CBSE
Class XII Physics
Sample Paper - 5

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

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

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

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

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

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

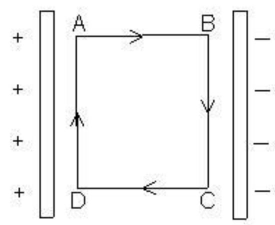
mass of proton $= 1.673 \times 10^{-27}$ kg

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

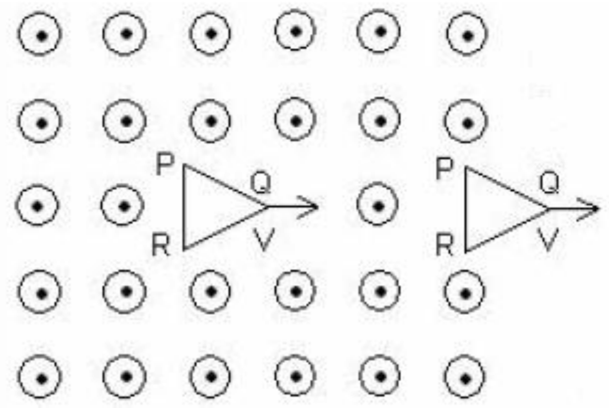
Boltzmann constant $= 1.38 \times 10^{-23}$ JK^{-1}

Section A

1. A uniform electric field $\vec{E}$ exists between two charged plates as shown in the figure. What would be the work done in moving a charge q along the closed rectangular path ABCDA? (1)



2. The figure given below shows two positions of a loop PQR in a perpendicular uniform magnetic field. In which position of the coil is there an induced emf? (1)



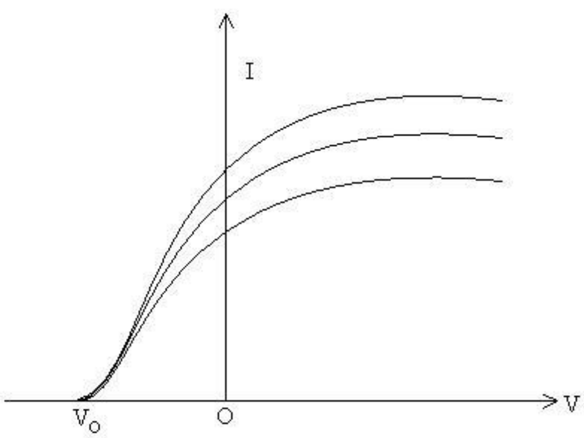
3. Why are microwaves used in RADAR? (1)

OR

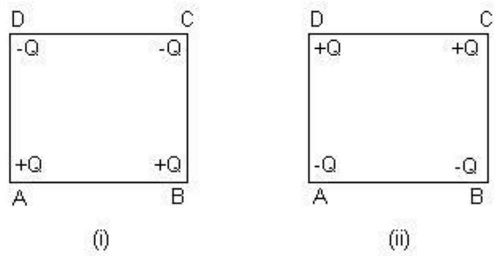
Arrange these in the decreasing order of frequency: microwaves, infra red waves, x-rays, visible rays (1)

4. The image of a candle is formed by a convex lens on a screen. The lower half of the lens is painted black to make it completely opaque. Draw the ray diagram to show the image formation. How will this image be different from the one obtained when the lens is not painted black? (1)

5. In an experiment on the photoelectric effect, the following graphs were obtained between the photoelectric current (I) and the anode potential (V). Name the characteristic of the incident radiation which was kept constant in this experiment. (1)

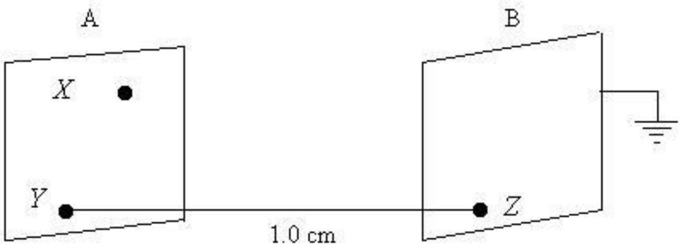


6. Four point charges are placed at four corners of a square in the two ways (i) and (ii) shown below. Will the electric field at the centre of the square be the same or different in the two configurations and why? (1)



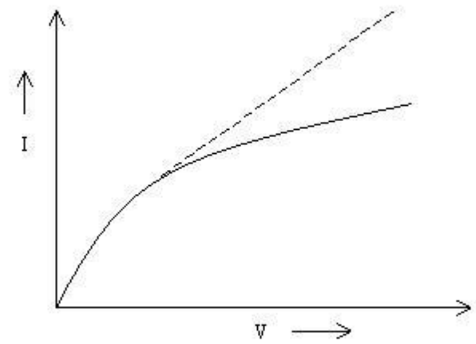
OR

Two identical metallic surfaces A and B are kept parallel to each other in air, separated by a distance of 1.0 cm as shown in the figure.

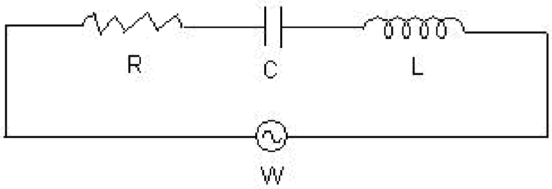


Surface A is given a positive potential of 10 V and the other surface B is earthed. What is the magnitude and direction of the uniform electric field between points y and z? (1)

7. The I–V characteristics of a resistor are observed to deviate from the straight line for higher values of current as shown below. Why is this so? (2)

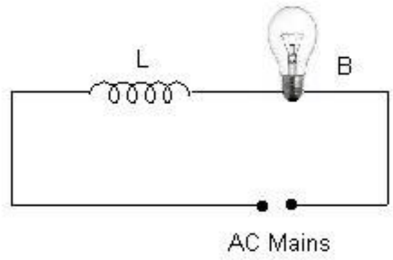


8. In the circuit shown below, R represents a resistance. If the frequency ν of the supply is doubled, how should the value of C and L be changed so that the glow in the bulb remains unchanged?



OR

A coil L with air as the core and a bulb B are connected in series to the AC mains as shown in the given figure.



The bulb glows with some brightness. How would the glow of the bulb change if an iron rod was inserted in the coil? Give reason in support of your answer. (1)

9. Experimental observations have shown that X-rays

(i) travel in vacuum with a speed of 3×10^8 m / s.

(ii) exhibit the phenomenon of diffraction.

What conclusions can be drawn about the nature of X-rays from each of these observations? (1)

10. Why is a semiconductor damaged by a strong current?

OR

What happens to the width of depletion layer of a p-n junction when it is

(i) forward biased?

(ii) reverse biased? (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 : Electric field at a point superimpose to give one resultant electric field.
Reason : Electric lines of force cross each other.

12. Assertion : If the distance between parallel plates of a capacitor is halved and dielectric constant is made three times, then the capacitor becomes 6 times.
Reason : Capacity of the capacitor does not depend upon the nature of the material.

13. A convex mirror cannot form real images.
Reason (R):

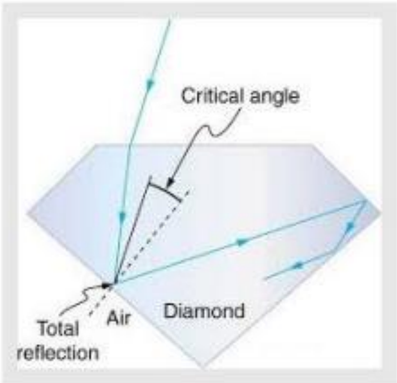
Convex mirror converges the parallel rays that are incident on it.

14. Assertion : In Young's double slit experiment, interference pattern disappears when one of the slits is closed.
Reason : Interference occurs due to superposition of light waves from two coherent sources

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. Sparking Brilliance of Diamond

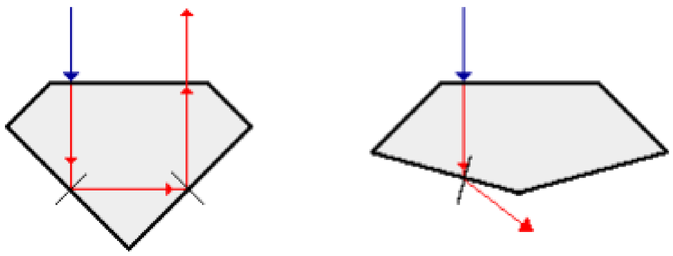


The total internal reflection of the light is used in polishing diamonds to create a sparking brilliance. By polishing the diamond with specific cuts, it is adjusted the most of the light rays approaching the surface are incident with an angle of incidence more than critical angle. Hence, they suffer multiple reflections and ultimately come out of diamond from the top. This gives the diamond a sparking brilliance.

1. Light cannot easily escape a diamond without multiple internal reflections. This is because:
   a) Its critical angle with reference to air is too large
   b) Its critical angle with reference to air is too small
   c) The diamond is transparent
   d) Rays always enter at angle greater than critical angle
2. The phenomenon of Total Internal reflection occurs when
   a) Light travels from rarer to denser medium
   b) Light travels from denser to rarer medium
   c) it does not depends on medium
   d) None of these
3. The basic reason for the extraordinary sparkle of suitably cut diamond is that
   a) It has low refractive index
   b) It has high transparency

c) It has high refractive index
d) It is very hard

4. A diamond is immersed in a liquid with a refractive index greater than water. Then the critical angle for total internal reflection will
   a) will depend on the nature of the liquid
   b) decrease
   c) remains the same
   d) increase
5. The following diagram shows same diamond cut in two different shapes.



   The brilliance of diamond in the second diamond will be:
   a) less than the first
   b) greater than first
   c) same as first
   d) will depend on the intensity of light

16. Faraday Cage:

A Faraday cage or Faraday shield is an enclosure made of a conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage.

1. Which of the following material can be used to make a Faraday Cage?
   a) Plastic
   b) Glass
   c) Copper

d) Wood

2. Example of a real-world Faraday cage is
   a) car
   b) plastic box
   c) lightning rod
   d) metal rod
3. What is the electrical force inside a Faraday cage when it is struck by lightning?
   a) The same as the lightning
   b) Half that of the lightning
   c) Zero
   d) A quarter of the lightning
4. An isolated point charge +q is placed inside the Faraday cage. Its surface must have charge equal to
   a) Zero
   b) +q
   c) −q
   d) +2q
5. As the electric field inside the faraday cage is zero, what would be the electric potential inside the cage
   a) zero
   b) Constant
   c) Increases as we move from center towards the surface of the cage
   d) decreases as we move from center towards the surface of the cage

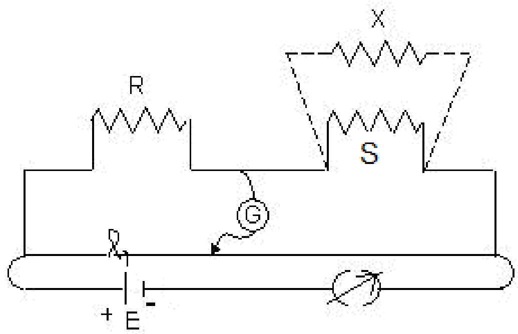
Section C

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

17. A message signal of frequency 10 kHz is used to modulate a carrier of frequency 1 MHz. Find the side bands produced. (2)

18. Write the relation between the angle of incidence (i), the angle of emergence (e), the angle of prism (A) and the angle of deviation (δ) for rays undergoing refraction through a prism. What is the relation between refractive index of the material of a prism in terms of A and δ. (2)

19. When two known resistances, R and S , are connected in the left and right gaps of a meter bridge, the balance point is found at a distance 'l' from the zero end of the meter bridge wire. An unknown resistance X is connected in parallel to the resistances, and the balance point is now found at a distance l_2 from the zero end of the meter bridge wire. Obtain a formula of X in terms of l_1, l_2 and S.



(2)

OR

Derive the balance condition for a Wheatstone's meter bridge.

20. A concave lens has the same radius of curvature r for both sides and has a refractive index 1.5 in air. It is immersed in a liquid of refractive index 1.4. Calculate the ratio of the focal length of the lens. (2)

21. Why is diffraction of sound waves more easily observed than diffraction of light waves? Light of wavelength 600 nm is incident normally on a single slit of width 0.5 mm. Calculate the separation between two dark bands on the sides of the central maximum. The diffraction pattern is observed on a screen placed at 2 m from the slit. (2)

22. Obtain Einstein's photoelectric equation. Explain how it enables us to understand the Linear dependence of the maximum kinetic energy of the emitted electrons on the frequency of the incident radiation (2)

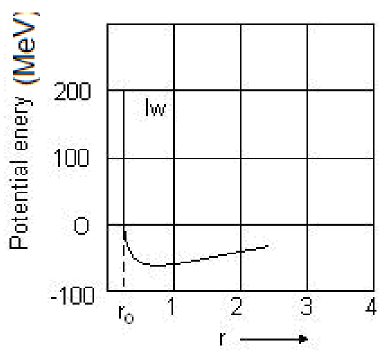
OR

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

23. What is mutual induction? On which two factors do mutual inductance of two coils depend?

24.

(a) The potential energy (v)for a pair of nucleons varies with the separation (r) between them in the manner shown below.



Use this graph to explain why the force between the nucleon must be regarded as

(i) Strongly repulsive for separation values less than r_o

(ii) Attractive nuclear force $(r > r_o)$

(b) Write the two characteristic features of nuclear force. (2)

25. State the principle of working of p–n diode as a rectifier. Explain with the help of a circuit diagram the use of the p–n diode as a full-wave rectifier. Draw a sketch of the input output waveforms. (2)

OR

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

Section D

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

26. In an AM demodulator, the output circuit consists of $R = 1k\Omega$ and $C = 10pF$. A carrier signal of 100 kHz is to be demodulated. Is the given setup good for this purpose? If not, then suggest a value of C which would make the diode circuit good for demodulating this carrier signal. (3)

27. Two large metal plates each of area 1 m^2 are placed facing each other at a distance of 5 cm and carry equal and opposite charges on their faces. If the electric field between the plates is 1000 NC^{-1}, then find the charge on each plate. (3)

OR

Define electron volt. Express it in joule.

28. A magnet 2 cm long has pole strength of 60 Am. Find the magnitude of magnetic field B at a point on its axis at a distance of 20 cm from it. What would be the value of B if the point was to lie at the same distance on the equatorial line of the magnet? (3)

29. What emf will be induced in a 10 H inductor in which current changes from 10 A to 7 A in 9×10^{-2} s?

OR

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

30. i. Give one point of difference between nuclear fission and nuclear fusion.

ii. Suppose we consider fission of a Fe_{26}^{56} into two equal fragments of Al_{13}^{28} nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process. Given mass of Fe_{26}^{56} = 55.93494 u and Al_{13}^{28} = 27.98191u.

Section E

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

31. An electric dipole is held in a uniform electric field.

(i) Show that no translatory force acts on it.

(ii) Derive an expression for the torque acting on it.

(iii) The dipole is aligned parallel to the field. Calculate the work done in rotating it through $180°$. (5)

OR

(a) Two extremely small charged copper spheres have their centres separated by a distance of 50 cm in vacuum. What is the mutual force of electrostatic repulsion if the charge on each is 6.5×10^{-7} C ?

(b) What will be the force of repulsion if the

(i) charge on each sphere is doubled and their separation is halved

(ii) two spheres are placed in water (5)

32.

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

(b) Two parallel coaxial circular coils of equal radius R and equal number of turns N carry equal currents 'I' in the same direction and are separated by a distance 2R. Find the magnitude and direction of the net magnetic field produced at the midpoint of the line joining their centres. (5)

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

CBSE
Class XII – Physics
Sample Paper – 5 Solution

Section A

1. The net work done in moving a charge q along the closed rectangular path ABCDA is zero.

2. There will be an induced emf in the second position when the loop is exiting the field.

3. Microwaves possess greater energy and least angular speed, so they are used in RADAR.

OR

X-rays, infra red waves, visible rays, microwaves

4.

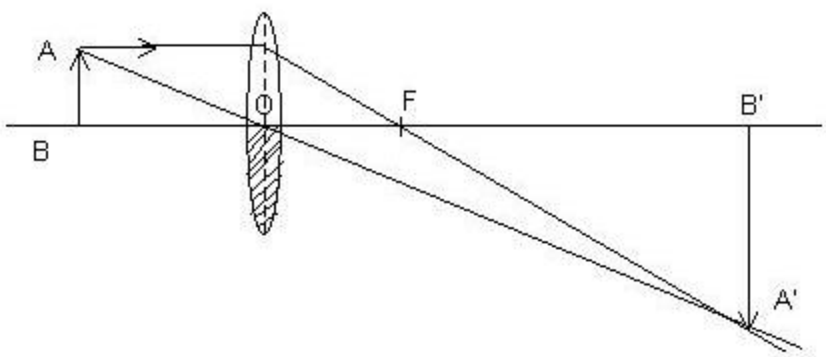


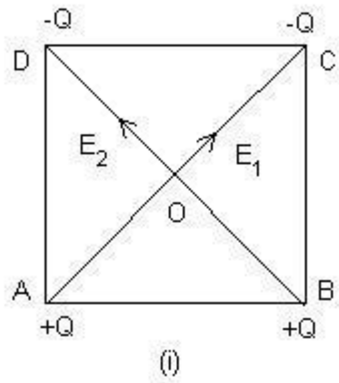
Image will be less bright.

5. Frequency of the incident radiation was kept constant.

6. The length of the edge of the cube is a , so

$$OA = OB = OC = OD = \frac{a}{\sqrt{2}}$$

and $E_1 = E_2 = E$ and $\angle AOB = 90^\circ$



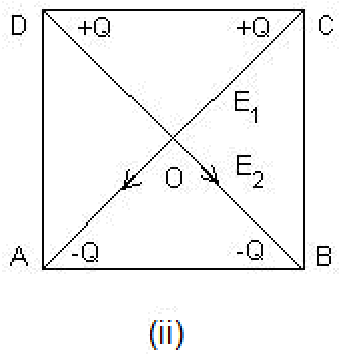
(i)

The net electric field at O in the figure (i) is

$E_o = \sqrt{E_1^2 + E_2^2} = E\sqrt{2}$ (i)

E_o is directed at 45° from OD.

In figure (ii), the magnitude of $\vec{E}$ remains the same but the direction changes.



(ii)

OR

$V = 10$ volts x = 1 cm = 0.01 m

$$E = \frac{V}{x} = \frac{10}{0.01} = 10^3 \text{ volt / metre}$$

Direction of $\vec{E}$ is from surface A towards surface B.

7. At higher values of voltage, the resistor shows non-ohmic character, so the resistor does not obey Ohm's law. This is the reason for the deviation of the I–V graph from the straight line.

8. For the same glow of a bulb, the current in the resistance R (i.e. bulb) should remain the same, i.e. the value of impedance

$Z = \sqrt{R^2 + (X_L - X_C)^2}$ will remain the same, i.e. the value of $(X_L - X_C)$ should remain the same.

We have

$X_L = 2\pi \nu L$

So, on doubling the value of ν, L should be halved for the same value of X_L.

Also, we have

$$X_C = \frac{1}{2\pi \nu C}$$

So, on doubling the value of ν , C should be halved for the same value of X_C .

OR

On inserting the magnetic core (rod) inside the solenoid, the value of $L\left(=\frac{\mu_o \mu_r N^2 A}{l}\right)$ will increase, and hence, the induced emf also increases which opposes the flow of current inthe circuit. Thus, the bulb will glow with less brightness.

9. As X-rays travel with the speed of light in vacuum, it shows that these are electromagnetic waves.
Phenomenon of diffraction supports the wave-like characteristics of X-rays.

10. When a strong current is passed through a semiconductor, it heats up. Thus, a large number of covalent bonds break up in a semiconductor, resulting in a large number of charge carriers. As a result, the material starts behaving as a conductor. At this stage, the semiconductor loses the property of low conduction; hence, it is damaged.

OR

(i) Width of depletion layer's decreases in forward bias
(ii) Width depletion layer increases in reverse bias.

11. (c) Assertion is true Reason is false
If electric lines of forces cross each other, then the electric field at the point of intersection will have two direction simultaneously which is not possible physically

12. B)
C is given by

$$C_1 = \frac{K\varepsilon_0 A}{d} \propto \frac{k}{d}$$

$$\frac{C_1}{C_2} \propto \frac{k_1}{d_1} \times \frac{d_2}{k_2}$$

As pr the question

$$\frac{C_1}{C_2} \propto \frac{k_1}{d_1} \times \frac{d_1/2}{3k_1}$$

$$C_2 = 6C_1$$

13. (c) Assertion is true but Reason is flase.

14. (a) Both A and R are true and R is the correct explanation of A
When one of the slits is closed, there appears general illumination from a single source. Interference does not take place.

15. 1. b) Its critical angle with reference to air is too small
2. b) Light travels from denser medium to rarer medium.
3. c) It has high refractive index
4 .d) Increase
5. a) Less than the first

16. 1.C) Copper
2. a) Car
3.c) Zero
4.c) –q
5. b) Constant

Section C

17. The side bands are at 1000 + 10 = 1010 kHz
And 1000 10 = 990 kHz.

18. Let i be the angle of incidence,
e be the angle of emergence,
A be the angle of the prism,
δ be the angle of deviation.
The required expression is
$\delta = (i+e) - A$
The refractive index μ of the material of prism is related with $\angle A$ and δ_m as

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin(A/2)}$$

19. In the first case,

$$\frac{R}{S} = \frac{l_1}{100 - l_1} \qquad (1)$$

In the second case,

$$\frac{R}{X+S} = \frac{l_2}{100 - l_2} \qquad (2)$$

Dividing equation (2) by (1), we get

$$\frac{S}{X+S} = \frac{l_2(100 - l_1)}{l_1(100 - l_2)}$$

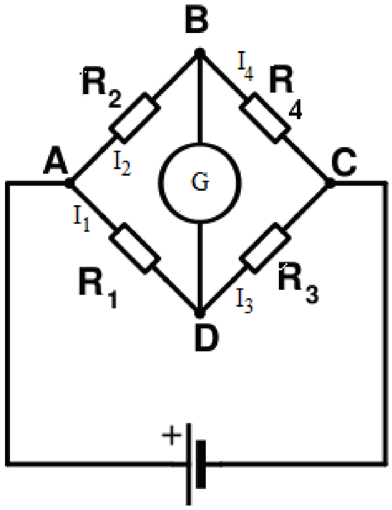
$$\frac{X+S}{S} = \frac{l_1(100 - l_2)}{l_2(100 - l_1)}$$

$$1+\frac{X}{S}=\frac{l_1(100-l_2)}{l_2(100-l_1)}$$

$$X=S\left(\frac{l_1(100-l_2)}{l_2(100-l_1)}-1\right)$$

OR

A Wheatstone bridge is an arrangement of four resistances which can be used to measure one of them in terms of the rest.



$I_1 = I_3$ and $I_2 = I_4$.

Next, we apply Kirchhoff's loop rule to closed loops ADBA and CBDC.

The first loop ADBA gives

$I_1R_1 + 0 - I_2R_2 = 0$ ($I_g = 0$)

and the second loop CBDC gives, upon using $I_3 = I_1$, $I_4 = I_2$

$-I_4R_4 + 0 + I_3R_3 = 0$

Upon using $I_3 = I_1$, $I_4 = I_2$and taking the ratio of the above two equations, we obtain

$$\frac{R_1}{R_3}=\frac{R_2}{R_4}$$

This last equation relating to the four resistors is called the balance condition for the galvanometer to give zero or null deflection.

20. Given that

$R_1 = r$

and $R_2 = -r$

Refractive index of the lens with respect to air $\mu_a = 1.5$

Refractive index of the lens with respect to liquid $\mu_l = \frac{1.5}{1.4}$

length of the lens for air medium is equal to the radius of curvature of its surfaces.
Again, for a liquid medium, we have

$$\frac{1}{f_2} = (\mu_1 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$= \left(\frac{(1.5 - 1)}{1.4}\right)\left(\frac{1}{r} + \frac{1}{r}\right)$$

$$\frac{1}{f_2} = \frac{0.1}{1.4} \times \frac{2}{r}$$

$$\frac{1}{f_2} = \frac{1}{7r}$$

$$f_2 = 7r$$

Thus, the focal length for the liquid medium is 7 times the radius of curvature of its surfaces.
Hence, the ratio is

$$\frac{f_1}{f_2} = \frac{1}{7}$$

21. For the diffraction of a wave, an obstacle of the size of wavelength of the wave is needed. As the wavelength of light is of the order of 10^{-6} m and obstacles of this size are rare, so, diffraction of light is not common, while diffraction of sound is common because of its large wavelength.
Separation between two dark bands on either side of the central maximum is equal to the width of the central maximum.

$$\beta_o = \frac{2D\lambda}{d} = \frac{2 \times 2 \times 6000 \times 10^{-10}}{0.5 \times 10^{-3}}$$

$$\beta_o = 4.8 \text{ mm}$$

where d = slit width
D = separation betweenscreen and slit
λ = wavelength of light used

22. Einstein's photoelectric equation is in accordance with the energy conservation law as applied to the photons absorbed and to the emitted electron.
Energy of incident photon = max KE + work function of metal

$$hv = \frac{1}{2}mv^2_{max} + W_o$$

$$K_{max} = \frac{1}{2}mv^2_{max} = hv - W_o$$

At threshold frequency (ν_o), no KE is given to the electron, so

$$hv_o = w_o$$

Therefore, $K_{max} = hv - hv_o$

This is Einstein's photoelectric equation.

Above the threshold frequency ν_0, K_{max} of emitted electrons depends linearly on the frequency of incident radiation.

OR

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

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

$$r_0 = \frac{9\times10^9\times2\times79\times\left(1.6\times10^{-19}\right)^2}{12.5\times1.6\times10^{-13}}$$

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

23. The property of two coils by virtue of which each opposes any change in the strength of current flowing through the other by developing an opposing emf is called mutual induction.

SI unit of coefficient of mutual induction is Henry (H).

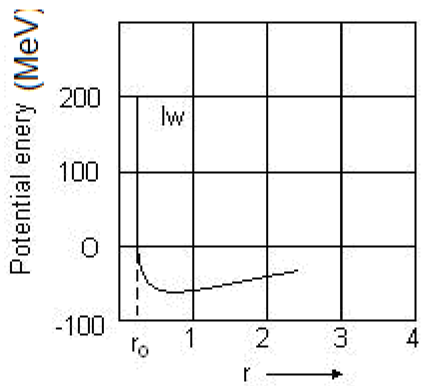
The mutual inductance depends on

i) Distance between the two coils.

ii) Relative placement of two coils

iii) Geometry of two coils like size, shape, number of turns and nature of the material on which the two coils are wound.

24.



(a) Potential energy of a pair of nucleons as a function of their separation (r) is shown in the figure above.

(i) The graph shows the short range character of nuclear force of the order of 2-3 fm. It is attractive but becomes strongly repulsive when the separation is less than about 1 fm (known as hard core region) i.e. $r > r_o$.

(ii) From the graph, it is evident that for $r > r_o$, the potential energy is negative, thereby implying the attractive nature of the nuclear force for $r > r_o$.

(b) Characteristics of nuclear forces:

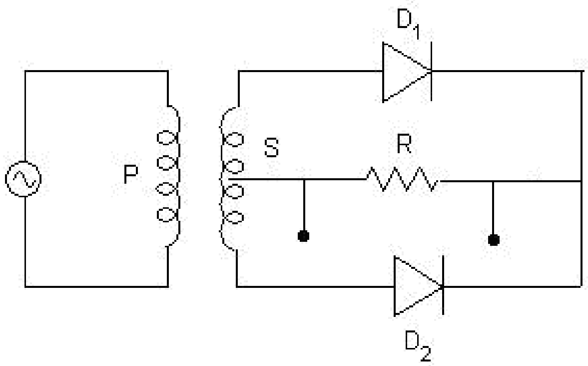
(i) These are short range forces.

(ii) These are charge independent.

25. A device which converts alternative current (AC) to direct current (DC) is known as a rectifier.

Principle: The junction diode conducts only when forward biased and it does not conduct when reverse biased. This makes the junction diode work as a rectifier.

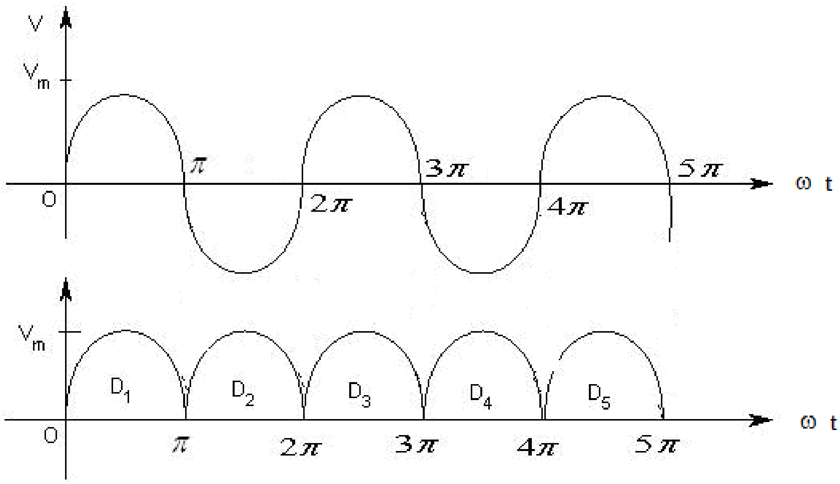
Full-wave rectifier:



In the figure, P is the primary coil and S is the secondary coil of the transformer. D_1 and D_2 are the diodes which are connected to the secondary coil of the transformer. The load R, across which the output voltage is obtained, is connected to a mid-point on the secondary coil.

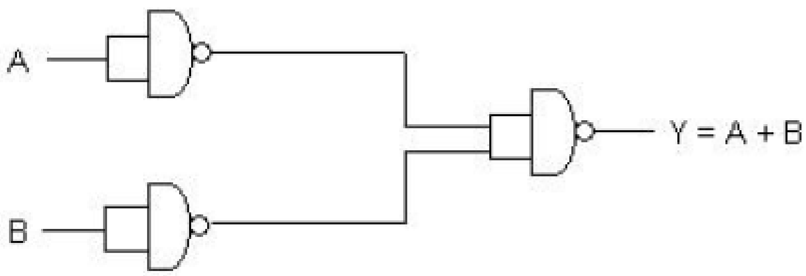
Working: When the half-cycle of the input AC signal flows through the primary coil, induced emf is set up in the secondary winding coil because of mutual induction. Now the diode D_1 becomes forward biased and the diode D_2 becomes reverse biased. Thus, there is output because of the diode D_1

During the negative half-cycle of the AC input signal, the diode D_2 becomes forward biased and conducts current, while the diode D_1 becomes reverse biased and does not conduct current. Thus, in this case, the output is due to the diode D_2

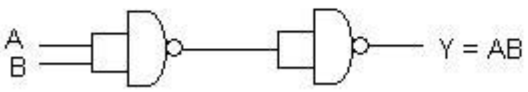


OR

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



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



26. Given that

$R = 1k\Omega = 10^3 \Omega$

$C = 10pF = 10^{-11} F$

$\therefore \quad RC = 10^3 \times 10^{-11} = 10^{-8} s$

and $\quad f_c = 100kHz = 10^5 Hz$

$\therefore \quad \frac{1}{f_c} = 10^{-5} sec$

We find that $\frac{1}{f_c}$ is not less than RC as is required for demodulation; therefore, the arrangement is not for the desired purpose.

For a satisfactory arrangement, let us try

$C = 1\mu F = 10^{-6} F$

$RC = 10^3 \times 10^{-6} = 10^{-3} s$

Now $\frac{1}{f_c} << RC$

$\therefore$ The condition is satisfied. This is good enough for demodulation.

27. A= 1 m^2, d= 5 cm, q = ?

E = 1000 NC^{-1}

$E = \frac{\sigma}{\varepsilon_0} = \frac{q/A}{\varepsilon_0}$

$q = A\ \varepsilon_0\ E = 1 \times \left(8.85 \times 10^{-12}\right) \times 1000$

$q = 8.85 \times 10^{-9}\ C$

OR

The kinetic energy gained or lost by an electron in moving through a potential difference of one volt is called electron volt.

1 eV = 1.6×10^{-19} Coulomb × 1 Volt

Thus, 1 eV = 1.6×10^{-19} Joule

28. $2l = 2$ cm = 0.02 m, m= 60 Am, B = ?

d= 20 cm = 0.2 m

On axial line, as l < d,

$$B = \frac{\mu_0}{4\pi} \frac{2 \times m \times 2l}{d^3}$$

$$= \frac{10^{-7} \times 2 \times 60 \times 0.02}{0.2^3}$$

$$B = 3 \times 10^{-5} \text{ T}$$

At the same distance, on equatorial line

$$B_2 = \frac{1}{2} B_1$$

$$B_2 = \frac{1}{2} \times 3 \times 10^{-5} \text{T} = 1.5 \times 10^{-5} \text{T}$$

29. L = 10 H,

I_1 = 10 A, I_2 = 7 A, dt = 9×10^{-2} s

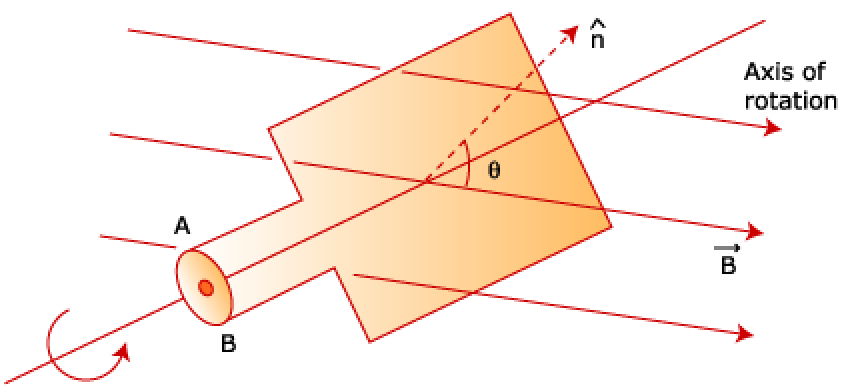
$$e = \frac{-L\, dI}{dt} = \frac{-L(I_2 - I_1)}{dt}$$

$$e = \frac{-10\,(7 - 10)}{9 \times 10^{-2}}$$

Thus, e = 333.3 V

OR

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 the flux through the loop is $\Phi = BA\cos\theta$.

If this loop rotates with a constant angular velocity $\omega = \frac{d\theta}{dt}$, then 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.

$\therefore$ emf is induced between ends A and B and is 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.

30. i. Fission is the splitting of a large atom into two or more smaller ones. Fusion is the fusing of two or more lighter atoms into a larger one. Fission reaction does not normally occur in nature.

ii.

$$Fe_{26}^{56} \rightarrow 2Al_{13}^{28}$$

$M_1 = 55.93494$ u atomic mass of Fe

$M_2 = 27.98191$ u is the atomic mass of Al

Q value is $(M_1 - 2M_2) \times 931.5$ Mev

$(55.93 - 2 \times 27.98) \times 931.5$

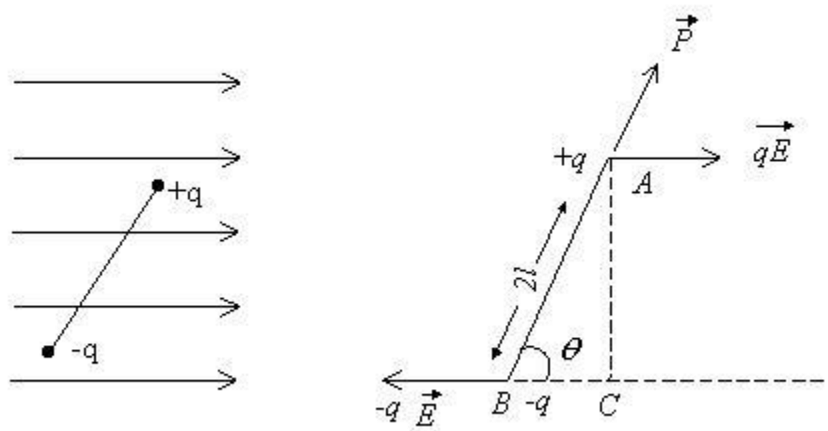
$= -26.902$ MeV

Qis negative. Hence fission is not possible.

Section E

31.

(i) Considering an electric dipole of dipole moment $\vec{p}$ held at an angle θ in a uniform electric field $\vec{E}$ as shown in the given figure.



The force experienced by the charges q and $-q$ are $q\vec{E}$ and $-q\vec{E}$ respectively.

Hence, net force = $q\vec{E} + (-q\vec{E}) = 0$

Therefore, the net translatory force on the dipole is zero.

(ii) Toque = Force $\times$ perpendicular distance

$= qE.AC$

$\tau = qEAB\sin\theta$

$= qE2l\sin\theta$

$\tau = pE\sin\theta$

or $\vec{\tau} = \vec{p} \times \vec{E}$

(iii) Work done in turning an electric dipole in an electric field by angle θ

(from θ_1 to θ_2)

$W = pE(\cos\theta_1 - \cos\theta_2)$

Here, $\theta_1 = 0^\circ$ and $\theta_2 = 180^\circ$

So, $W = pE\left[\cos 0^\circ - \cos 180^\circ\right]$

$= pE\left[1-(-1)\right]$

$W = 2pE$

OR

(a) Given: For two extremely small charged copper spheres in vacuum.

$q_1 = q_2 = 6.5 \times 10^{-7} C$

Separation between the spheres, $r = 50cm = 0.5m$

Force of mutual repulsion $F = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_2}{r^2}$

$$F = \frac{9 \times 10^9 \times (6.5 \times 10^{-7})(6.5 \times 10^{-7})}{(0.5)^2}$$

$F = 1.52 \times 10^{-2} N$

(b)

(i) (As $F \alpha \frac{q_1 q_2}{r^2}$, when charge on each sphere is doubled and their separation is halved, the new force of repulsion will become 16 times.

$F' = 16F = 16 \times 1.52 \times 10^{-2}$

$F' = 2.43 \times 10^{-1} N = 0.243N$

(ii) In a liquid (water) of dielectric constant, the $(k = 80)$, new force of repulsion f'' will be F/k, i.e.

$$F'' = \frac{1.52 \times 10^{-2}}{80}$$

$F'' = 1.90 \times 10^{-4} N$

32.

(a) Principle of a moving coil galvanometer: A current-carrying coil placed in a magnetic field experiences a torque.

Suppose current I is passing through the coil. This coil experiences a torque.

$\tau = NIBA \sin\theta$

where N is the total number of turns in the coil, θ is the angle between magneticfield vector and area vector of the coil.

Counter torque is developed in the spring. If k is the restoring torque per unit angular twist, for an angular twist of θ , we have

Restoring torque $\tau' = k\theta$

In equilibrium $\tau = \tau'$

$NIBASin\theta = k\theta$

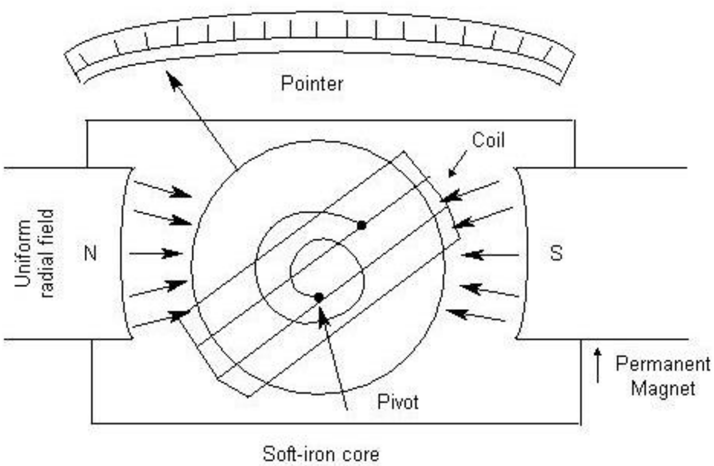
\ $$I = \frac{k}{NBA}\frac{\theta}{\sin\theta}$$

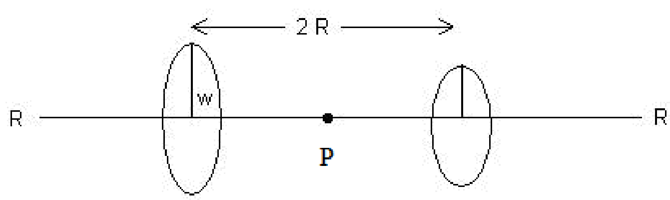
If the magnetic field is radial, i.e. the plane of the coil is parallel to the direction of the magnetic field, then

$\theta = 90^\circ$,

\ $$I = \frac{k}{NBA}\theta \Rightarrow I \alpha\ \theta A$$

Thus, the following current is proportional to deflection:





Magnetic field induction at an axial point at a distance x from the centre of a coil of radius R , number of turns N and carrying current I is given by

$$B' = \frac{\mu_o N I R^2}{2\left(R^2 + x^2\right)^{3/2}}$$

Resultant field B due to both coils at the mid-point P is obtained by putting $x = R$

$$B = 2 \times \frac{\mu_o I N R^2}{2\left(R^2 + R^2\right)^{3/2}} = \frac{\mu_o N I R^2}{\left(2R^2\right)^{3/2}}$$

$$B = \frac{\mu_o N I}{2\sqrt{2}R} \; Wb/m^2$$

This field acts along the common axis of the coils.

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

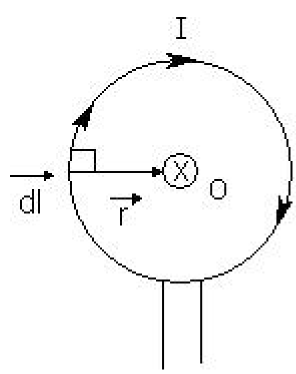
$$dB = \frac{\mu_o}{4\pi}\frac{Idl}{r^2} \qquad \left(\because \theta = 90^\circ\right)$$

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

$$\text{Sin } i_c = \frac{1}{\mu}$$

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)

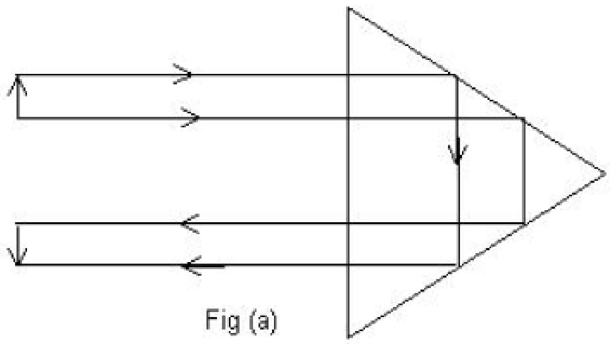


Fig (a)

(ii) To invert object fig (b),

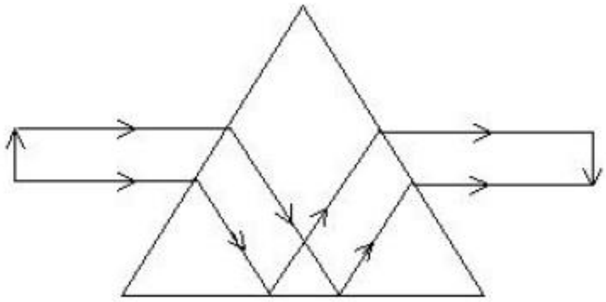


Fig (b)

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 $AM \perp OI$

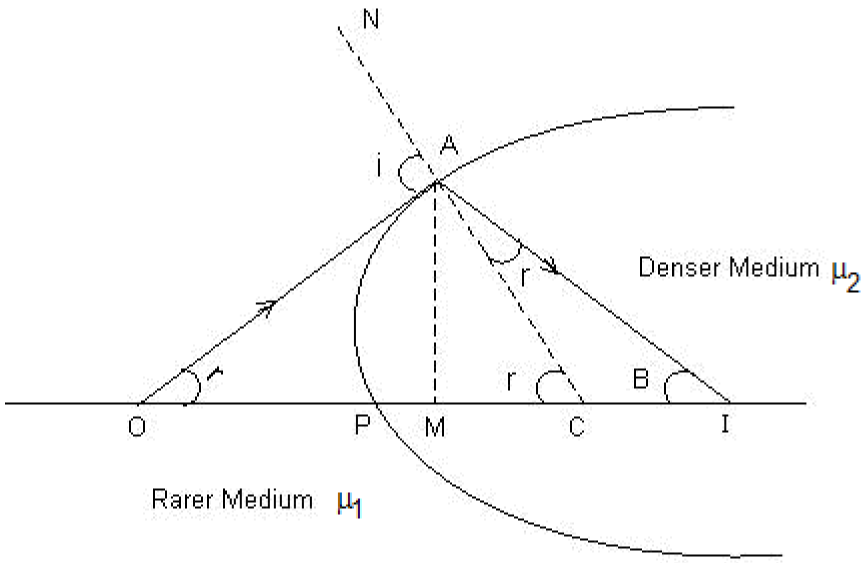
In ΔIAC

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

$r = \gamma - \beta$

Similarly, in $\Delta\ OAC$

$i = \alpha + \gamma$



According to Snell's law

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

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.