbidden energy gap between the conduction and valence bands is very large, and conduction band is practically empty, as shown below:



Large amount of energy is required by electrons to jump to the conduction band. Thus, the conduction band remains empty. So no current flows through insulators.

OR

Current gain $\alpha = \frac{\text{voltage gain}}{\text{resistance gain}}$

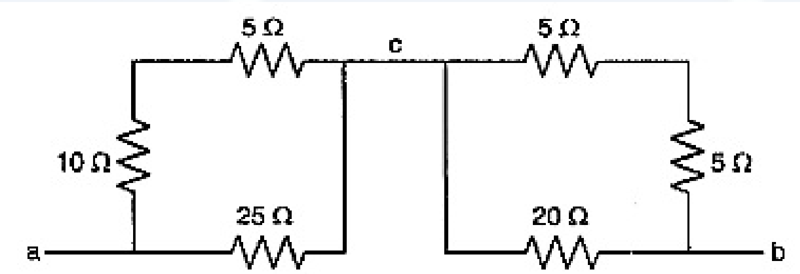
$\Rightarrow \alpha = \frac{2800}{3000}$ = 0.93

$\text{Power gain} = \frac{(\text{voltage gain})^2}{\text{resistance gain}}$

$= \frac{(2800)^2}{3000}$ = 2613.3

Section C

28. As a first step the circuit may be redrawn as follows.

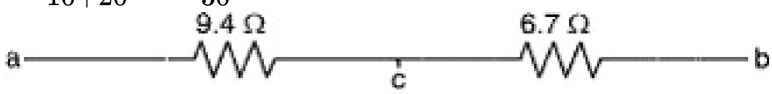


The left block is equivalent to 15 ohm and 25 ohm in parallel

i.e. $\frac{25 \times 15}{25+15} = 9.4\Omega$

The right block is equivalent to 10 ohm and 20 ohm in parallel

i.e. $\frac{10 \times 20}{10+20} = \frac{200}{30} = 6.7\Omega$



The circuit now reduces as two resistors in series 9.4 + 6.7 = 16.1Ω

29. C_{23} = 100 pF

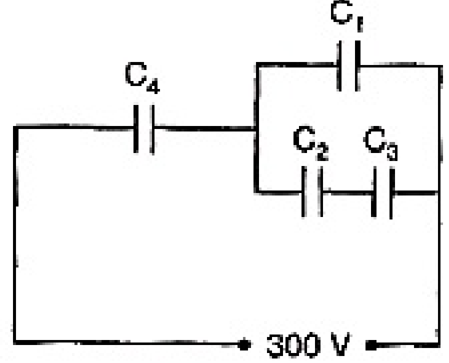
C_{123} = 200pF

C_{123} and C_4 are in series.

$\therefore C_{1234} = \frac{200 \times 100}{200+100} = \frac{200}{3} pF$

The given circuit may be redrawn as shown in following figure

Now, $\frac{V_{123}}{V_4} = \frac{C_4}{C_{123}} = \frac{100}{200} = \frac{1}{2}$



So, voltage across C_4 is 200 V. The voltage across the combination of C_1, C_2 and C_3 is 100 V. Since C_1 and C_{23} are in parallel, therefore, the voltage across C_1 as well as across the series combination of C_2 and C_3 is 100 V. Again, C_2 and C_3 are equal therefore, 100 V would be shared equally between C_2 and C_3.

$\therefore V_2 = 50V$ and V_3 = 50V

Again, $Q_1 = 100 \times 10^{-12} \times 100C = 10^{-8}C$

$Q_2 = 200 \times 10^{-12} \times 50C = 10^{-8}C$

$Q_3 = 200 \times 10^{-12} \times 50C = 10^{-8}C$

$Q_4 = 100 \times 10^{-12} \times 200C = 2 \times 10^{-8}C$

30. Average power in LCR circuit:

Let the alternating e.m.f applied to an LCR circuit is

$E = E_0 \sin \omega t$ ....(i)

If alternating current developed lags behind the applied e.m.f by a phase angle ϕ then

$I = I_0 \sin(\omega t - \phi)$

Total work done over a complete cycle is

$$W = \int_0^T EI\ dt$$

$$= \int_0^T E_0 \sin \omega t \cdot I_0 \sin(\omega t - \phi) dt$$

$$= E_0 I_0 \int_0^T \sin \omega t \sin(\omega t - \phi) dt$$

$$= \frac{E_0 I_0}{2} \int_0^T 2 \sin \omega t \sin(\omega t - \phi) dt$$

$$= \frac{E_0 I_0}{2} \int_0^T [\cos(\omega t \pm \omega t + \phi) - \cos(\omega t + \omega t - \phi)] dt$$

[∵ 2sin A sin B = cos(A - B) - cos(A + B)]

Or $W = \frac{E_0 I_0}{2} \int_0^T [\cos\phi - \cos(2\omega t - \phi)]\, dt$

or $W = \frac{E_0 I_0}{2} \left[t\cos\phi - \frac{\sin(2\omega t - \phi)}{2\omega} \right]_0^T$

$$= \frac{E_0 I_0}{2} [T \cos\phi]$$

$$W = \frac{E_0 I_0}{2} \cdot \cos\phi \cdot T$$

Average power in LCR circuit over a complete cycle is

$$P = \frac{W}{T} = \frac{E_0 I_0}{2} \cos\phi = \frac{E_0}{\sqrt{2}} \cdot \frac{I_0}{\sqrt{2}} \cos\phi$$

$$\therefore P = E_v I_v \cos\phi$$

31. Intensity of electromagnetic wave is defined as the energy crossing per second per unit area perpendicular to the direction of propagation of electromagnetic waves. The intensity of electromagnetic wave at a point is;

$$I = U_{av} c$$

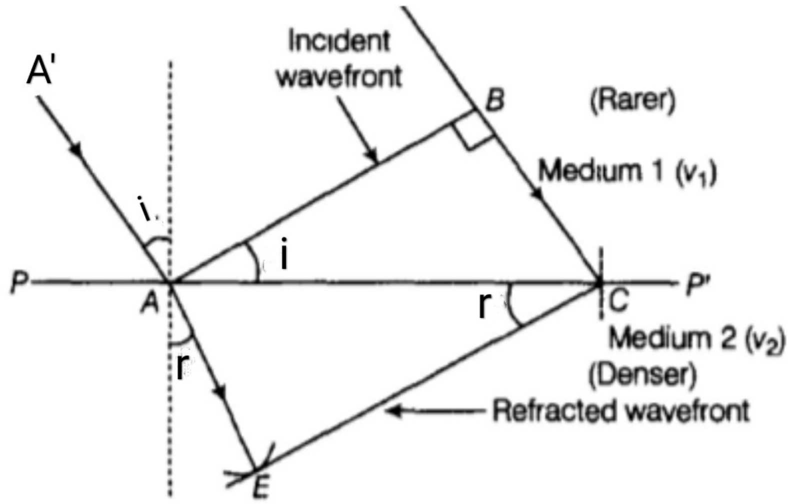
where $U_{av} = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\frac{B_0^2}{\mu_0}$

and c is the velocity of electromagnetic wave,

$$\therefore I = \frac{1}{2}\varepsilon_0 E_0^2\, c = \frac{1}{2}\frac{B_0^2}{\mu_0} c$$

Here E_0 and B_0 are maximum values of electric field and magnetic field respectively.

32. **Snell's law of refraction**: Let PP' represents the surface separating medium 1 and medium 2 as shown in figure.



Let v_1 and v_2 represents the speed of light in medium 1 and medium 2 respectively.

We assume a plane wavefront AB propagating in the direction A'A incident on the interface at an angle of incidence i. Let t be the time taken by the wavefront to travel the distance BC in medium 1 and AE in medium 2 respectively.

$\therefore$ BC = speed of light in medium 1 × time = v_1t [$\because$ distance = speed $\times$ time]

In order to determine the shape of the refracted wavefront, we draw an arc of radius v_2t from the point A in the second medium (the speed of the wave in second medium is v_2 and applying the formula distance = speed × time). Let CE represents a tangent plane drawn from the point C.

Then AE = speed of light in medium 2 × time = V_2t

$\therefore$ CE would represent the refracted wavefront.

In ΔABC and ΔAEC, we have

$\frac{\sin i}{\sin r} = \frac{v_1 t}{AC} \cdot \frac{AC}{v_2 t}; \quad \therefore \frac{\sin i}{\sin r} = \frac{v_1}{v_2}$

If c represents the speed of light in vacuum, then

$\mu_1 = \frac{c}{v_1}$ and $\mu_2 = \frac{c}{v_2}$ [since refractive index of a medium = speed of light in vacuum or air ÷ speed of light at that medium]

$\Rightarrow \quad v_1 = \frac{c}{\mu_1}$ and $v_2 = \frac{c}{\mu_2}$

where, μ_1 and μ_2 are the refractive indices of medium 1 and medium 2 respectively.

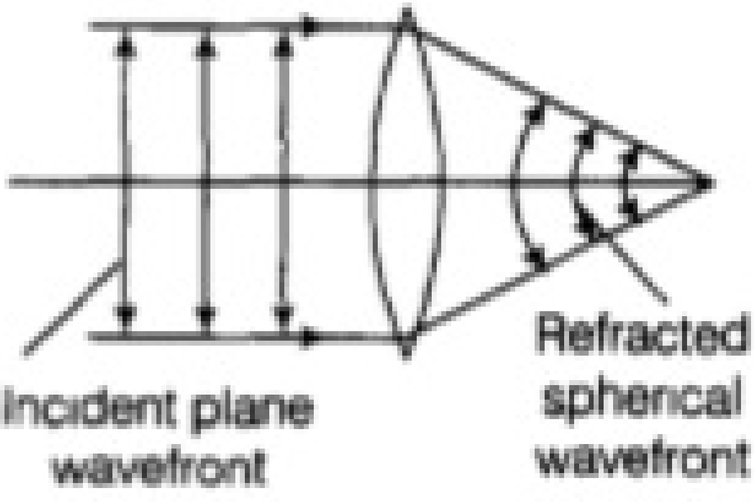
$\therefore \quad \frac{\sin i}{\sin r} = \frac{c/\mu_1}{c/\mu_2}$

$\Rightarrow \quad \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \mu_1 \sin i = \mu_2 \sin r$

This is the snell's law of refraction.

OR

When light is emitted from a source, then the particles present around it begins to vibrate. The locus of all such particles which are vibrating in the same phase is termed as wavefront.



Huygens' principle: *Every point on a wave-front may be considered a source of secondary spherical wavelets which spread out in the forward direction at the speed of light. The new wave-front is the tangential surface to all of these secondary wavelets.*

Now when a plane wavefront (parallel rays) is incident on a thin convex lens, the emergent rays are focused on the focal point of the lens. Thus the shape of emerging wavefront is spherical.

33. a. From $\nu = \frac{c}{n}\alpha$,

where $\alpha = \frac{2\pi Ke^2}{ch}$

= 0.0073

$v_1 = \frac{3\times10^8}{1} \times 0.0073 = 2.19 \times 10^6 m/s$

$v_2 = \frac{3\times10^8}{3} \times 0.0073 = 1.095 \times 10^6 m/s$

$v_3 = \frac{3\times10^8}{3} \times 0.0073 = 7.3 \times 10^5 m/s$

b. Orbital period, $T = \frac{2\pi r}{v}$

As $r_1 = 0.53 \times 10^{-10} m$

$T_1 = \frac{2\pi\times0.53\times10^{-10}}{2.19\times10^6} = 1.52 \times 10^{-16} s$

As $r_2 = 4\ r_1$ and $v_2 = \frac{1}{2}v_1$

$T_2 = 8\ T_1 = 8 \times 1.52 \times 10^{-16} s = 1.216 \times 10^{-15} s$

As $r_3 = 9r_1$ and $v_3 = \frac{1}{3}v_1$

$\therefore T_3 = 27\ T_1 = 27 \times 1.52 \times 10^{-16} s = 4.1 \times 10^{-15} s$

34. d.c. resistance

$r_{dc} = \frac{0.5}{5\times10^{-3}} = 100\Omega$

a.c. resistance

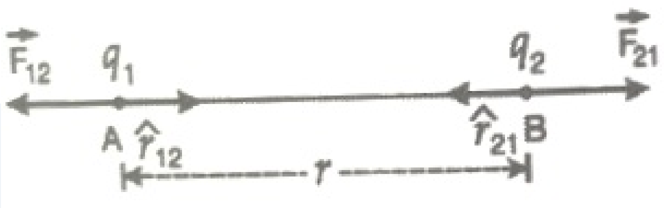
$r_{ac} = \frac{0.8-0.5}{(80-20)\times10^{-3}}$

$= \frac{0.3}{60 \times 10^{-3}} = 5\mu$

Section D

35. a. Columb's law states that two point charges attract or repel each other with a force which is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

Consider that two like charges q_1 and q_2 are present at points A and B in vacuum at a distance r apart. The two charges will exert equal repulsive forces on each other. Let $\overrightarrow{F_{12}}$ be the force on charge q_1 due to charge q_2 and $\overrightarrow{F_{21}}$ be the force charge q_2 due to charge q_1 as shown in fig.



According to Coulomb's law, the magnitude of force on charge q_2 due to q_1 is given by

$$\left|\overrightarrow{F_{12}}\right| = \left|\overrightarrow{F_{21}}\right| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2} \quad ..... (1)$$

Let $\hat{r}_{12}$ be a unit vector pointing from charge q_1 to q_2 and $\hat{r}_{21}$, a unit vector pointing from charge q_2 to q_1. As the force vector $\overrightarrow{F_{12}}$ is along the direction of unit vector $\overrightarrow{F_{21}}$ is along the direction of unit vector $\hat{r}_{21}$, we have

$$\overrightarrow{F_{12}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2} \hat{r}_{21} \quad ..... (2)$$

Also, as the force vector $\overrightarrow{F_{12}}$ is along the direction of unit vector $\hat{r}_{21}$, it follows that

$$\overrightarrow{F_{21}} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2} \hat{r}_{12}$$

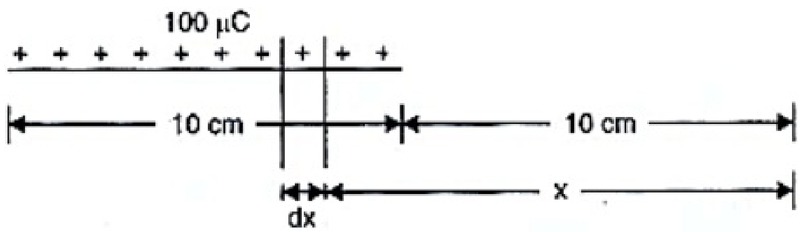
The equation (1) and (2) express Columb's law in vector form.

b. Force on $12\mu C$ charge due to an elementary part of the linear charge,

$$dF = \frac{1}{4\pi\varepsilon_0} \cdot \frac{(\lambda dx) 12 \times 10^{-6}}{x^2}$$

$$= 9 \times 10^9 \times \frac{100 \times 10^{-6}}{10 \times 10^{-2}} \times 12 \times 10^{-6} \times \frac{dx}{x^2}$$

$$= 1.08 \frac{dx}{x^2}$$



Net force on $12\mu C$ charge

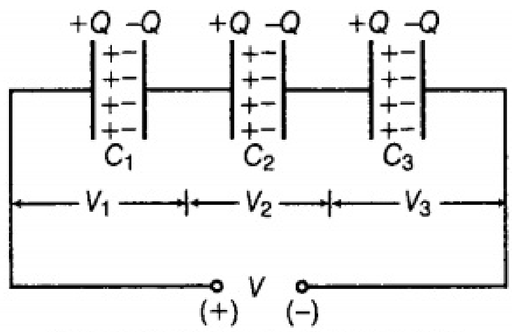
$$F=\int dF=1.08\int_{0.10}^{0.20}\frac{dx}{x^2}=1.08\left[-\frac{1}{x}\right]_{0.01}^{0.20}$$

$$=1.08\left[\frac{1}{0.10}-\frac{1}{0.20}\right]=10.8\left[1-\frac{1}{2}\right]=5.4N$$

OR

a. During charging of the capacitor, work is done by the battery which is stored in the form of potential energy inside the capacitor.
Consider a capacitor which is to be charged by charge Q with the help of a battery. Let at any instant charge on the capacitor is q and the potential difference between the two plates of the capacitor is V.
We know that,
q = CV ⇒ V = q/C
Now small work done to charge the capacitor by small charge dq,
dW = Vdq = $\frac{q}{C}dq$
where, q = instantaneous charge, C = capacitance and V = voltage
∴ Total work done in storing charge from 0 to Q(total charge) is given by
$\Rightarrow W=\int_0^Q \frac{q}{C}dq=\frac{Q^2}{2C}$

b. In a series combination of capacitors, the same charge lie on each capacitor for any value of capacitances.



Capacitors in series combination

Also, the net potential difference across the combination is equal to the algebraic sum of potential differences across each capacitor i.e. $V = V_1 + V_2 + V_3$ ....(i)

where V_1 , V_2, V_3 and V are the potential differences across C_1, C_2, C_3 and equivalent capacitor, respectively.

Again $q_1 = C_1V_1 \Rightarrow V_1 = \frac{q_1}{C_1}$

Similarly, $V_2 = \frac{q}{C_2}$ and $V_3 = \frac{q}{C_3}$

$\therefore$ Total potential difference [From Eq.(i)]

$\Rightarrow V = \frac{q}{C_1} + \frac{q}{C_2} + \frac{q}{C_3}$

$\Rightarrow \frac{V}{q} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$\Rightarrow \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ [$\frac{V}{q} = \frac{1}{C}$, where C is equivalent capacitance]

36. i. Here, B = 1.8×10^{-4}T,

Area of the window, A = 85×60 cm^2 = $85 \times 60 \times 10^{-4}$ m^2

Now, magnetic flux through the window,

ϕ = BA = $1.8 \times 10^{-4} \times 85 \times 60 \times 10^{-4}$

= 9.18×10^{-5}T

ii. When the window is open, the plane of the window is parallel to the earth's magnetic field. Therefore, the magnetic flux through the window zero.

Change in magnetic flux through the window,

$\Delta\phi$ = 9.18×10^{-5} - 0 = 9.18×10^{-5} Wb

Time in which window is opened, Δt = 0.20s

Therefore, e.m.f. induced in the side CD,

$e = \frac{\Delta\phi}{\Delta t} = \frac{9.18\times10^{-5}}{0.20}$

= 4.59×10^{-4} V

iii. Since the frame of the window is a closed circuit and arm CD acts as a source of e.m.f., a current will flow in the frame.

OR

Given, N = 20, r = 10 cm, $= 10 \times 10^{-2}m$

B = 0.10 T, I = 5.0 A

$\theta = 0^\circ$ (angle between field and normal to the coil)

Area of the coil, $A = \pi r^2 = \pi \times (10 \times 10^{-2})^2 = \pi \times 10^{-2}m^2$

a. Torque $\tau = NIBA\ \sin\theta$

$= 20 \times 5.0 \times 0.10 \times \pi \times 10^{-2} \sin 0^{\circ}$
$= 20 \times 5.0 \times 0.10 \times \pi \times 10^{-2} \times 0 = 0$

b. Net force on a planer current loop in a magnetic field is always zero, as net force due to couple of force is zero.

c. If v_d is the drift velocity of electron

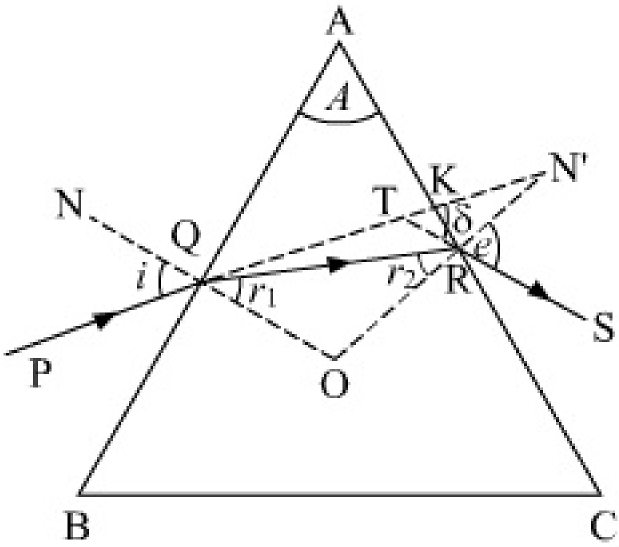
$F = qv \times B$
$= ev_d \cdot B \sin 90^{\circ}$

Force on one electron $= Bev_d = Be\frac{I}{neA} = \frac{BI}{nA}$

Here, n = $10^{29} m^{-3}$, A = $10^{-5} m^2$

Force on one electron $= \frac{0.10 \times 5.0}{10^{29} \times 10^{-5}} = 5 \times 10^{-25} N$

37. a. The figure below shows the passage of light through a triangular prism ABC.



The angles of incidence and refraction at first face AB are $\angle i$ and $\angle r_1$

The angles of incidence at the second face AC is $\angle r_2$ and the angle of emergence $\angle e$

δ is the angle between the emergent ray RS and incident ray PQ and is called the angle of deviation.

Here, $\angle$PQN = i, $\angle$SRN' = e, $\angle$RQO = r_1, $\angle$QRO = r_2, $\angle$KTS = δ

$\because$ $\angle$TQO = i and $\angle$RQO = r_1, we have

$\angle$TQR = i - r_1

$\angle$TRO = e and $\angle$QRO = r_2

$\angle$TRQ = e - r_2

In triangle TQR, the side QT has been produced outwards. Therefore, the exterior angle δ should be equal to the sum of the interior opposite angles.
i.e., $\delta = \angle TQR + \angle TRQ = (i - r_1) + (e - r_2)$

$\delta = (i + e) - (r_1 + r_2)$ ...(i)

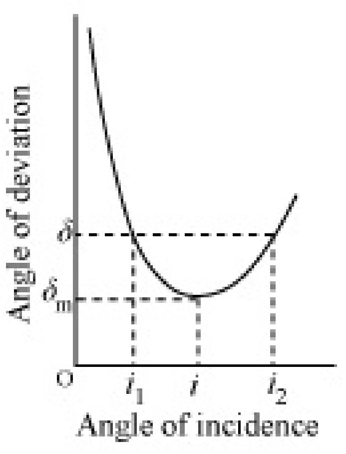
In triangle QRO,

$r_1 + r_2 + \angle ROQ = 180^o$ ...(ii)

From quadrilateral AROQ, we have the sum of angles ($\angle AQO + \angle ARO = 180^o$) This means that the sum of the remaining two angles should be 180^o.

i.e., $\angle A + \angle QOR = 180^o$ [$\angle A$ is called the angle of prism]
From equations (i) and (ii),
$r_1 + r_2 = A$ ...(iii)

Substituting (iii) in (i), we obtain,
$\delta = (i + e) - A$
$A + \delta = i + e$



If the angle of incidence is increased gradually, then the angle of deviation first decreases, attains a minimum value (δ_m), and then again starts increasing.
When angle of deviation is minimum, the prism is said to be placed in the minimum deviation position.
There is only one angle of incidence for which the angle of deviation is minimum.
When
$\delta = \delta_{\mathrm{m}}$ [prism in minimum deviation position],
$e = i$ and $r_2 = r_1 = r$ ...(iv)

$\because r_1 + r_2 = A$

From equation (iv), r + r = A

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

Also, we have

A + δ = i + e

Setting,

$\delta = \delta_{\mathrm{m}}$ and e = i

A + δ_{m} = i + i

$i = \frac{(A+\delta_{\mathrm{m}})}{2}$

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

$\therefore \mu = \frac{\sin\left(\frac{A+\delta_{\mathrm{m}}}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

b. The incident ray travelling from denser medium to rarer medium grazes along the surface of the separation of the medium only when the light ray incident at the surface at an angle called critical angle (C) such that the angle of reflection is 90°. Therefore, following Snell's law, we can write

$\frac{\mu_1}{\mu_2} = \frac{\sin 90}{\sin C}$

$\frac{\mu_1}{\mu_2} = \frac{1}{\sin C}$

$\frac{\sqrt{2}}{1} = \frac{1}{\sin C}$

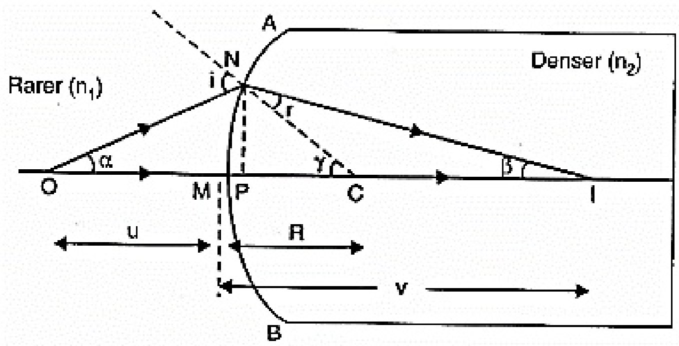
Sin C = $\frac{1}{\sqrt{2}}$

C = $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$

$\therefore$ Critical angle = Angle of incidence = 45°

OR

AMB is a convex surface separating two media of refractive indices n_1 and $n_2(n_2 > n_1)$. Consider a point object O placed on the principal axis. A ray ON is incident at N and refracts along NI. The ray along ON goes straight and meets the previous ray at I. Thus I is the real image of O.



From Snell's law, $n_2 = \frac{\sin i}{\sin r}$

$n_1 \sin i = n_2 \sin r$

$\frac{n_2}{n_1} = \frac{\sin i}{\sin r}$

or $n_1 i = n_2 r$ [$\because \sin\theta \cong \theta$ as θ is very small]

From $\Delta NOC, i = \alpha + \gamma$

From $\Delta NIC, \gamma = r - \beta$

or $r = \gamma - \beta$

$\therefore n_1(\alpha + \gamma) = n_2(\gamma - \beta)$

or $n_1\alpha + n_2\beta = (n_2 - n_1)\gamma$

But $\alpha \cong \tan\alpha = \frac{NP}{OP} = \frac{NP}{OM}$ [P is close to M]

$\beta \cong \tan\beta = \frac{NP}{PI} = \frac{NP}{MI}$

$\gamma \cong \tan\gamma = \frac{NP}{PC} = \frac{NP}{MC}$

$\therefore n_1 \cdot \frac{NP}{OM} + n_2 \cdot \frac{NP}{MI} = (n_2 - n_1)\frac{NP}{MC}$

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

Using Cartesian sign convention,

OM = -u, MI = +v, MC = +R

$\therefore \frac{n_1}{-u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$

or $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$