CBSE
Class XII – Physics
Sample Paper 2– Solution

Section A

1. Approximately 311 V

$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$

$V_{peak} = \sqrt{2} V_{rms}$

$V_{peak} = \sqrt{2} \times 220 = 311.08$ V

2. DC

After being fully charged, the capacitor does not allow the charge to flow through it, and hence,it acts as an infinite resistance.

OR

Electric field

3. Both A and B are true.

Emf can be induced either by moving the conductor or by changing the magnetic field or both.

4. $v \perp l \perp B$

$Emf = Blv$. Emf is not induced when the metal rod moves in the direction of the magnetic field or when the length is in the same direction of the magnetic field.

5. $f \geq f_0$.

The photoelectric effect takes place when energy of incident radiation is more than the work function of the metal.

OR

Violet, Indigo and Blue,as these colours has shorter wavelength and hence generate enough energy to eject electron.

6. Both decreases

$p = \frac{h}{\lambda}, E = hf = \frac{hc}{\lambda}$.

7. Frequency

During refraction frequency of the source remains constant.

OR

The brilliance of a diamond is due to total internal reflection. Optical fibre works on the principle of total internal reflection. This phenomenon is used in many optical instruments like telescopes, microscopes, binoculars, spectroscopes, periscopes etc.

8. 60 cm in front of the mirror
When the object is placed at the centre of curvature, the image is also formed at the centre of curvature.

9. Zero
Flux is given by $\phi = \frac{q}{\varepsilon_0}$. The net charge inside the closed surface is zero. Hence,the electric flux would be zero.

10. $4\mu F, 36\mu F$
Minimum capacitance
In series
$$\frac{1}{C} = \frac{1}{12} + \frac{1}{12} + \frac{1}{12}$$
$c = 4\mu F$
Mximum capacitance
In parallel
$C = 12 + 12 + 12 = 36\mu F$

OR

Joule

Section B

11. Assertion and Reason both are false.
A: The emf will be same but current will different as resistance will be different of Cu and Al.
R: Mutual inductance depends on orientation of coil, size, shape, no. of turns and relative position.

12. Both A and R are true and R is the correct explanation of A
We know that $E = -13.6/n^2$ eV
It shows that total energy of electron in a stationary orbit in a hydrogen atom is negative, which means the electron is bound to the nuclear and is not free to leave it.

13. Both A and R are true but R is NOT the correct explanation of A

When intensity of light emerging from two slits is equal, the intensity at minima, $I_{min} = \left(\sqrt{I_a} - \sqrt{I_b}\right)^2 = 0$, or absolute dark. It provides a better contrast.

14. If both assertion and reason are true but reason is not the correct explanation of the assertion.
Equivalent capacitance of parallel combination is Cp=C1+C2+C3

15. A) iv. $C' = KC$. If the medium between the plates of a capacitor is filled with an insulating substance (dielectric), the electric field due to the charged plates induces a net dipole moment in the dielectric. This effect, called polarisation, gives rise to a field in the opposite direction. The net electric field inside the dielectric and hence the potential difference between the plates is thus reduced. Consequently, the capacitance increases from its value C when there is no medium (vacuum).
b) i. Potential difference across the plates of the capacitor would remain same.
c)iii. Final charge on the plates of the capacitor would be Kq
d)i. As E=V/d and here V and d both remains constant hence the electric field betweenthe plated would remain same as before .
e) ii. A s $U=CV^2/2$, so if capacitance becomes KC U would become KU

16. A) i. Increases
B) iii. Independent of intensity.
c) i. $V_{01} > V_{02} > V_{03}$
d)iii. No emission of photoelectron takes place
e)iii. Workfunction

Section C

17. Torque $\tau = pE\sin\theta$
$\because\ p = 4 \times 10^{-9}\,Cm,\ E = 5 \times 10^{4}\ NC^{-1},\ \theta = 30^{o}$
$\tau = 4 \times 10^{-9} \times 5 \times 10^{4}\ \sin\ \theta = 30^{o}$
$\tau = 10^{-4}\,Nm$

OR

Capacitance of parallel plate capacitor $C = \dfrac{\varepsilon_o A}{d} \propto A$
Plate area of C_2 is double that of C_1, thus, $C_2 = 2C_1$.
Slope of *q* – *V* graph $= \dfrac{q}{V} = C$
As the slope of A is greater than the slope of *B*, *A* corresponds to a larger capacitance, i.e. C_2 and B to a smaller capacitance, i.e. C_1.

18. Resistance, $R = \dfrac{\rho\ell}{A} = \dfrac{\rho\ell}{\pi r^2}$

New radius $r' = r/2$

New length $\ell' = \ell/4$

$\therefore$ New resistance $R^1 = \frac{\rho \ell^1}{\pi r'^2} = \frac{\rho(\ell/4)}{\pi(r/2)^2} = \frac{\rho \ell}{\pi r^2} = R$

Resistance of the wire will remain unchanged.

19. Wavelength $\lambda = \frac{c}{\nu} = \frac{3 \times 10^8}{6 \times 10^{12}} = 5 \times 10^{-5}$ m

This wavelength corresponds to infrared waves.

Applications of infrared waves:

(i) They are used in greenhouses to warm plants.

(ii) They are used in taking photographs in fog.

20. According to Einstein, when a photon of incident light strikes a bound electron of metal, its energy is used in two ways:

(i) In overcoming the work function of the metal to free metallic electrons

(ii) In imparting kinetic energy to this freed electron,

i.e. $h\nu = w + E_k$

When $E_k = 0$, $\nu = \nu_0$ (threshold frequency),

$h\nu_0 = w + 0$

$w = h\nu_0$

Therefore, $h\nu = h\nu_0 + E_k$

$E_k = h(\nu - \nu_0)$

So, as the frequency of incident radiation ν increases, the maximum KE of photoelectrons alsoincreases.

OR

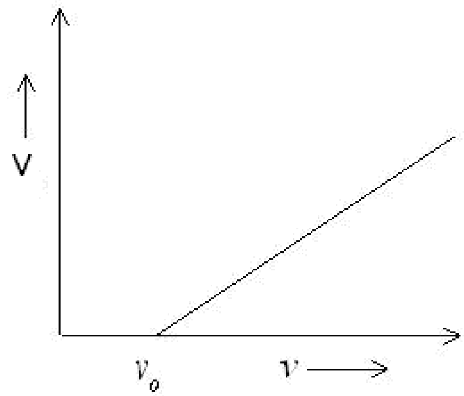
From Einstein's photoelectric equation,

$E_k = h\nu - h\nu_0$

$eV = h\nu - h\nu_0$ (V = stopping potential)

$V = \frac{h}{e}\nu - \frac{h}{e}\nu_0$

Thus, V vs ν graph is a straight line of the form $y = mx + c$ and the slope of graph is $m = \frac{h}{e}$.



21. When a strong current is passed through a semiconductor, it heats up the semiconductor. Due to which a large number of covalent bonds break up in the semiconductor. This results 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.

22. A transducer is a device which converts one form of energy to another. A microphone at the transmitting station and a loudspeaker at the receiving station are examples of transducers.

23.

(a) Advantages of pulse code modulation over amplitude modulation:
  (i) Free from noise and interfering signals
  (ii) Allows coded electrical signals

(b) Range of FM signals: 88–108 MHz

First, the FM signals are in the form of a frequency variation, so they do not get disturbed by the noise generated by atmospheric or man-made electrical discharge. Second, the amplitude variations due to noise in FM signals can easily be removed before demodulation.

OR

The satellite which appears to be at a fixed position at a definite height to an observer on the Earth.

Essential conditions:

(i) A geostationary satellite should be at a height of nearly 36,000 km above the equator.

(ii) Its period of revolution around the Earth should be the same as that of the Earth about its axis which is 24 hours.

(iii) It should revolve in an orbit concentric to the plane of the equator.

(iv) Its sense of rotation should be the same as that of the Earth about its own axis, i.e. from west to east. Its orbital velocity is nearly 3.1 km/s.

24. (i)The induced emf in both the loops will be same as areas of the loop and time periods are same as they are identical and rotated with same angular speed.

(ii)The current induces in Cu coil is more than Al coil as Cu coil have got lesser resistance and $I \propto \frac{1}{R}$

25. i) $P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P} = \frac{220 \times 220}{100} = 484\Omega$

ii) $I_{rms} = \frac{V_{rms}}{R} = \frac{220}{484} = 0.45 amper$

Section D

26. (i)According to Gauss's law, electric flux through $S_1$and S_2 is given as follows

$$\phi_1 = \frac{1}{\varepsilon_0} Q$$

$$\phi_2 = \frac{1}{\varepsilon_0}(Q + 2Q) = \frac{1}{\varepsilon_0}.3Q$$

$$\frac{\phi_1}{\phi_2} = \frac{1}{3}$$

(ii) When a medium of dielectric constant K = 5 is introduced in the space inside S_1 in place of air, the flux through S_1 will be modified to

$$\phi_1' = \frac{1}{\varepsilon} Q = \frac{1}{k\varepsilon_0} Q = \frac{\phi_1}{k} = \frac{\phi_1}{5}$$

Thus, the flux will be reduced to (1/5) of its previous value.

OR

The described arrangement is equivalent to two capacitors joined in parallel where the area of the plates of either capacitor is $\frac{A}{2}$.

Thus, $C_1 = \frac{k_1 \varepsilon_0 (\frac{A}{2})}{d} = \frac{k_1 \varepsilon_0 A}{2d}$

and $C_2 = \frac{k_2 \varepsilon_0 (\frac{A}{2})}{d} = \frac{k_2 \varepsilon_0 A}{2d}$

Therefore, net capacitance of the capacitor

$$C = C_1 + C_2 = \frac{k_1 \varepsilon_0 A}{2d} + \frac{k_2 \varepsilon_0 A}{2d}$$

$$= \frac{\varepsilon_0 A}{d}(\frac{k_1 + k_2}{2})$$

27. Eddy currents are currents induced in the bulk pieces of conductors when the amount of magnetic flux linked with the conductor changes.

To minimise eddy currents:

(i) The metal core to be used in an appliance should be in the form of thin sheets. These sheets must be electrically insulated, and the planes of these sheets are arranged parallel to the magnetic field so that they cut across the eddy current paths.

(ii) Large resistance between the thin sheets confines the eddy currents to the individual sheets. Hence, the eddy currents can be reduced to a large extent.

(iii) As the dissipation of energy is directly proportional to the square of the strength of electric current, heat loss gets highly reduced.

Although eddy currents have disadvantages,they can be used in many ways.

Applications: (any two)

(i) Electromagnetic damping:

When a steady current is passed through the coil of a galvanometer, it is deflected. Hence, the coil oscillates in its mean position for some time before coming to rest. Thus, it is unable to read the galvanometer deflection.

When eddy currents flow in metallic frames, the coil comes to rest at the equilibrium position instantly. This is called electromagnetic damping.

(ii) Magnetic brakes:

In some electrically powered trains, strong electromagnets are situated in the train just above the rails. When these electromagnets are activated, eddy currents induced in the rails oppose the motion of the train.

(iii) Induction motor:

In an induction or AC motor, a rotating magnetic field produces strong eddy currents in a rotor, which starts rotating in the direction of the rotating magnetic field.

28. The radius (size) R of the nucleus is related to its mass number (A) as

$R = R_0 A^{1/3}$, where $R_0 = 1.1 \times 10^{-15}$ m

If *m* is the average mass of a nucleon, then

Mass of the nucleus = mA, where A = mass number

Volume of the nucleus $= \frac{4}{3}\pi R^3 = \frac{4}{3}\pi R_0^3 A$

$\therefore$ Density of the nucleus $\rho_N = \frac{\text{mass}}{\text{volume}} = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$

$$\rho_N = \frac{3m}{4\pi R_0^3}$$

Thus, nuclear density ρ_N is independent of mass number A.

OR

The element which have same atomic number but different mass number are called isotopes Example Isotopes of carbon $6C^{10}$,$6C^{11}$,$6C^{12}$,$6C^{14}$The buclides of different element having same mass number but different atomic number are called isobarsFor example H_1^3 and He_2^3

Li_3^7 and Be_4^7

29.

(i) High frequency band: $3 MHz - 30 MHz$

(ii) Ultra high frequency band: $300 MHz - 3000 MHz$

(iii)Super high frequency band: $3000 MHz - 30,000 MHz$

30. Due to the electric field, both electrons and holes in a semiconductor move in the opposite direction with drift velocities v_e and v_h, respectively.
Mobility of electrons is defined as drift velocity per unit electric field.
If there is no electric field,the drift velocity becomes zero.
Thus, mobility of electrons

$$\mu_e = \frac{v_e}{E} \text{ or } v_e = \mu_e E$$

and mobility of holes is,

$$\mu_h = \frac{v_h}{E} \text{ or } v_h = \mu_h E$$

$$\text{We know, } \frac{E}{\rho} = e\left(n_e v_e + n_h v_h\right)$$

$$\therefore \frac{E}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right) E$$

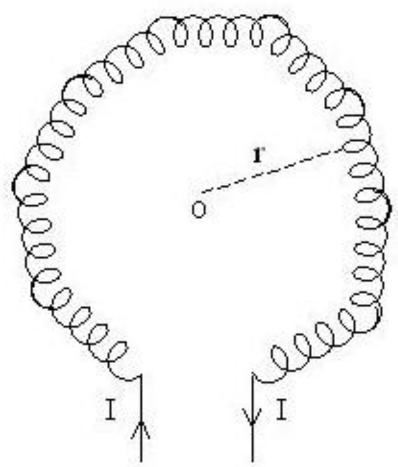
$$\therefore \frac{1}{\rho} = e\left(n_e \mu_e + n_h \mu_h\right)$$

$$\Rightarrow \text{Conductivity, } \sigma = e\left(n_e \mu_e + n_h \mu_h\right)$$

As the number of electrons n_e and the number of holes n_h increase with an increase in temperature, conductivity of the semiconductor also increases with a rise in temperature.

Section E

31. Magnetic field due to a toroidal solenoid:
A long solenoid shaped in the form of a closed ring is called a toroidalsolenoid.
Let *n* be the number of turns per unit length of the toroid and I be the current through it. The current causes the magnetic field inside the turns of the solenoid. The magnetic lines of force inside the toroid are in the form of concentric circles. By symmetry, the magnetic field has the same magnitude at each point of the circle and is along the tangent at every point on the circle.



For points inside the core of the toroid:

Consider a circle of radius r in the region enclosed by the turns of the toroid. Now we apply Ampere's circuital law to this circular path, i.e.

$\oint B \cdot dl = \mu_0 I$

$\oint B\, dl \cos 0^\circ = \mu I$

$B\ 2\pi r = \mu_o I$

$\because$ Current enclosed by circular path $= (n 2\pi r) I$

$B 2\pi r = \mu_o\ n 2\pi r I$

$B = \mu_o n I$

OR

Torque on a current-carrying loop: Consider a rectangular loop PQRS of length l, breadth *b*, suspended in a uniform magnetic field $\vec{B}$. The length of loop $= PQ = RS = \ell$ and breadth $QR = SP = b.$

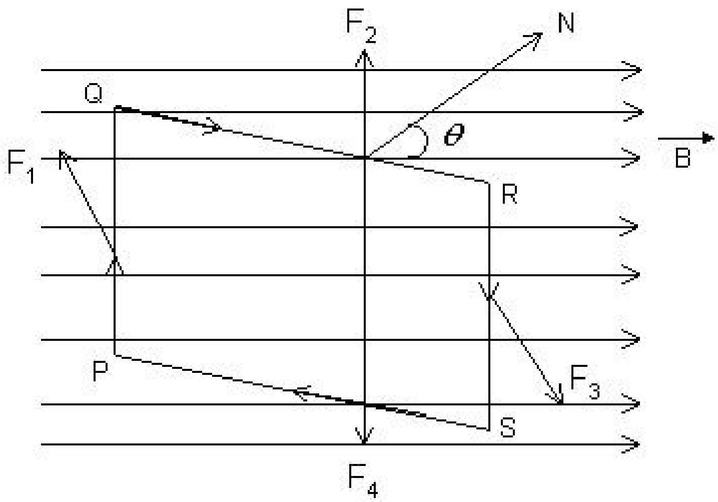
Let at any instant the normal to the plane of the loop make an angle θ with the direction of the magnetic field B and I is the current in the loop.

We know that a force acts on a current-carrying wire placed in a magnetic field. Therefore, each side will experience a force. The net force and torque acting on the loop will be determined by the forces acting on all sides of the loop. Suppose that the forces on side PQ, QR, RS and SP are F_1, F_2, F_3 and F_4, respectively. The sides QR and SP make angle $(90^\circ - \theta)$ with the direction of $B.$ Therefore, each of the forces F_2 and F_4 acting on these sides has the same magnitude.

$F^1 = Blb \sin(90^\circ - \theta) = Blb \cos\theta$

According to Fleming's left-hand rule, the forces F_2 and F_4 are equal and opposite, but their line of action is the same. Therefore, these forces cancel each other, i.e. the resultant of F_2 and F_4 is zero.

Axis of the loop or normal to the loop:



Sides PQ and RS of the current loop are perpendicular to B; therefore, the magnitude of each of the forces F_1 and F_3 is

$F = IlB \sin 90^\circ = IlB$

According to Fleming's left-hand rule, the forces F_1 and F_3 acting on sides PQ and RS are equal and opposite, but their lines of action are different. Therefore, the resultant force of F_1 and F_3 is zero, but they form a couple called the deflecting couple.

Moment of couple or torque

$\tau = \text{force} \times$ perpendicular distance

$\tau = (BIl) b \sin\theta = I(lb) B \sin\theta$

$\because \quad lb = \text{area of loop } (A)$

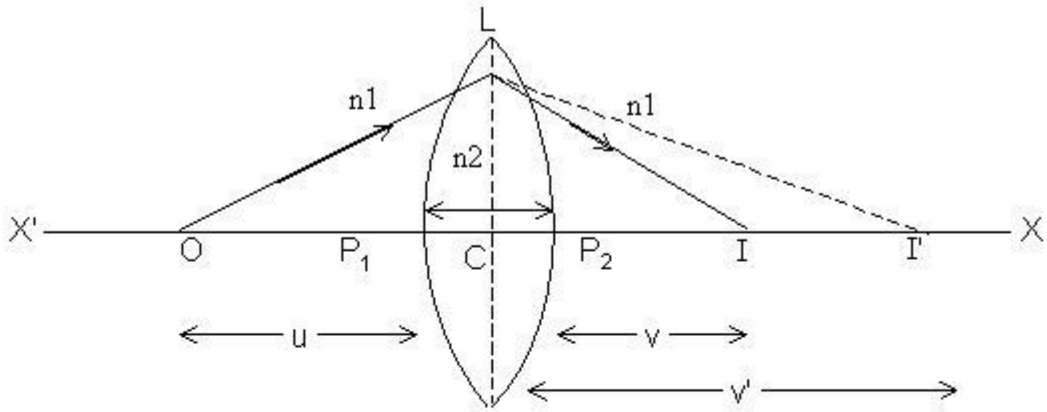
$\therefore \quad \tau = IAB \sin\theta$

If the loop contains N – turns, then

$\tau = NIAB \sin\theta$

32. Lens maker's formula: Suppose L is a thin lens. The refractive index of the material of the lens is n_2 and it is placed in a medium of refractive index n_1. The optical centre of the lens is *c* and x' x is the principal axis. The radii of curvatures of the surfaces of the lens are R_1 and R_2, and their poles are P_1 and P_2. The thickness of the lens is t, which is very small. O is a point object on the principal axis of the lens. The distance of the object from pole P_1 is u. The first refracting surface from an image of O at I' is at a distance v' from P_1.

From the refraction formula at the spherical surface, we have



$\because \qquad \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R_1} \qquad (1)$

The image I' acts as a virtual object for the second surface, and after refraction at the second surface, the final image is formed at I. The distance of I from pole P_2 of the second surface is v. The distance of the virtual object (I') from pole P_2 is $(v' - t)$.

For refraction at a second surface, the ray is going from the second medium (refractive index n_2) to the first medium (refractive index n_1); therefore, from the refraction formula at the spherical surface, we have

$$\frac{n_1}{v} - \frac{n_2}{(v' - t)} = \frac{n_1 - n_2}{R_2} - \qquad (2)$$

For a thin lens, t is negligible as compared to v', from (2).

$$\frac{n_1}{v} - \frac{n_2}{(v')} = -\frac{n_2 - n_1}{R_2} \qquad -(3)$$

Adding equations (1) and (3), we get

$$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = \left[\frac{n_2}{n_1} - 1\right]\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{v} - \frac{1}{u} = ({}_1n_2 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \quad -(4)$$

where ${}_1n_2 = \frac{n_2}{n_1}$ is the refractive index of the second medium with respect to the first medium.

If the object O is at infinity, then the image will be formed at the second focus, i.e.

$u = \infty, \quad v = f_2 = F$

Therefore, from equation (4),

$$\frac{1}{F} - \frac{1}{\infty} = ({}_1n_2 - 1) = \left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

$$\frac{1}{F} = ({}_1n_2 - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right] \text{ - (5)}$$

This is the formula of refraction for a thin lens. The formula is called the lens maker's formula.

If the first medium is air and the refractive index of the material of the lens is n, then ${}_1n_2 = n$; therefore,equation (5) may be written as

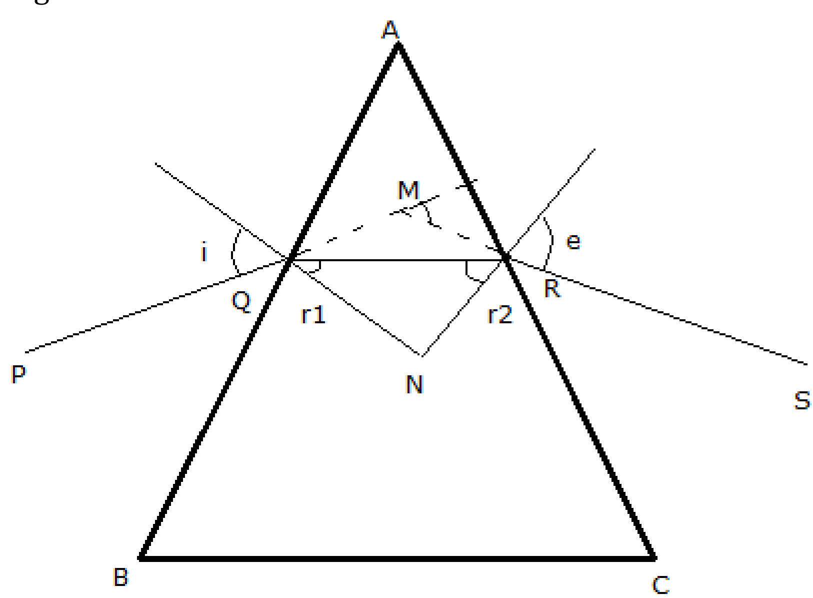
$$\frac{1}{F} = (n - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

OR

The figure shows the passage of light through a triangular prism ABC. The angles of incidence and refraction at the first face AB are i and r1 while the angle of incidence (from glass to air) at the second face AC is r2 and the angle of refraction or emergence e. The angle between the emergent ray RS and the direction of the incident ray PQ is called the angle of deviation δ.

In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles. Therefore, the sum of the other angles of the quadrilateral is 180°.

From the triangle



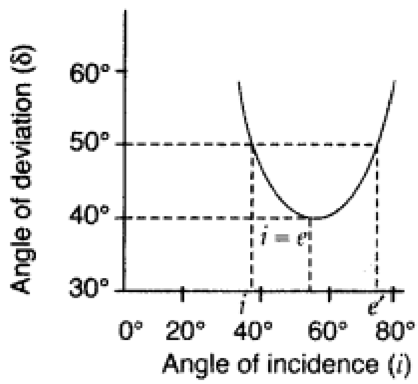
Comparing these two equations, we get

$r_1 + r_2 = A$

The total deviation δis the sum of deviations at the two faces,

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

$\delta = i + e - A$ - - - - - - - - - (i)



A plot between the angle of deviation and angle of incidence is shown in the figure. In general, any given value of δ, except for i = e, corresponds to two values i and hence of e. This, in fact, is expected from the symmetry of i and e in equation (i) above, i.e., δ remains the same if i and e are. interchanged. Physically, this is related to the fact that the path of ray in the diagram above can be traced back, resulting in the same angle of deviation. At the minimum deviation dm, the refracted ray inside the prism becomes parallel to its base. We have,

δ=dm

When angle of incidence (i) and angle of emergence (e) are equal, ie,

Angle i= angle r

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

$$\angle A = \angle d_m$$

$$\mu = \frac{\sin\left(\frac{A + d_m}{2}\right)}{\sin\frac{A}{2}} = \frac{\sin A}{\sin\frac{A}{2}} = \frac{2\sin\frac{A}{2}\cos\frac{A}{2}}{\sin\frac{A}{2}}$$

$$= 2\cos\frac{A}{2} = 2\cos 30^0 = 2 \times \frac{\sqrt{3}}{2} = 1.732$$

33. (i) The logic gate shown is the OR gate.

(ii)The truth table of the OR gate is

A	B	Y
0	0	0
1	0	1
0	1	1
1	1	1

(iii) The input wave forms A and B are discrete square waves.
For convenience, the components of the wave fronts A and B are shown by vertical dotted lines.

Between a & b, A = 1, B = 1 $\rightarrow$ y = 1

Between b & c, A = 0, B = 0, $\rightarrow$ y = 0

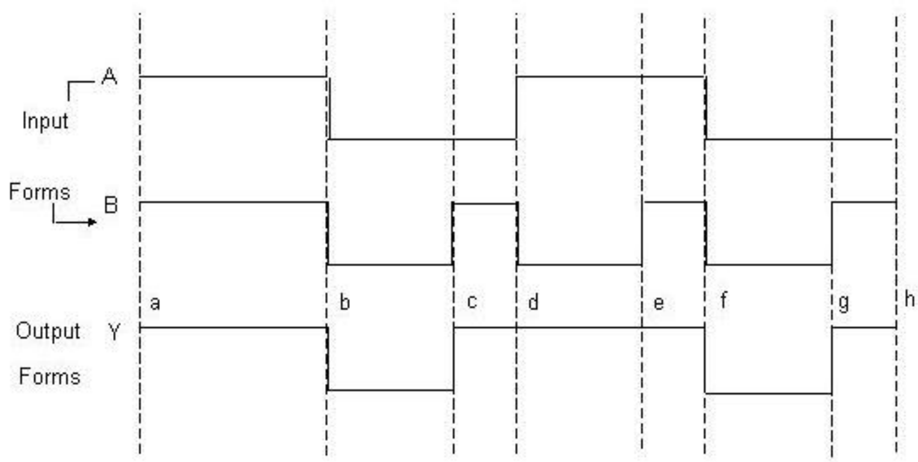
Between c & d, A = 0, B = 1, $\rightarrow$ y = 1

Between d & e, A = 1, B = 0 $\rightarrow$ y = 1

Between e & f, A = 1, B = 1 $\rightarrow$ y = 1

Between f & g, A = 0, B = 0 $\rightarrow$ y = 0

Between g & n, A = 0, B = 1 $\rightarrow$ y = 1



OR

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

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

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

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

The applied signal voltage = 20 mV

Thus, the voltage gain is

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