CBSE Board
Class XII Physics

Time: Three Hours **Maximum Marks: 70**

General Instructions

(a) All questions are compulsory.

(b) There are 29 questions in total. Questions 1 to 8 carry one mark each, questions 9 to 16 carry two marks each, questions 17 to 25 carry three marks each and questions 27 to 29 carry five marks each.

(c) Question 26 is a value based question carrying four marks.

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

(e) Use of calculator is not permitted.

(f) You may use the following physical constants wherever necessary.

$$e = 1.6 \times 10^{-19} \text{ C}$$
$$c = 3 \times 10^{8} \text{ m s}^{-1}$$
$$h = 6.6 \times 10^{-34} \text{ J s}$$
$$\mu_o = 4\pi \times 10^{-7} \text{ T ma}^{-1}$$
$$K_B = 1.38 \times 10^{23} \text{ J K}^{-1}$$
$$N_A = 6.023 \times 10^{23} \text{ /mole}$$
$$m_n = 1.6 \times 10^{-27} \text{ kg}$$

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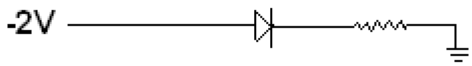
1. Is the force acting between two point electric charges q_1 and q_2 kept at some distance apart in air, attractive or repulsive when (i) $q_1q_2 > 0$ (ii) $q_1q_2 < 0$? (1)

2. On a graph show the stopping potential for a given photosensitive surface varying with the frequencies n_1 and n_2 of incident radiations where $n_1 > n_2$. Given that intensity is same for both light radiations. (1)

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

4. Is the diode in the following circuit forward biased or reverse biased? Give reason for your answer.



(1)

5. What is the frequency range of signals that are transmitted using optical fibres? (1)

6. A spherical Gaussian surface encloses charges q_1 and q_2 with
$q_1 = 8.85\times10^{-6} C$ and $q_2 = -8.85\times10^{-6} C$

(i) Calculate the electric flux passing through the surface.
(ii) How would the flux change if the spherical Gaussian surface is replaced with a cubical Gaussian surface and why? (1)

7. For a given thermocouple, the emf generated across its ends is given by $E = at + bt^2$ where t in °C is the temperature of the hot junction, the cold junction being at 0 °C. If a = 10 mV /°C and b = -0.02 mV/°C^2, calculate the value of inversion temperature in °C. (1)

8. A 3.0 V battery is connected to an ammeter and a resistor of 3 ohms in series with it. What is the value of the current if the ammeter used is a galvanometer with a resistance of 60 ohm? (1)

9. An electric bulb B and a parallel plate capacitor C are connected in series to the a.c. mains. The bulb glows with some brightness. How will the glow of the bulb be affected on introducing a dielectric slab between the plates of the capacitor? Give reasons in support of your answer. (2)

10. Discuss the intensity of transmitted light when a Polaroid sheet is rotated between two crossed Polaroids. (2)

11. Why is NAND gate called a universal gate. How can it to be used to realize a basic OR gate? (2)

12. What is modulation? What are the different types of modulation? (2)

13. Nuclear density of hydrogen is 2.3x10^{17} kg/ m^3. Given A = 56 for iron, find its nuclear density. (2)

14. Distinguish between frequency modulation and amplitude modulation. (2)

15. State Ampere's circuital law. Write the expression for the magnetic field at the centre of a circular coil of radius R carrying a current I. Draw the magnetic field lines due to this coil.

(2)

OR

15.0 μF capacitor is connected to a 220V, 50Hz source. Find the capacitive reactance and the rms current in the circuit. If the frequency is doubled, what happens to the capacitive reactance and the current? (2)

16. Write the expression for the force acting on a charged particle of charge q moving with velocity **v** in the presence of a magnetic field **B**.
Show that in the presence of this force
(i) the kinetic energy of the particle does not change.
(ii) its instantaneous power is zero. (2)

17. In Young's double slit experiment using monochromatic light of wavelength λ, the intensity at a point on the screen where path difference is λ, is K units. What is the intensity of light at a point where path difference is λ/3? (3)

18. An electron, α-particle and a proton have the same de-Broglie wavelength. Which of these particles has (i) minimum kinetic energy, (ii) maximum kinetic energy, and why?

(3)

19. State the law of radioactive decay. Establish a mathematical relation between half-life period and disintegration constant of a radioactive nucleus. (3)

20. 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)

21. We do not choose to transmit an audio signal by just directly converting it to an e.m. wave of the same frequency. Give three reasons for the same. (3)

22. A parallel plate capacitor is charged to potential V by a source of emf E. After removing the source, the separation between the plates is doubled.
How will the following change:

(i) electric field,
(ii) potential difference, and
(iii) capacitance of the capacitor? Justify your answers. (3)

23. For a transistor, the current amplification factor is 0.8 when the transistor is connected in common emitter configuration. Calculate the change in the collector current when the base current changes by 6 mA. (3)

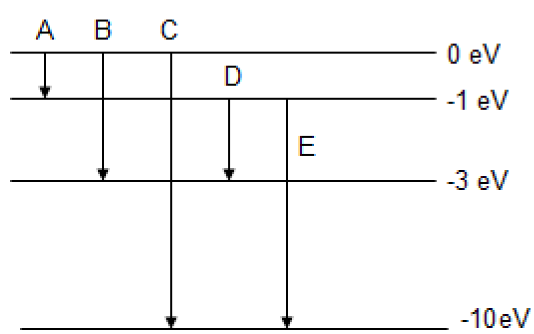
OR

How many electrons should be removed from a coin of mass 3.2 g, so that it just float in an electric field of intensity 10^{10} NC^{-1}, directed upward. (3)

24. When a transistor amplifier of current gain of 75 is given an input signal, $V_i = 2 \sin(157t + \pi/2)$, the output signal is found to be $V_0 = 200 \sin(157t + 3\pi/2)$.

In which mode is the transistor being used? Justify your result with proper explanation. (3)

25. The energy levels of an atom of element are shown in the following diagram. Which one of the level transitions will result in the emission of photons of wavelength 620 nm? Support your answer with mathematical calculations. (3)



26. One day Sita was coming back to home from school by her school bus. She saw a man was lying down at the road side and no one was there to help him. She thought it as the case of a major accident. She asked the driver to stop the bus and came out of the bus. She took the injured person to the nearest hospital taking help of a taxi. She sent the patient under treatment and for the condition analysis through X-ray etc. After his first aid, she called her parents and explained the entire situation. Her parents felt proud of Sita and her bravery. When the patient became conscious she took his parents contact number and called them to take care of the patient. The patient's parents thanked her and obliged her for the help.

(a) What are the values that are associated with Sita?

(b) What is an X-ray? How it is used in the medical field? (4)

27.

(a) Define the term dipole moment and its direction. State its SI unit. Deduce the expression for the torque acting on it.

(b) In a particular situation, it has its dipole moment aligned with the electric field. Is the equilibrium stable or unstable? (5 marks)

OR

A transistor is used in common emitter mode in an amplifier circuit. When a signal of 20 mV is added to the base-emitter voltage, the base current changes by 20 μA and the collector current changes by 2 mA. The load resistance is 5 $k\Omega$. Calculate (a) the factor β, (b) the input resistance R_{BE}, (c) the transconductance and (d) the voltage gain. (5)

28.

(a) State Lenz's law. Which conservation law can be used to explain this law?

(b) A wheel with 10 metallic spokes each 0.5m long is rotated with a speed of 120rev/min in a plane normal to the horizontal component of earth's magnetic field at a place where the earth's field is 0.4×10^{-4}G. What is the induced emf between the axle and the rim of the wheel?

(c) Two moving coil meters, M_1 and M_2 have the following particulars:

$R_1 = 10\ \Omega$, $N_1 = 30$,

$A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$

$A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T

(The spring constants are identical for the two meters). Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1. (5)

OR

(a) An electron & 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 & proton are 9.1×10^{-31} kg & 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 center of the coil if

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

(ii) radius of the coil is doubled ?

(iii) what will be the direction of the magnetic field? (5 marks)

29.

(a) Derive an expression for the magnifying power of an astronomical telescope. Draw a ray diagram showing image formation in it.

(b) An astronomical telescope consists of two thin lens set 36cm apart and has a magnifying power 8. Calculate the focal length of the lens.

(c) A giant refracting telescope at an observatory has an objective lens of focal length 15 cm. If an eye-piece of focal length 1.0 cm is used, what is the angular magnification of the telescope? If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens? The diameter of the moon is 3.48×10^6 m, and the radius of lunar orbit is 3.8×10^8 m. (5)

OR

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

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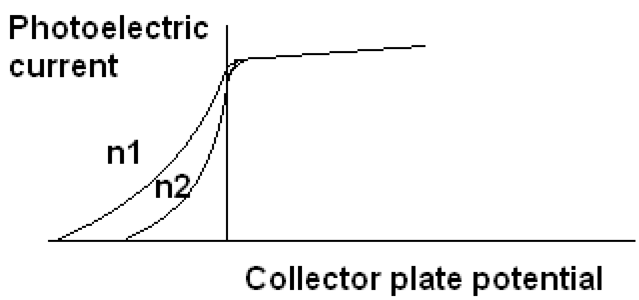
Class XII – Physics
Solution

A1. $q_1q_2 > 0$ means that q_1 and q_2 have the same sign. Either both charges are positive or both are negative so the force between them will be repulsive.
$q_1q_2 < 0$, then force will be attractive.

A2.



A3. The side bands are at 1000+10 = 1010kHz
and 1000 -10 = 990kHz.

A4. The diode is reverse biased.
This is because the p side is at a lower voltage than the n side.

A5. 1THz to 1000THz

A6.

(i) The flux is zero as the net charge enclosed by the Gaussian surface will be zero.
(ii) If the Gaussian surface is made cubical, the flux is the same. It stays zero, this is because the flux depends only on the charge enclosed & is independent of the shape of the Gaussian surface.

A7. The neutral temperature will be $\theta_n = -\frac{a}{b} = \frac{10}{0.02} = 500^0 C$.

The inversion temperature is twice the neutral temperature, so it is 1000^0C.

A8. Total resistance of the circuit is 60+3 = 63 ohms. The current in the circuit is I = 3/63 = 0.048 A.

A9. On introducing a dielectric in the capacitor, its capacitance will increase.

Then, the total impedance of the circuit will decrease as $Z=\sqrt{R^2+\left(\frac{1}{\omega C}\right)^2}$.

Hence, the current in the circuit increases and the brightness of the lamp increases.

A10. Two crossed polaroids are placed perpendicular to each other. Let the intensity of incident light be I_0. The light transmitted by first Polaroid has intensity $I_0/2$ because if unpolarised light is incident on a polaroid the transmitted intensity is half the original intensity.

The light transmitted by second Polaroid has intensity $\frac{I_0}{2}\left(\cos^2\theta\right)$ where θ is the angle between the axes of first and second Polaroid.

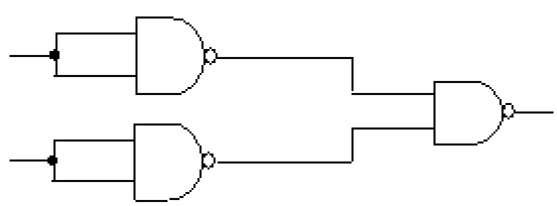
Thus, the light transmitted by third Polaroid has intensity

$$\frac{I_0}{2}\left(\cos^2\theta\right)\cos^2(90^0-\theta)=\frac{I_0}{2}\left(\cos^2\theta\right)(\sin^2\theta)=\frac{I_0}{8}\sin^2 2\theta.$$

This intensity will be maximum when $\theta=45^0$

A11. NAND gate is called a universal gate because it can be used to obtain other basic gates like AND, NOT and OR gates.

NAND gates can be combined as shown below to realize a basic OR gate.



A12. Some characteristics of the carrier signal are varied in accordance with the modulating or message signal. This is called modulation.

Amplitude modulation, frequency modulation and phase modulation of waves are the different types of modulation.

A13. Nuclear density for iron will be $2.3\text{x}10^{17}$ kg/m^3.

Nuclear density is independent of mass number A, so iron also has the same nuclear density as hydrogen.

A14. In amplitude modulation (AM), the amplitude of modulated (carrier) wave varies in accordance with amplitude of information (signal) wave. When amplitude of the information wave increases, the amplitude of modulated wave also increases and vice – versa.

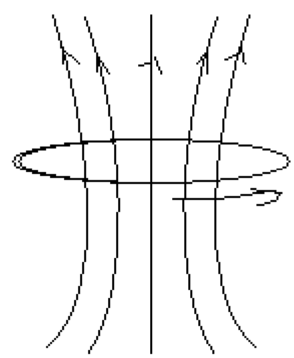
In frequency modulation (FM), the frequency of modulated wave varies in accordance with the frequency of the signal wave. In this case the amplitude of modulated wave is fixed.

A15. Ampere's circuital law states that $\oint \vec{B}.d\vec{l} = \mu_0 i$ where I refers to the current passing through amperian loop S around the current element.

The magnitude of the magnetic field due to a circular coil of radius R carrying a current i at its centre is

$$B = \frac{\mu_0 i}{2R}$$

Magnetic field lines due to circular current carrying coil is represented as



OR

The capacitive reactance is

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(50)(15.0x10^{-6})} = 212\Omega$$

The rms current is

$$i = \frac{V}{X_C} = \frac{220}{212} = 1.04A \qquad (1/2)$$

The peak current $\sqrt{2}\ i = \sqrt{2}(1.04) = 1.47A$

If the frequency is doubled, the capacitive reactance is halved and the current gets doubled.

A16. Force acting on charge q moving with velocity v in magnetic field B:

$$\vec{F} = q(\vec{v} \times \vec{B})$$

(i) Kinetic energy of the particle does not change as the force acting on it is always perpendicular to the velocity. A force that is perpendicular to the velocity cannot change the magnitude of the velocity. All that the force does is to change the direction of the particle keeping the magnitude of velocity unchanged.

(ii) The instantaneous power is **F.v**, where F and v are the force and velocity vector respectively. Since the force and velocity are perpendicular to each other, so **F.v** = 0.

A17. Intensity is $I = 4I_0 \cos^2 \Phi/2$

When path difference is λ, phase difference is 2π

$I = 4I_o \cos^2\pi = 4\, I_o = K$ (given)

When path difference is $\Delta = \lambda/3$, then the phase difference will be

$\Phi' = 2\pi\, \Delta / \lambda$

$= 2\pi \times \lambda/3\lambda = 2\pi/3$

Hence the intensity at a point where the path difference is $\lambda/3$, is

$I' = 4I_0 \cos^2 2\pi/6$ (since $K = 4I_0$)

$= K \cos^2 \pi/3 = K \times \{1/2\}2 = (¼)\, K.$

A18.

The de Broglie wavelength is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$$

For the electron, proton and α-particle, λ is same

$$m_e K_e = m_p K_p = m_\alpha K_\alpha = \text{constant}$$

As mass of electron is minimum its kinetic energy will be maximum.

As mass of alpha-particle is maximum its kinetic energy is minimum.

A19. In any radioactive sample, the number of nuclei undergoing the decay per unit time is proportional to the total number of nuclei in the sample.

Radioactive decay law is

$$\frac{dN}{dt} = -\lambda N$$

Integrating the above expression gives

$$N(t) = N_0 e^{-\lambda t}$$

Put $N(t) = \frac{N_0}{2}$ and $t = T_{1/2}$

$$T_{1/2} = \frac{0.693}{\lambda}$$

A20.

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 × 10^{26}/2

Energy released = (3.01 × 10^{26})(1.863 × 10^{6})(1.6x10^{-19}) J = 9.0×10^{13} J

A21.

(i) If the audio signal is directly transmitted, the size of antenna will be very large which is not practically feasible. This is because, the size of the antenna required is proportional to $\lambda / 4$.

(ii) Effective power radiated by antenna is proportional to square of frequency. For an audio frequency wave the radiated power will be extremely small.

(iii) iIf different programmes, audio frequencies are directly transmitted then what you will hear at the receiver will be a mixture of all these signals.

A22.

(i) E remains same as it depends on the charge on the plates and the medium between the plates. Q remains same as charge does not change on the plates.
(ii) V = Ed, so as the distance is doubled V also doubles.
(iii) C = Q/V and V is doubled whereas Q remains same. So C is halved.

A23.

α=0.8

β= α/(1-α)

=0.8/(1-0.8) = 4

$\Delta I_C = \beta \Delta I_b = 6 \times 4 = 24$ mA

OR

Here, m = 3.2g = 3.2 × 10^{-3} kg
E = 10^{10} NC^{-1}
Let n be the number of electrons removed from the coin. Then the charge on the coin is
q = +n e
When the coin just floats,
Upward force of electric field = weight of the coin
n q E = mg

n = $\frac{mg}{qE} = \frac{3.2 \times 10^{-3} \times 9.8}{1.6 \times 10^{-19} \times 10^{10}} = 1.96 \times 10^{7}$ electrons

A24.

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

Besides this, 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 common-emitter mode.

A25.

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

Here λ = 620 nm = 620 x 10^{-9} m

$$E = \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{620 \times 10^{-9}} J$$
$$= \frac{6.62 \times 10^{-34} \times 3 \times 10^{8}}{620 \times 10^{-9} \times 1.6 \times 10^{-19}} eV = 2eV$$

Transition D will result in the emission of photons of wavelength 620 nm.

A26.

(a) The values are helping nature, presence of mind, on-the-spot decision making capacity, knowledge of procedure of a work, agility and soft heartedness.

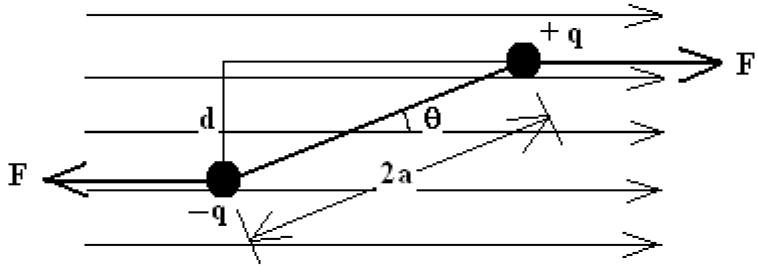
(b) X-rays are high-frequency electromagnetic radiations emitted when fast moving electrons are obstructed by metal surface.

The penetrating power of X-rays has made it popular and familiar to general public. It is extensively used to detect diseases inside the body. Photograph films are used on which the internal body parts pictures are captured. So, this is used to study and detect bone fracture. Chest radiographers are used for the study of lungs. Dentist uses X-ray to study the reasons of teeth decay. X-rays are also used in cancer therapy.

A27. Dipole moment vector **p** has magnitude 2qa and is in the direction of the dipole axis from −q to q.

Its SI unit is C-m.

Force of qE acts on charge q and force −qE acts on charge −q.



So the torque = $2a \times qE\sin\theta = pE\sin\theta = \vec{p}\times\vec{E}$

The equilibrium is stable as the torque acting on it will be zero when it is aligned in the direction of the field.

OR

(a) $\beta = \dfrac{\Delta I_C}{\Delta I_B} = \dfrac{2\text{ mA}}{20\,\mu\text{A}} = 100$

(b) The input resistance R_{BE} = $\dfrac{\Delta V_{BE}}{\Delta I_B} = \dfrac{20\text{ mV}}{20\,\mu\text{A}} = 1\text{ k}\Omega$

(c) Transconductance = $\dfrac{\Delta I_C}{\Delta V_{BE}} = \dfrac{2\text{ mA}}{20\,mV} = 0.1\text{ mho}$

(d) The change in input voltage is $R_L \Delta I_C = (5\,k\Omega)(2\text{ mA}) = 10\text{ V}$

The applied signal voltage = 20 mV

Thus, the voltage gain is,

$$= \frac{10\text{ V}}{20\text{ mV}} = 500$$

A28.

(a) Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in the magnetic flux that produces it.
This law can be explained by the law of conservation of energy.

(b) Induced emf = $(1/2)\omega BR^2 = (1/2)\times 4\pi \times 0.4\times 10^{-4}\times (0.5)^2 = 6.28\times 10^{-5} V$

(c) Given

$R_1 = 10\ \Omega$, $N_1 = 30$, $A_1 = 3.6 \times 10^{-3}\ m^2$, $B_1 = 0.25$ T

$R_2 = 14\ \Omega$, $N_2 = 42$, $A_2 = 1.8 \times 10^{-3}\ m^2$, $B_2 = 0.50$ T

Current sensitivity is $\dfrac{\phi}{i} = \left(\dfrac{NAB}{K}\right)$

Thus, the ratio of current sensitivities is $= \dfrac{N_1}{N_2}\dfrac{A_1}{A_2}\dfrac{B_1}{B_2} = \dfrac{S_1}{S_2}$

$$= \frac{30}{42}\left(\frac{3.6}{1.8}\right)\left(\frac{0.25}{0.50}\right)$$

$$= \left(\frac{5}{7}\right)$$

Ratio of voltage sensitivities $= \left(\dfrac{S_1}{S_2}\right)\left(\dfrac{R_2}{R_1}\right)$

$$= \left(\frac{5}{7}\right)\left(\frac{14}{10}\right) = 1$$

OR

(a) Radius of circular path in magnetic field

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

Since $m_p > m_e$

Therefore radius of proton's circle will be larger

$$\frac{r_p}{r_e} = \frac{m_p}{m_e} = \frac{1.67x10^{-37}}{9.1x10^{-31}} = 1835$$

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

The work done by the magnetic force

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

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

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

$$dW = 0$$

Thus on moving the charged particle in 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

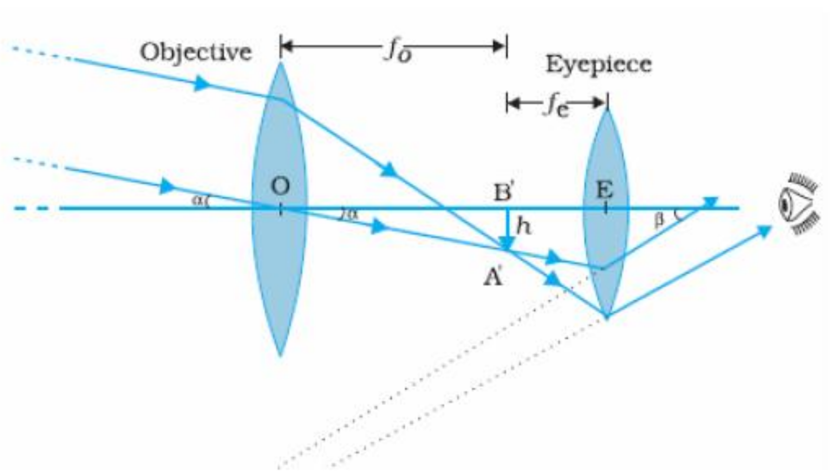
(ii) the field will be halved

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

A29.

(a) Magnifying power is the ratio of the angle subtended at the eye by the final image to the angle which the object subtends at the lens or the eye.

$$m = \frac{\beta}{\alpha} = \frac{h}{f_e} \cdot \frac{f_o}{h} = \frac{f_o}{f_e}$$



(b) Given

Magnification $m = f_o / f_e$ and length of the tube, $f_o + f_e = L$

$8 = f_o / f_e$ & $f_o + f_e = 36$

Hence $8f_e + f_e = 36$

Or $f_e = 4cm$

Therefore, $f_o = 32cm$

(c)

Angular magnification

$$m = \frac{15}{0.01} = 1500$$

Let diameter of image be d. Then,

$$\frac{d}{1500} = \frac{3.48\times10^6}{3.8\times10^8}$$

$$\Rightarrow d = 13.7cm$$

OR

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

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

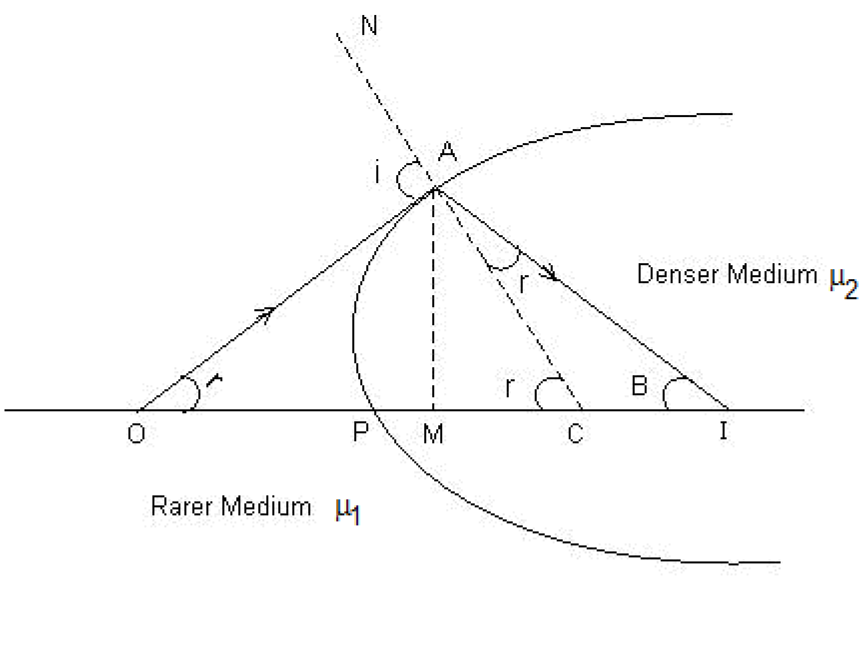
In ΔIAC

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

$$\therefore \quad r = \gamma - \beta$$

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

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 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.