CBSE
Class XII Physics
Sample Paper 4

Time: 3 Hours **Maximum Marks: 70**

General Instructions:

1. All questions are compulsory. There are 33 questions in all.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
3. Section A contains ten very short answer questions and four assertion reasoning MCQs of 1 mark each, Section B has two case based questions of 4 marks each, Section C contains nine short answer questions of 2 marks each, Section D contains five short answer questions of 3 marks each and Section E contains three long answer questions of 5 marks each.
4. There is no overall choice. However internal choice is provided. You have to attempt only one of the choices in such questions

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

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

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

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

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

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

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

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

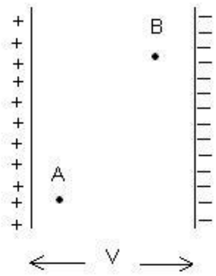
mass of proton $= 1.673 \times 10^{-27}$ kg

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

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

Section A

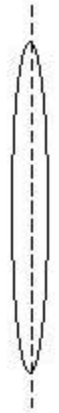
1. Suppose one proton A and one electron B are placed between two parallel plates having a potential difference V as shown in the figure.



Will A and B experience equal or unequal force? (1)

2. To which frequency of light is the human eye most sensitive? (1)

3. A lens of focal length 30 cm is cut vertically as shown in the figure. What will be the new focal length? (1)



4. Are matter waves electromagnetic waves? Write de Broglie wave equation. (1)

OR

What will happen if energy of the electron orbiting around the nucleus becomes positive?

5. Is electric current a vector or scalar quantity? Explain. (1)

OR

If the resistance of a wire is 3 μΩ, then find the conductance of the wire.

6. Name the dielectric whose molecules have (i) non-zero (ii) zero dipole moment. (1)

OR

How much work is required to be done to reduce the separation between two like charges of magnitude 100 μC each from 20 cm to 10 cm?

7. Why is wave nature of matter not more apparent to our daily observations? (1)

8. Why is a spark produced in the switch when light is put off? (1)

OR

An iron bar falling through a hollow region of a thick cylindrical shell made of copper experiences a retarding force. What can you conclude about the nature of the iron bar?

9. What is a communication satellite? Name an Indian communication satellite. (1)

10. Show that only an accelerated charge can produce an electromagnetic wave. (1)

For question numbers 11, 12, 13 and 14, two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

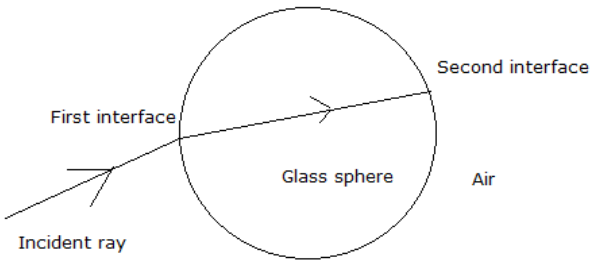
a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true but R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

11. Assertion: For a ray going from a denser medium to rarer medium, the ray may suffer total internal reflection.
Reason: A ray is incident from outside on a glass sphere surrounded by air as shown in figure. This ray may suffer total internal reflection at the second interface.



12. Assertion: In a hydrogen atom, energy of emitted photon corresponding to transition from n=2 to n=1 is much greater as compared to transition from $n=\infty$ to $n=2$
Reason: Wavelength of photon is directly proportional to the energy of emitted photon

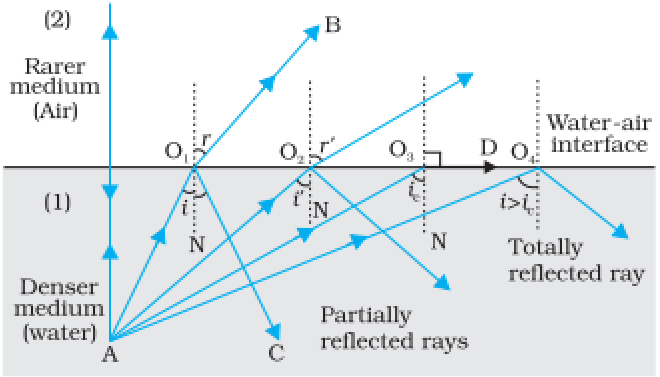
13. Assertion : $\frac{1}{f}=\frac{\mu_2-\mu_1}{\mu_1}\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$
Reason: The focal length of a lens does not depend on the medium in which it is submerged.

14. Assertion: Basic difference between an electric line and magnetic line of force is that former is discontinuous and the latter is continuous or endless.
Reason: No electric lines of forces exist inside a charged body but magnetic lines do exist inside a magnet.

Section – B

Questions 15 and 16 are Case Study based questions and are compulsory. Attempt any 4 sub parts from each question. Each question carries 1 mark.

15. Consider a ray of light that travels from a denser medium to rarer medium. As the angle of incidence increases in the denser medium the angle of refraction in the rarer medium increases. The angle of incidence for which the angle of refraction becomes 90^0 is called critical angle.



$$\frac{\text{Sin}\, c}{\text{Sin}\, 90^0} = \frac{\mu_1}{\mu_2} \Rightarrow \text{Sin}\, C = \frac{\text{Refractive index of rarer medium}}{\text{Refractive index of rarer medium}}$$

When the angle of incidence of a ray travelling from a denser medium to a rarer medium is greater than the critical angle, no refraction occurs. The incident ray is totally reflected back into the same medium. Here, the laws of reflection hold good. Some light is also reflected before critical angle is achieved but not totally.

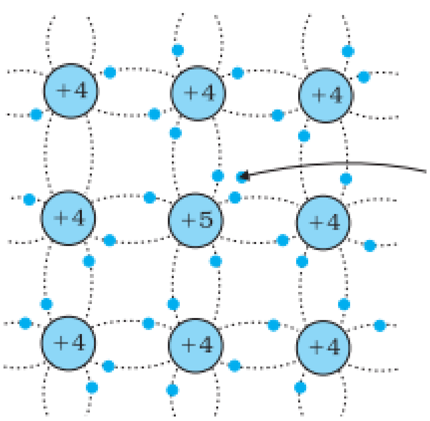
1. Find the maximum angle that can be made in glass medium (μ=1.5) if a light ray is refractd from glass to vacuum
   a. $\text{Sin}^{-1}\frac{3}{2}$
   b. $\text{Sin}^{-1}\frac{4}{3}$
   c. $\text{Sin}^{-1}\frac{2}{3}$
   d. None of these
2. Following are the application of Total Internal Reflection , EXCEPT:
   a. Brilliance of diamond
   b. Phenomenon Mirage
   c. Transmission of signals using optical fiber
   d. Dispersion produced by thin prism
3. Which of the following is the necessary condition for the Phenomenon of Total Internal Reflection:
   a. Light must incident on the interface from denser medium.
   b. Angle of incidence must be greater than critical angle.

c. Angle of incidence is such that angle of refraction is 90^0
d. Both a and b

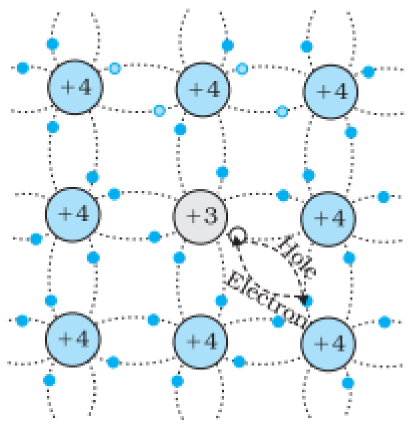
4. Considering the figure shown in the passage, when light travels from denser medium to rarer medium, the ray become parallel to the surface after refraction when
a. $i=i_c$
b. $i=90^0$
c. $i=r$
d. $i>i_c$

5. Considering the figure shown in the passage, when light travels from denser medium to rarer medium, the maximum deviation of ray is achieved at
a. $i=i_c$
b. $i=90^0$
c. $i=r$
d. None of these

16. When a small amount of a suitable impurity is added to the pure semiconductor, the conductivity of the semiconductor is increased manifold. Such materials are known as extrinsic semiconductors The deliberate addition of a desirable impurity is called doping and the impurity atoms are called dopants. Such a material is also called a doped semiconductor. There are two types of dopants used in doping the tetravalent Si or Ge:
(i) Pentavalent (valency 5); like Arsenic (As), Antimony (Sb), Phosphorous (P), etc
(ii) Trivalent (valency 3); like Indium (In), Boron (B), Aluminium (Al), etc



n-type



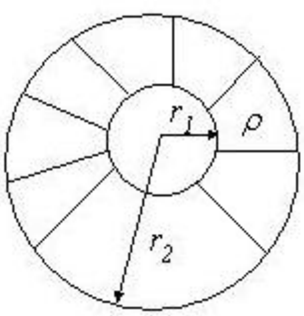
p-type

When phosphorus atom with five outer electron is substituted for a silicon atom an extra electron is made available for conduction. This addition increases conductivity and the semiconductor is called n-type semiconductor. On the other hand when aluminum atom having three valence electron is substituted for a silicon atom, a hole is created in the valence band and this type of semiconductor is called p-type semiconductor.

1. Let n_p and n_e be the number of wholes and conduction electron in an extrinsic semiconductor then
   a. $n_p > n_e$
   b. $n_p < n_e$
   c. $n_p = n_e$
   d. $n_p \neq n_e$
2. When an impurity is doped into an intrinsic semiconductor, the conductivity of semiconductor
   a. Increases
   b. Decreases
   c. Remains the same
   d. Becomes Zero.
3. The electrical conductivity of intrinsic semiconductor can be increased by
   a. Doping acceptor impurities
   b. Doping donor impurities
   c. Increasing the temperature
   d. All of these
4. The impurity atoms with which pure silicon may be doped to make it a p-type semiconductor are those of
   a. Boron
   b. Antimony
   c. Aluminum
   d. Both a and c
5. A semiconductor is doped with a donor impurity
   a. The hole concentration decreases
   b. The The hole concentration increases
   c. electron concentration decreases
   d. None of these

Section C

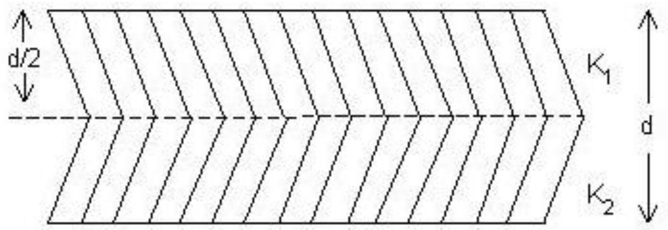
17. Two hollow spheres of radius r_1 and r_2 are given. The space between them is filled with material of resistivity (ρ) as shown. Calculate its resistance. (2)



18. The output of a 2-input NAND gate is fed to a NOT gate. Write the truth table for the output of combination for inputs of A and B. (2)

19. A tank is filled with water to a height of 12.5 cm. The apparent depth of a needle lying at the bottom of the beaker is measured by a microscope to be 9.4 cm. What is the refractive index of water? If water is replaced by a liquid of refractive index 1.63 up to the same height, then by what distance would the microscope have to be moved to focus on the needle again? (2)

20. Calculate the capacitance of the capacitor shown below. (2)



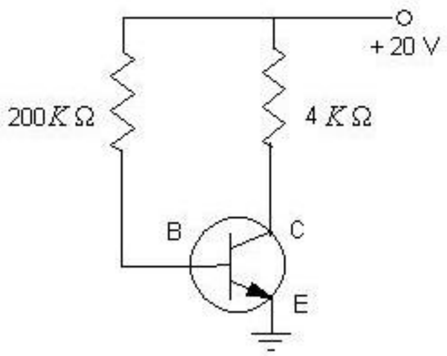
OR

A conducting slab of thickness‘t’ is introduced without touching between the plates of a parallel plate capacitor separated by a distance ‘d’ (t < d). Derive an expression for the capacitance of the capacitor. (2)

21. In the following circuit, the transistor used has a $\beta = 100$. Find V_{CE}, V_{BE}, and V_{BC} for $I_c = 2mA$. (2)

OR

Show how the following gates can be obtained by using NAND gates only (i) OR gate (ii) AND gate



22. An electron and a photon each have a wavelength of 1 nm. (2)
Find
i) Their momenta
ii) Kinetic energy of electron

23. A potential difference of V volts is applied to a conductor of length L and diameter D. How are the electric field and resistance of the conductor affected when in turn. (2)

i) V is halved

ii) L is doubled

OR

Derive an expression for the equivalent emf and the equivalent internal resistance of a series combination of n cells in an electric circuit.

24. A magnet is dropped down along a vertical copper tube. What will happen to its ultimate motion? A cylindrical bar magnet is kept along the axis of a circular coil. Will there be a current induced in the coil if the magnet is rotated about its axis? (2)

25. Explain the terms (i) pulse–amplitude modulation (PAM) and (ii) pulse–code modulation (PCM). Which modulation is preferred in transmitting signals and why? (2)

Section –D

All questions are compulsory. In case of internal choices, attempt any one.

26. For refraction through a glass prism, derive the prism formula:

$$n_{21} = \frac{\sin[(A + D_m)/2]}{\sin[A/2]}$$ (3)

27. It is often heard 'The domestic supply is at a voltage of 220 V'. What voltage value is this referring to? Express both peak and rms values.

What is the instantaneous and average power per cycle supplied to the capacitor? (3)

28. Briefly explain the principle of working of an AC generator. What is the maximum emf produced by it? (3)

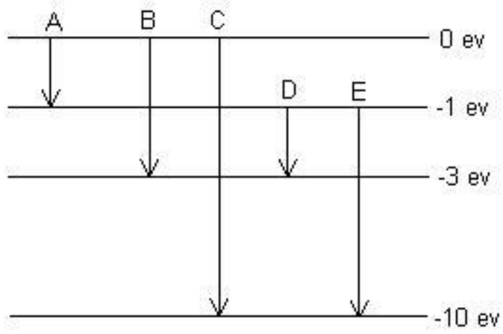
OR

When a transistor amplifier of current gain of 75 is given an input signal, V_i= 2 sin (157t + π /2), the output signal is found to be V_0= 200 sin (157t +3 π /2).In which mode is the transistor being used? Justify your result with proper explanation.

29. A 12.5 MeV α-particle approaching a gold nucleus is deflected by 180^0. How close does it approach the nucleus? (3)

OR

Energy levels of an atom of an element are shown in the following diagram. Which one of the level transitions will result in the emission of photons of wavelength 620 nm?



30. In the fusion reaction ${}_1H^2 + {}_1H^2$ --------->${}_2He^3 + {}_0n^1$, the masses of deuteron, helium and neutron expressed in amu are 2.015, 3.017 and 1.009, respectively. If 1 kg deuterium undergoes complete fusion, find the amount of total energy released. (3)

Section E

All questions are compulsory. In case of internal choices, attempt any one.

31.

(a) Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area 1.0 x 10^{-7} m^2 carrying a current of 1.5 A. Assume that each copper atom contributes roughly one conduction electron. The density of copper is $9.0 \times 10^3\ kg/m^3$, and its atomic mass is 63.5 u.

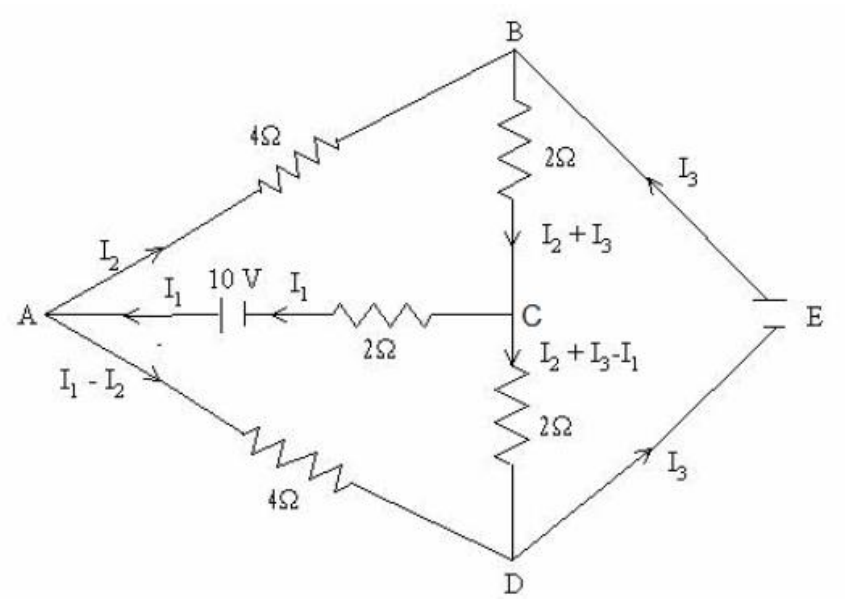
(b) Compare drift speed obtained above with

(i) Thermal speed of copper atoms at ordinary temperatures.

(ii) Speed of propagation of electric field along the conductor which causes the drift motion. (5)

OR

Determine the current in each branch of the network shown in the figure.



32.

(a) An electron and a proton moving with the same speed enter a uniform magnetic field B perpendicularly. Which particle will have larger radius of its circular path? Find the ratio of their radii. The masses of electron and proton are 9.1×10^{-31} kg and 1.67×10^{-27} kg.

(b) Show that for a moving charged particle in a uniform magnetic field, the kinetic energy of the particle remains constant.

(c) A coil placed in the plane of the page has a current in the clockwise direction when looking from above. What will be the change in the magnetic field at the centreof the coil if

(i) the current through the coil is reduced to half

(ii) the radius of the coil is doubled

OR

State Biot–Savart's law. Using Biot–Savart's law, derive an expression for the magnetic field at the centre of the circular coil for number of turns 'N', radius 'r' and carrying a current ' i'. A semicircular arc of radius 20 cm carries a current of 10 A. Calculate the magnitude of the magnetic field at the centre of the arc. (5)

33. Explain the phenomenon of total internal reflection. State two conditions that must be satisfied for total internal reflection to occur. Derive the relation between the critical angle and the refractive index of the medium. Draw a ray diagram to show how a right-angled isosceles prism can be used to (i) deviate a ray through 180° and (ii) to invert it. (5)

OR

Prove that $\frac{-\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$ when refraction occurs from a rarer to a denser medium at a convex refracting spherical surface.

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Class XII – Physics
Sample Paper 4–Solution

Section B

1. The proton A and the electron B will experience electrostatic force of equal magnitude but in the opposite direction.

2. The human eye is the most sensitive for 5.405×10^{14} Hz.

3. Since $\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Taking $R_1 = R,\ R_2 = -R,\ \frac{1}{f} = \frac{2(n-1)}{R}$ .... (1)

When the lens is cut, $R_1 = R, R_2 = \infty,\ \frac{1}{f'} = \frac{n-1}{R}$ .....(2)

From equations (1) and (2), we get

$f' = 2f = 60\text{cm}$

4. No, matter waves are not electromagnetic waves.

The de Broglie wave equation is $\lambda = \frac{h}{mv}$

OR

The negative energy of the electron orbiting around the nucleus keeps it bounded with the nucleus. If the energy of the electron becomes positive, then the electron will no longer be bounded with the nucleus.

5. Electric current is a vector or scalar quantity, because it does not follow the laws of vector addition, i.e. the angles between the wires carrying current does not affect the total current in the circuit.

OR

$R = 3 \times 10^{-6}\ \Omega$

We know,

$G = \frac{1}{R}$

$\therefore\ G = \frac{1}{3 \times 10^{-6}} = 0.33 \times 10^{5}$ S

6.

(i) water (H_2O)

(ii) oxygen (O_2)

OR

Here, $q_1 = q_2 = 100\mu C$, $r = 10cm$, $r_2 = 20cm$

Work done is

$$W = \frac{q_1 q_2}{4\pi\varepsilon_0}\left[\frac{r_2 - r_1}{r_1 r_2}\right]$$

$$= \left(100 \times 10^{-6}\right)^2 \times 9 \times 10^9 \left[\frac{10}{200}\right] \times \frac{1}{10^{-2}}$$

$$= 450\ J$$

7. de Broglie wavelength associated with a body of mass m moving with a velocity v is given by $\lambda = \frac{h}{mv}$ Since the mass of objects used in our daily lives is large, the de Broglie wavelength associated with these objects is small and is not visible. Hence, the wave nature of matter is not more apparent to our daily observations.

8. When light is put off, a large emf is produced to oppose the decay of current in the circuit. This large induced emf across the gap causes sparking in the switch.

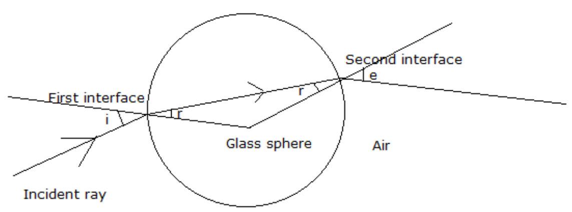
OR

An iron bar experiences a retarding force. It indicates the presence of eddy currents, which are produced whenever there is a change in magnetic flux. So, we conclude that the iron bar is a magnet.

9. A communication satellite is a satellite which can provide a communication link between two stations on the Earth which are separated by a large distance. A geostationary satellite having electronic equipment by which the signals may be received, amplified and transmitted back to the Earth can act as a communication satellite. The communication satellites of India are INSAT 2 B and INSAT 2 C.

10. A stationary charge produces only an electric field around it. When a charge moves with a constant velocity, it produces a constant magnetic field in addition to the electric field. As the charge is accelerated, both electric and magnetic fields change with time and space. One becomes the source of the other, thus giving electromagnetic waves.

11. C) From symmetry, the ray shall not suffer TIR at second interface, because the angle of incidence at first interface equals to angle of emergence at second interface. hence assertion is true but reason is false.



12. C) Assertion is true but Reason is false.
Layman Series: Its energy is in the ultraviolet region. Balmer series: Its energy in visible region. Now frequency of energy of ultraviolet photon is much greater than frequency of visible region.

$$\Delta E = \frac{hc}{\lambda}$$

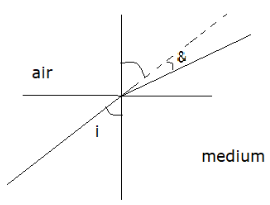
13. c) Assertion is true reason is false. As can be seen from the expression of f, it depends upon the refractive index of the medium in which the lens is submerged.

14. A) Both A and R are true and R is the correct explanation of A.
In case of the electric field of an electric dipole, the electric lines of force originate from positive charge and end at negative charge. Since isolated magnetic lines are closed continuous loops extending throughout the body of the magnet.

Section B

15.

1. **(c)**Maximum angle of refraction from denser medium to rarer medium is the critical angle Hence,
   $1.5 \sin C = 1 \times \sin 90^0$
   $\sin C = 2/3$
   $C = \sin^{-1} 2/3$
2. **(d)**Dispersion produced by thin prism. This phenomenon arise due to the fact that refractive index varies with wavelength. It has been observed for a prism that μ decreases with increase in the wavelength $\mu_{blue} > \mu_{red}$
3. **(d)** Both a and b. The necessary condition for the Phenomenon of Total Internal Reflection: Light must incident on the interface from denser medium. Angle of incidence must be greater than critical angle.
4. **(a)** $i = i_c$ The rays become parallel to the surface when angle of incidence is equal to the critical angle for that given pair of media.
5. **(a)** $i = i_c$ .The figure shows the deviation of light travelling from denser medium to rarer medium. As the angle of incidence increases the deviation δ would increase and it reaches it maxia at $i = i_c$.



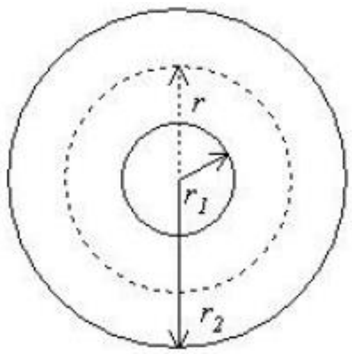
16.

1. **(d)**_In n-type semiconductor $n_p < n_e$ whereas in p-type semiconductor $n_p > n_e$. Hence for extrinsic semiconductor $n_p \neq n_e$
2. **(a)** Increases
3. **(d)** All of these
4. **(d)** Both a and c
5. **(a)** The hole concentration decreases

Section C

17. Resistance = $\rho \frac{\ell}{A}$

$$dR = \frac{\rho\, dr}{4\pi r^2}$$



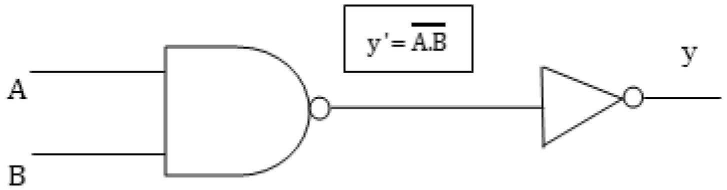
$$\therefore \text{ Total resistance } = \int_{r_1}^{r_2} \frac{\rho\, dr}{4\pi r^2} = \frac{\rho}{4\pi}\left[-\frac{1}{r}\right]_{r_1}^{r_2}$$

$$R = \frac{\rho}{4\pi}\left[\frac{1}{r_1} - \frac{1}{r_2}\right]$$

18. If the output y' of a two-input NAND gate is used as input of the NOT gate:
Here, the Boolean expression for output y is

$$y = \overline{A.B}$$

$$y = \overline{\overline{A.B}} = A.B$$



A	B	y'	y
0	0	1	0
1	0	1	0
0	1	1	0
1	1	0	1

19.

(i) Actual depth t =12.5 cm

Apparent depth a = 9.4 cm

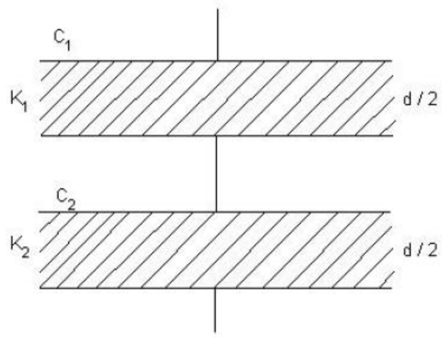
$${}_a\mu_w = \frac{t}{a} = \frac{12.5}{9.4} = 1.33$$

(ii) ${}_a\mu_l = 1.63$

$$a^l = \frac{t}{{}_a\mu_l} = \frac{12.5}{1.63} = 7.7\,cm$$

Therefore, the microscope has to be moved by $(9.4 - 7.7)\,cm$, i.e. 1.7 cm

20. The capacitor can be considered split into two capacitors in series as shown below



Here, $c_1 = \frac{2K_1\varepsilon_o A}{d}$ and $c_2 = \frac{2k_2\varepsilon_0 A}{d}$

The capacitance of capacitors in series is

$$\frac{1}{c} = \frac{1}{c_1} + \frac{1}{c_2}$$

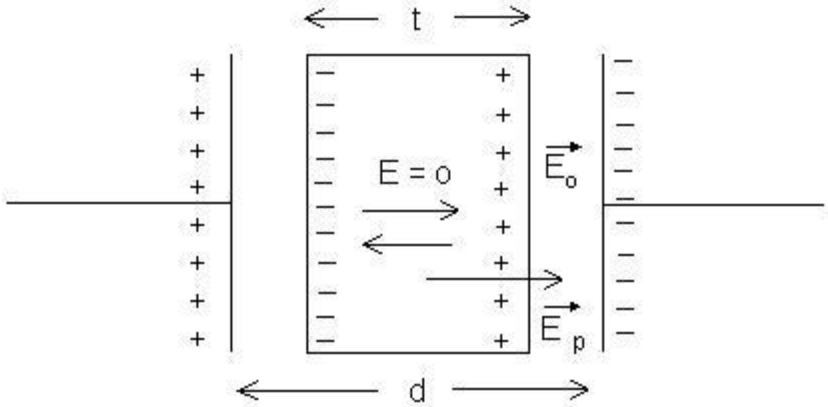
$$\Rightarrow \qquad c = \frac{c_1 c_2}{c_1 + c_2}$$

$$c = \frac{2\varepsilon_o A}{d}\left(\frac{k_1 k_2}{k_1 + k_2}\right)$$

OR

Let σ be the surface charge density of capacitor plates of area A. The electric field between the plates in the air space is

$$E_o = \frac{\sigma}{\varepsilon_o}$$



As in the case of a conducting slab $E_p = E_o$,the net electric field inside the conducting slab is zero.

Now potential difference between the plates of capacitor is

$$V = E_o(d - t) = \frac{\sigma}{\varepsilon_o}(d - t)$$

$$Q = \sigma A$$

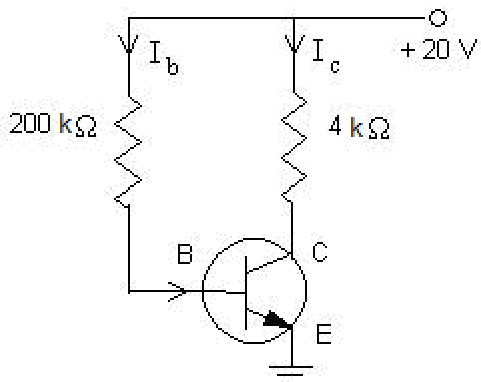
$$C = \frac{Q}{V} = \frac{\varepsilon_o A}{d - t} = \frac{C_o}{1 - t/d}$$

where $C_o = \frac{E_o A}{d}$

21. Since $\beta = 100$

$I_c = 2 \times 10^{-3}$ A

$V_{CE} = ?; V_{BE} = ?; V_{BC} = ?$



$$V_{CE} = V'_{BE} - I_C \times 4 \times 10^3$$

$$= 20 - 2 \times 10^{-3} \times 4 \times 10^{+3} = 20 - 8$$

$$V_{CE} = 12 \text{ volt}$$

$$\beta = \frac{I_c}{I_b}$$

$$I_b = \frac{I_c}{\beta} = 2 \times 10^{-5} \text{ A}$$

$$V_{BE} = V_{EE} - I_b \times 2 \times 10^{-5} \text{ A}$$

$$V_{BE} = 20 - 4 = 16 \text{ volt}$$

and

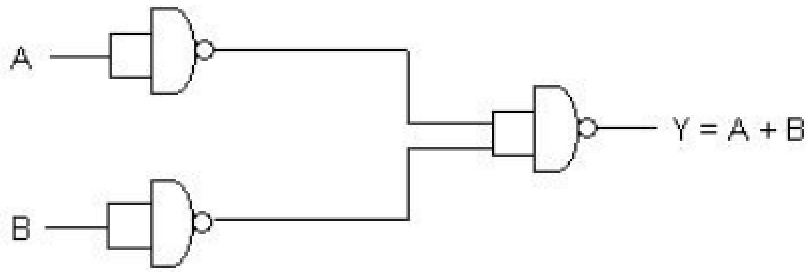
$$V_{BC} = V_{BE} - V_{CE}$$

$$= 16 - 12$$

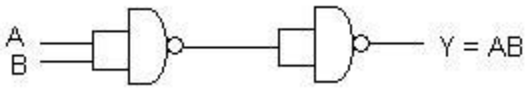
$$V_{BC} = 4 \text{ volt}$$

OR

(i) Realisation of the OR gate using the NAND gate



(ii) Realisation of the AND gate using the NAND gate



22.

Since $\lambda = \frac{h}{p}$

(i) Momentum, $p = \frac{h}{\lambda} = \frac{6.63 \times 10^{-34}}{10^{-9}}$

$$p = 6.63 \times 10^{-25} \text{ kg m/s}$$

The momentum of electron and photon will be the same.

(ii) Kinetic energy of the electron $= \frac{h^2}{2\lambda^2 me}$

$$= \frac{(6.63 \times 10^{-34})^2}{2 \times (10^{-9})^2 \times 9.11 \times 10^{-31} \times 1.6 \times 10^{-19}}$$

$$= 1.51 \text{ eV}$$

23. Effect on electric field:

(i) $E = \frac{V}{L}$

When V is halved,

$$E' = \frac{V}{2L} = \frac{E}{2}$$

Electric field gets halved.

(ii) When L is doubled,

$$E' = \frac{V}{2L} = \frac{E}{2}$$

Electric field gets halved.

Effect on resistance:

When potential is halved, the current also reduces in the same proportion. Thus, resistance does not change.

i.e. $\frac{V}{I} = R = \text{constant}$

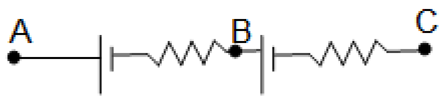
(i) $R = \frac{\rho l}{A}$

(ii) As length is doubled, resistance also doubles.

OR

Consider first two cells in series, where one terminal of the two cells is joined leaving the other terminal in either cell free.

Let *V* (A), *V* (B), *V* (C) be the potentials at points A, B and C as shown below.



Then *V* (A) – *V* (B) is the potential difference between the positive and negative terminals of the first cell.

We know that

$V(A) - V(B) = E_1 - Ir_1$, where E_1 is the emf of the 1st cell.

Similarly,

$V(B) - V(C) = E_2 - Ir_2$, where E_2 is the emf of the 2nd cell.

Hence, the potential difference between the terminals A and C of the combination is

$$V_{AC} = [V(A) - V(B)] + [V(B) - V(C)]$$

$$= E_1 + E_2 - I(r_1 + r_2)$$

If we wish to replace the combination by a single cell between A and C of emfE_{eq} and internal resistance r_{eq}, then we would have

$V_{AC} = E_{eq} - I\, r_{eq}$

Comparing the last two equations, we get
$E_{eq} = E_1 + E_2$
and $r_{eq} = r_1 + r_2$

The rule for a series combination can be clearly extended to n number of cells:
(i) Equivalentemf of a series combination of n cells is just the sum of their individual emfs, and
(ii) Equivalent internal resistance of a series combination of n cells is just the sum of their internal resistances.

24. As the magnet falls with greater and greater velocity, stronger and stronger current is induced in the copper tube which opposes the motion of the magnet.
When the opposing force due to the induced current equals the weight of the magnet, it acquires a constant terminal velocity.
No, because flux Φ which is equal to NBA is constant.

25. **Pulse–amplitude modulation (PAM)**
Here, the carrier wave is in the form of pulses and the information signal is a continuous wave.
(i) Amplitude of the pulse varies in accordance with the modulating signal. It could be single polarity or double polarity PAM.
(ii) **Pulse–code modulation (PCM)**

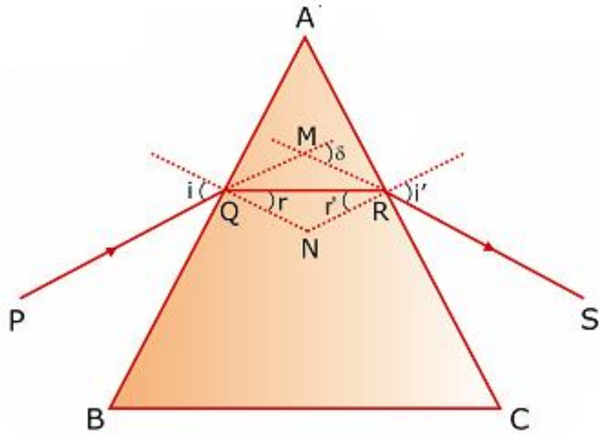
It is the modulation technique employed in digital communication. In PCM, the carrier wave is a continuous wave and the information signal is in the form of a coded pulse.

Common modulating techniques are
i) Amplitude shift keying (ASK)
ii) Frequency shift keying (FSK)
iii) Phase shift keying (PSK)

Since PCM is more error and noise free than PAM for communication, it is preferred.

Section D

26. Consider light passing through a prism ABC as shown.



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

In the quadrilateral AQNR,

$\angle A + \angle QNR = \angle 180^0$

From the triangle QNR,

$r + r' + \angle QNR = 180^0$

Comparing, we get

$r + r' = A$

The total deviation is the sum of deviations at the two faces:

$\delta = (i - r) + (i' - r')$

$\Rightarrow \delta = i + i' - A$

At the minimum deviation $\delta = D_m, i = i'$ which implies that r = r'.

We get from $r + r' = A$

$2r = A$

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

Similarly, the equation $\delta = i + i' - A$ gives

$D_m = 2i - A$

$\Rightarrow i = \frac{A + D_m}{2}$

The refractive index of the prism with respect to the medium outside is

$$n_{21} = \frac{n_2}{n_1} = \frac{\sin\left[(A + D_m)/2\right]}{\sin\left[A/2\right]}$$

This is the prism formula.

27. It is referring to the rms value. V_{rms}= 220 V.

So, the peak value for voltage is $V_0 = \sqrt{2}V_{rms} = 311$ V.

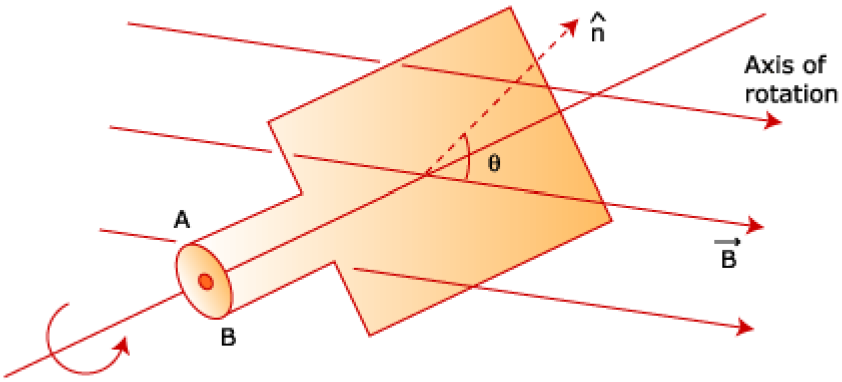
The instantaneous power is always $P(t)=V(t)I(t)$, and in this case, it is

$$P(t)=\frac{V_0^2}{X_c}\cos(\omega t+\phi)\cos(\omega t+\phi+\pi/2)$$

Thus, the average power is

$$\overline{P_c} = \frac{V_0^2}{2X_c}\cos\left(\frac{\pi}{2}\right) = 0$$

28. A wire loop of area A is free to rotate about an axis which is perpendicular to a uniform magnetic field B.



If the normal to the loop n makes an angle θ with B, then flux through the loop is

$\Phi = BA\cos\theta$.

If this loop rotates with a constant angular velocity $\omega = \frac{d\theta}{dt}$, the flux through it changes at the rate

$$\frac{d\Phi}{dt} = -BA\sin\theta\frac{d\theta}{dt} = -BA\omega\sin(\omega t + C_0)$$

where C_0 is a constant

∴ emf is induced between ends A and B given by

$\varepsilon = BA\omega\sin(\omega t + Co)$

$\varepsilon = V_m\sin(\omega t + Co)$

$V_m = BA\omega$ = Peak value of emf generated.

OR

Here, the current gain is 75, i.e. >1.

Besides, there is a phase difference of π between the signal at the input and the output.

Both these factors indicate that the amplifier is connected in the common emitter mode.

29. For a α particle, Z_1=2 and Z_2=79 for gold.

Also given that kinetic energy of α particle is K = 12.5 MeV =$12.5\times1.6\times10^{-13}$ J.

The distance of the closest approach is given by

$$r_0 = \frac{1}{4\Pi \in_0}\frac{Z_1 Z_2 e^2}{K}$$

$$r_0 = \frac{9\times10^9 \times 2\times 79\times\left(1.6\times10^{-19}\right)^2}{12.5\times1.6\times10^{-13}}$$

$$= 1.8\times10^{-14}\ \text{m}$$

OR

Energy of a photon of wavelength λ is $E = \frac{hc}{\lambda}$

For $\lambda = 620\text{nm}$

$$E = \frac{6.62\times10^{-34}\times3\times10^8}{620\times10^{-9}\times1.6\times10^{-19}} = 2.0\text{eV}$$

Thus, transition D for which E is 2.0 eV will take place.

30. 1 amu = 931.5 MeV

$\Delta m = 2(2.015) - (3.017 + 1.009) = 0.004$ amu

Hence, energy released per deuteron = (0.004 x 931.5)/2 = 1.863 MeV

The number of deuterons in 1kg =$N_A/2$ =$6.023 \times 10^{26}/2$

Energy released = $(3.01 \times 10^{26})(1.863 \times 10^6)(1.6\times10^{-19})$ J = 9.0×10^{13} J

Section E

31. (a) We know that $I = V_d neA$

$$V_d = \frac{I}{enA} \qquad (1)$$

Given that $I = 1.5\ A,\ A = 1.0\times10^{-7}\ m^2$

$e = 1.6\times10^{-19} C$

Density of copper $= 9.0\times10^3 kg/m^3$

Atomic mass of copper = 63.59u

Therefore, the number of atoms or number of free electrons per unit volume of copper is

$$(n) = \frac{6.0\times10^{23}}{63.59}\times9.0\times10^6$$

$$n = 8.5\times10^{28}\ m^{-3}$$

Thus, from equation (1), we get

$$\text{drift velocity } V_d = \frac{1.5}{8.5 \times 10^{28} \times 1.6 \times 10^{-19} \times 1.0 \times 10^{-7}}$$

$$V_d = 1.1 \times 10^{-3} \text{ m/s} = 1.1 \text{m s}^{-1}$$

(b)

(i) Thermal speed of copper atoms at temperature T is obtained from the formula

$$\frac{1}{2}MV^2 = \frac{3}{2}K_BT \Rightarrow V = \sqrt{\frac{3K_BT}{M}}$$

at $T = 300k$,

$V = 2 \times 10^2 \text{ m/s}$

Thus, drift speed of electrons is much smaller; about 10^{-5} times the typical thermal speed at ordinary temperatures.

(ii) Electric field travels along a conductor with a speed of electromagnetic wave $(3.0 \times 10^8 \text{ m/s})$. Drift speed in comparison is 10^{-11} times the speed of electric field.

OR

We take a closed loop ADCA and apply Kirchhoff's second rule

$-4(I,-I_2) + 2(I_2 + I_3 - I_1) - I_1 + 10 = 0$

$7I_1 - 6I_2 - 2I_3 = 10$ (1)

For the closed loop ABCA, we get

$-4I_2 - 2(I_2 + I_3) - I_1 + 10 = 0$

$I_1 - 6I_2 - 2I_3 = 10$ (2)

For the closed loop BCDEB, we get

$-2(I_2, +I_3) - 2(I_2 + I_3 - I_1) + 5 = 0$

$2I_1 - 4I_2 - 4I_3 = -5$ (3)

On solving equations (1), (2) and (3), we get

$I_1 = 2.5A$

$I_2 = 0.63A$

$I_3 = 1.88A$

Thus, the currents in various branches of the network are

$AB = I_2 = 0.63A$

$AD = I_1 - I_2 = 1.87A$

$CA = I_1 = 2.5A$

$CD = I_2 + I_3 - I_1 = 0.01A$

$DEB = I_3 = 1.88\ A$

$BC = I_2 + I_3 = 2.51A$

32.

(a) Radius of the circular path in a magnetic field

$$r = \frac{mv}{qB}$$

Since $m_p > m_e$

Therefore, the radius of the proton's circle will be larger.

$$\frac{r_p}{r_e} = \frac{m_p}{m_e} = \frac{1.67 x 10^{-37}}{9.1 x 10^{-31}} = 1835$$

(b) Lorentz force on moving a charged particle in the magnetic field is always perpendicular to the velocity of the particle.

The work done by the magnetic force

$$dW = \vec{F}.d\vec{\ell}$$

$$dW = Fd\ell \cos\theta$$

$$\text{but } \theta = 90^{\circ}$$

$$dW = 0$$

Thus, on moving the charged particle in a uniform magnetic field, no work is performed. Hence, the kinetic energy of the charged particle will remain constant.

(c)

(i) the field is reduced to half

(ii) the field will be halved

(iii) the field will be perpendicular to the plane of the page, pointing downwards

OR

Bio–Savart's Law: The magnetic field induction at a point P due to a current element is

$$dB = \frac{\mu_o}{4\pi} \frac{Idl \sin\theta}{r^2}$$

Magnetic field at the centre of a circular coil carrying current:

According to Biot–Savart's law, magnetic field at the centre of the coil carrying I due to current element Idl is

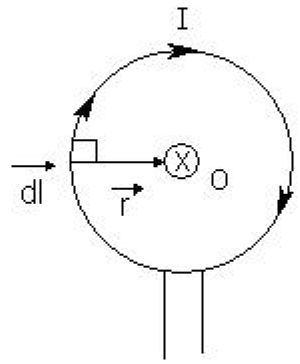
$$dB = \frac{\mu_o}{4\pi} \frac{Idl}{r^2} \qquad (\because \theta = 90^{\circ})$$

Magnetic field due to the whole loop is

$$B = \int dB = \frac{\mu_o}{4\pi} \frac{I}{r^2} \int dl$$

$$B = \frac{\mu_o}{4\pi} \frac{I}{r^2} \times 2\pi r$$

$$B = \frac{\mu_o I}{2r}$$



When there are N turns, we have

$$B = \frac{\mu_o N I}{2r}$$

Magnetic field at the centre of the semicircular arc of radius ‘r’ carrying current I is

$$B = \frac{\mu_o I}{4r}$$

Given $r = 20cm = 0.2m$

$I = 10A$

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

$$B = \frac{4\pi \times 10^{-7} \times 10}{4 \times 0.2}$$

$B = 1.57 \times 10^{-5}$ tesla.

It is perpendicular to the plane of the paper directed inwards.

33. Total Internal Reflection:

Total internal reflection is the phenomenon of the reflection of light rays back to the denser medium when they are incident on the boundary of a denser and rarer medium at an angle of incidence greater than the critical angle.

Conditions for total internal reflection:

(a) Light rays should go from the denser medium to the rarer medium.

(b) The angle of incidence should be greater than the critical angle i_c where $\sin i_c = \frac{1}{\mu}$

Then the rays are totally internally reflected.

for angle $i = i_c$

$r = 90^0$

$${}_2\mu_1 = \frac{\sin i}{\sin r} = \frac{\sin i_c}{\sin 90^0}$$

$$\Rightarrow \quad {}_1\mu_2 = \frac{1}{\sin i_c}$$

(i) To deviate ray through $180°$. fig (a)

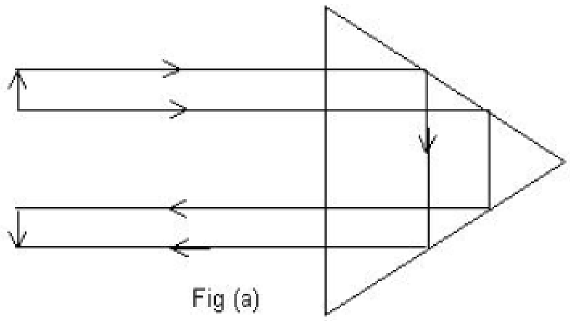


Fig (a)

(ii) To invert object fig (b),

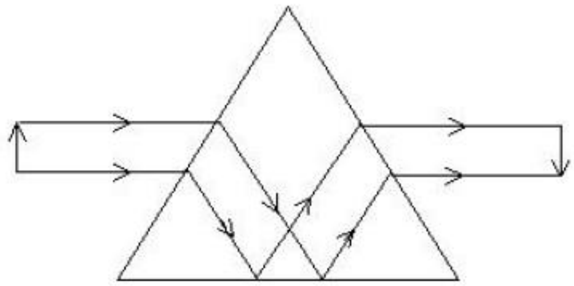


Fig (b)

OR

Let μ_1 be the refracting index of the rarer medium and μ_2 be the refracting index of the spherical convex refracting surface XY of the small aperture.

From A, draw AM such that $AM \perp OI$

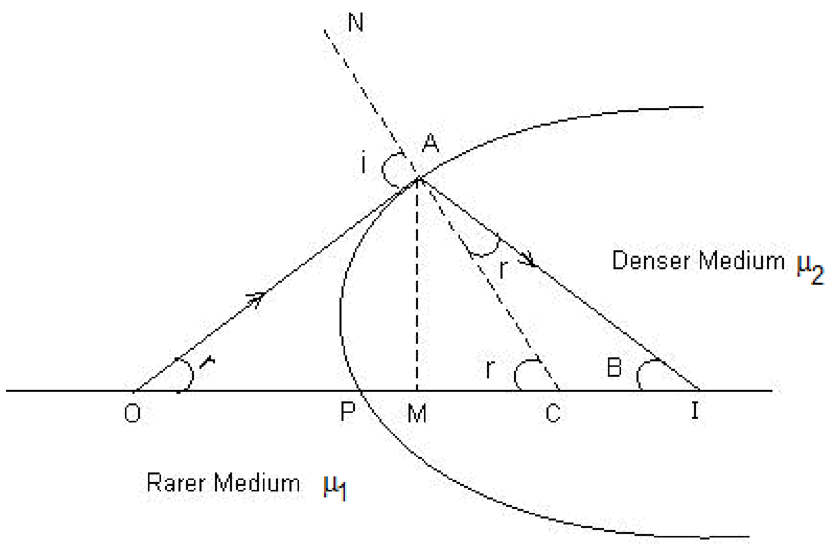
In ΔIAC

$$r + B = \gamma \text{ (Exterior angle property)}$$

$r = \gamma - \beta$

Similarly, in $\Delta\ OAC$

$i = \alpha + \gamma$



According to Snell's law

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

So, $\mu_1(\alpha+\gamma)=\mu_2(\gamma-\beta)$ (i)

Let $\alpha \approx \tan\alpha = \frac{AM}{OM}=\frac{AM}{PO}$

$$\beta = \tan\beta = \frac{AM}{MI}=\frac{AM}{PC}$$

As the spherical surface has a small aperture, we have

$$y = \tan\beta = \frac{AM}{MC}=\frac{AM}{PC}$$

Substituting the value in eq. (i), we have

$$\frac{\mu_1}{PO}+\frac{\mu_2}{PI}=\frac{\mu_2-\mu_1}{PC}$$

By sign convention, put $PO=-u,\ PI=+v,\ PC=+R$

We get

$$\frac{\mu_1}{-u}+\frac{\mu_2}{v}=\frac{\mu_2-\mu_1}{R}$$

which is the required relation.