DPP – 2

CLASS – 12th

TOPIC – Refraction through pain surface and TR

Q.1 Give the ratio of velocities of two light shi waves travelling in vacuum and having wavelengths 4,000 Å and 8,000 Å. (P.S.S.C.E. 2008; C.B.S.E. 1999 S) refr

Or

How the speed of light in vacuum is affected by the change of wavelength of light?

Q.2 Out of speed, frequency and wavelength, name the parameters which remain same after refraction?

Or

How does the frequency of ultraviolet light change, when it passes from air to glass?

Q.3 State the conditions for the phenomenon of total internal reflection?

Q.4 Name two examples of total internal reflection.

Q.5 What is critical angle? Give one applicatic of total internal reflection.

Q.6 The refractive index of glass is 1-5 and that of water is 1.3. If the speed of light in water is 2.25 x 108 m s-1, what is the speed of light in glass?

Q.7 A light of wavelength 6,000 Å in air, enters a medium with refractive index 1.5. What will be frequency and wavelength of light in the medium?

Q.8 Monochromatic light of wavelength 589 nm is incident from air on water surface. What are wave-length, frequency and speed of (a) reflected and (b) refracted light? Refractive index of water is 1.33.

Q.9 Refractive indices of water and glass are 4/3 and 3/2 respectively. A ray of light travelling in water is incident on the water-glass interface at 30°. Calculate the angle of refraction.

Q.10 A mark is made at the bottom of a beaker and a microscope is focussed on it. The microscope is then raised through 0.015 m. To what height water must be poured into the beaker to bring the mark again into focus ? Given ${}^{a}\mu_{w} = 4/3$

Q.11 What is the apparent position of an object below a rectangular block of glass 6 cm thick [Fig. 2.38], if a layer of water 4 cm thick is on top of the glass? Given that ${}^{a}\mu_{g} = 3/2$ and ${}^{a}\mu_{w} = 4/3$

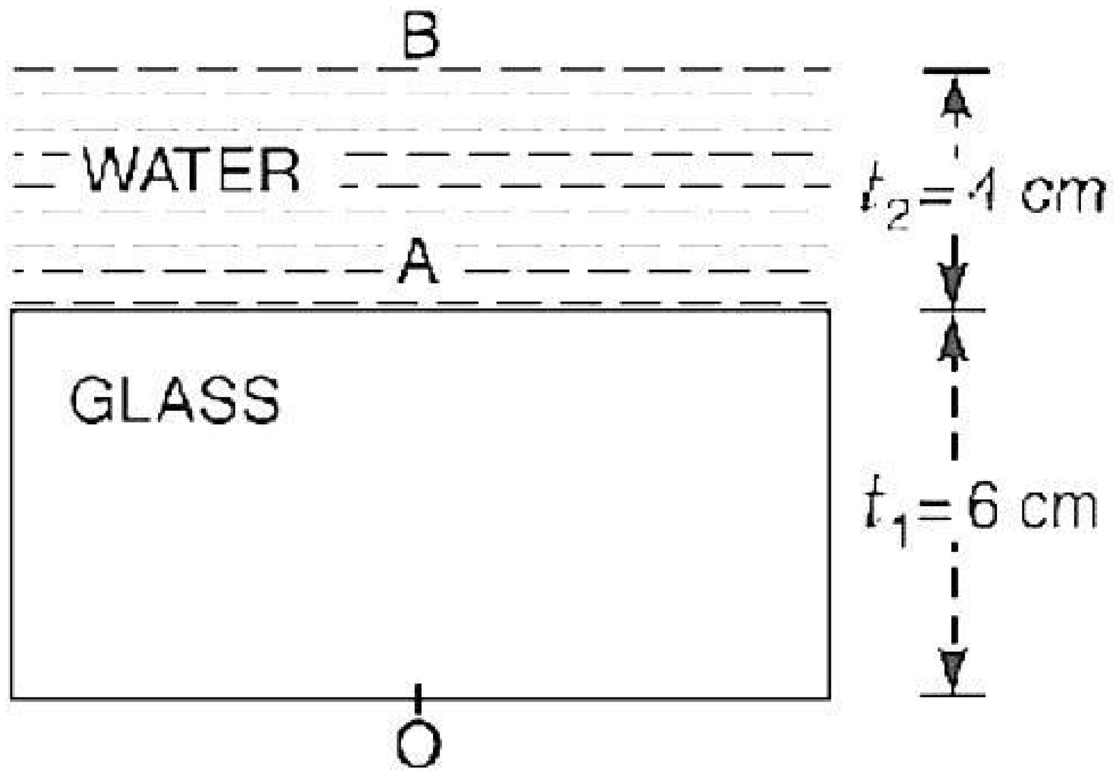

Fig. 2.38

Q.12 Find the critical angle for a glass the water interface, if refractive index of glass is 3/2 and that of water is 4/3.

or

A glass slab is immersed in water. Find the critical angle at glass-water interface. Given, " ${}^{a}\mu_{g} = 1{\cdot}5$ and ${}^{a}\mu_{w} = 1{\cdot}33$.

Q.13 Calculate the critical angle for a glass-air surface, if a ray of light which is incident in air on the surface is deviated through 15°, when its angle of incidence is 40°.

Q.14 A ray of light incident on the horizontal surface of a glass slab at 70° just grazes the adjacent vertical surface after refraction. Compute the critical angle and refractive index of the glass

SOLUTION

(PHYSICS) **RAY OPTICS**

DPP – 2

CLASS – 12th

TOPIC – Refraction through pain surface and TR

Sol.1. In vacuum, light of all the wavelengths travel with the same velocity i.e. $3 \times 10^8 \text{ m s}^{-1}$. Therefore, the ratio of the velocities of the two light waves is 1.

Sol.2. Frequency remains the same

Sol.3. For total internal reflection to take place, following conditions should be obeyed:

1. The ray incident on the interface should travel in optically denser medium.
2. The angle of incidence should be greater than the critical angle for the given pair of media.

Sol.4. 1. Brilliance of diamonds 2. Mirage

Sol.5. **Critical angle:** The angle of incidence in denser medium, for which angle of refraction in rarer medium is 90°, is called critical angle

Application: The ratio of the velocity of light in vacuum to the velocity of light in a medium is called absolute refractive index of the medium

Sol.6. Here, ${}^a\mu_g = 1{\cdot}5$; ${}^a\mu_g = 1{\cdot}3$

Let v_1 and v_2 be the speeds of light in glass and water respectively. If c is the speed of light in air, then

$$\frac{c}{v_1} = 1{\cdot}5 \quad \text{and} \quad \frac{c}{v_2} = 1{\cdot}3$$

$$\therefore \quad \frac{c}{v_2} \times \frac{v_1}{c} = \frac{1{\cdot}3}{1{\cdot}5}$$

$$\text{or} \quad v_1 = \frac{1{\cdot}3}{1{\cdot}5} \times v_2 = \frac{1{\cdot}3}{1{\cdot}5} \times 2{\cdot}25 \times 10^8$$

$$= \mathbf{1{\cdot}95 \times 10^8 \text{ m s}^{-1}}$$

Sol.7. Here wavelength of light in air,

$\lambda = 6{,}000 \text{ Å} = 6 \times 10^{-7} \text{ m}$;

refractive index of the medium, $\mu = 1{\cdot}5$

The frequency of the light does not change, when light travels from air to a refracting medium.

$\therefore \quad \nu' = \nu = \frac{c}{\lambda} = \frac{3\times10^8}{6\times10^{-7}}$ = **5×10^{14} s^{-1}**

The wavelength of light in the medium,

$\lambda' = \frac{\lambda}{\mu} = \frac{6,000}{1\cdot5}$ = **4,000 Å**

Sol.8. Here $\mu = 1\cdot33$;

wavelength of light in air, $\lambda_a = 589$ nm $= 589 \times 10^{-9}$ m

We know, velocity of light in air, $c = 3\times10^8$ m s^{-1}

(*a*) Wavelength of light on reflection remains unchanged.

Therefore, wavelength of light after reflection,

= **589 nm = 589 × 10^{-9} m**

Since after reflection, light travels in the same medium (air),

velocity of light after reflection = **3×10^8 m s^{-1}**

Frequency of light after reflection,

$$\nu = \frac{c}{\lambda_a} = \frac{3\times10^8}{589\times10^{-9}} = 5\cdot0934 \times 10^{14} \text{ Hz}$$

(*b*) On refraction, wavelength of light changes but its frequency remains unchanged.

Therefore, after refraction, frequency of light,

$\nu = 5\cdot0934 \times 10^{14}$ Hz

Let λ_w be the wavelength and v, velocity of light in water (after refraction).

Now, $v = \frac{c}{\mu} = \frac{3\times10^8}{1\cdot33} = 2\cdot256 \times 10^8$ m s^{-1}

Also, $\lambda_w = \frac{v}{\nu} = \frac{2\cdot256\times10^8}{5\cdot0934\times10^{14}}$

$= 442\cdot93 \times 10^{-19}$ m $= 442\cdot93$ nm

Sol.9. Here refractive index of glass ${}^a\mu_g = 4/3$;

refractive index of water, ${}^a\mu_w = 3/2$

Now, ${}^a\mu_w \times {}^w\mu_g = {}^a\mu_g$

Therefore, refractive index of glass *w.r.t.* water,

$${}^w\mu_g = \frac{{}^a\mu_g}{{}^a\mu_w} = \frac{3/2}{4/3} = 1\cdot125$$

Further, the angle of incidence, $i = 30°$

If r is the angle of refraction, then

$$\frac{\sin i}{\sin r} = 1\cdot125$$

or $\sin r = \frac{\sin 30°}{1{\cdot}125} = \frac{0{\cdot}5}{1{\cdot}125} = 0{\cdot}4444$

or $r = \mathbf{26° \, 23'}$

Sol.10. Here ${}^{a}\mu_{w} = 4/3$

The microscope was focussed directly on the mark over the beaker. On raising the microscope through 0.015 m, the mark no longer remains in focus. It will again come into focus, if the mark gets raised exactly through 0.015 m on pouring water into the beaker. Therefore, normal Shift, d = 0·015 m

If t is the height upto which water must be poured into the beaker, then normal shift,

$$d = t\left(1 - \frac{1}{{}^{a}\mu_{w}}\right)$$

or $0.015 = t\left(1 - \frac{1}{4/3}\right) = t\left(1 - \frac{3}{4}\right)$

or $t = \mathbf{0{\cdot}06\ m}$

Sol.11. Here ${}^{a}\mu_{g} = 1{\cdot}5,\ {}^{a}\mu_{w} = 1{\cdot}33$

The object Ŏ will appear to be raised due to the e normal shifts produced by water and glass. The normal shift in the position of the object due to glass,

$$d_1 = t_1\left(1 - \frac{1}{{}^{a}\mu_{g}}\right) = 6\left(1 - \frac{1}{3/2}\right) = 2\ \text{cm}$$

The normal shift in the position of the object due to water,

$$d_2 = t_2\left(1 - \frac{1}{{}^{a}\mu_{w}}\right) = 4\left(1 - \frac{1}{4/3}\right) = 1\ \text{cm}$$

Therefore, the object will appear to be displaced in upward direction through the distance,

$$d = d_1 + d_2 = 2 + 1 = \mathbf{3\ cm}$$

Sol.12. Here, the refractive index of glass = 1.5;

and the refractive index of water = 1.33

Therefore, the refractive index of glass w.r.t. water,

$${}^{w}\mu_{g} = \frac{1{\cdot}5}{1{\cdot}33} = 1{\cdot}1278$$

If C is critical angle for glass-water interface, then

$$\frac{1}{\sin C} = {}^{w}\mu_{g} = 1.1278$$

or $\sin C = \frac{1}{1 \cdot 1278} = 0 \cdot 8867$

or $\mathbf{C = 62°28'}$

Sol.13. Fig. 2.41 shows a ray of light AB incident on a glass-air surface at an angle of incidence, i = 40 deg The ray is refracted along BC, so that deviation in its path i.e. angle $\angle$ OBC = 15°

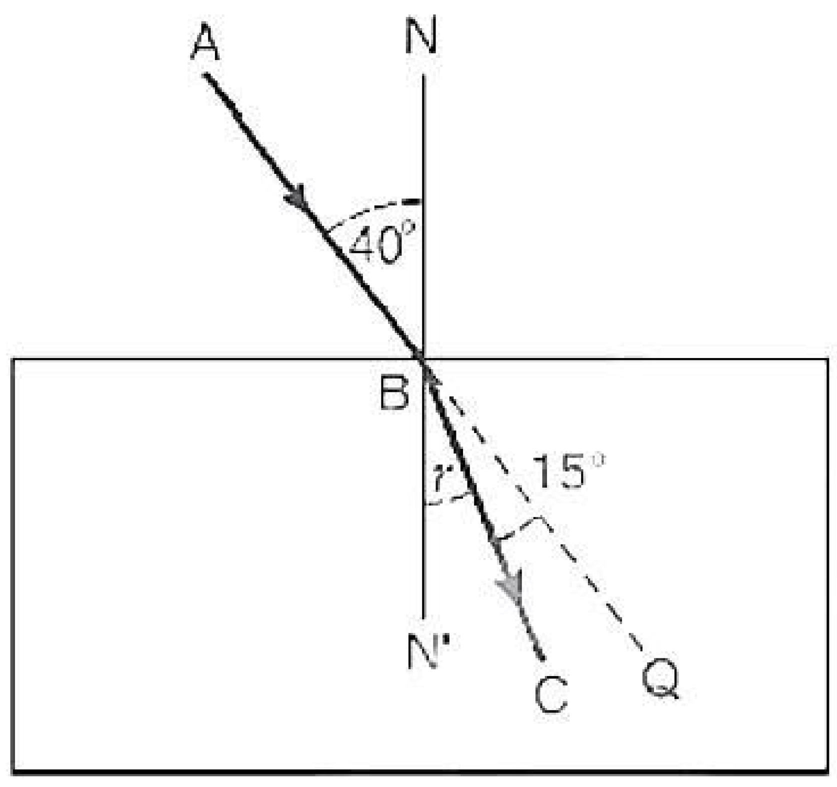

Fig. 2.41

Obviously, the angle of refraction,

$r = \angle CBN' = 40° - 15° = 25°$

If μ is refractive index of glass *w.r.t.* air, then

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin 40°}{\sin 25°} = \frac{0 \cdot 6428}{0 \cdot 4226} = 1 \cdot 52$$

If C is critical angle for glass-air surface, then

$$\mu = \frac{1}{\sin C}$$

or $\sin C = \frac{1}{\mu} = \frac{1}{1 \cdot 52} = 0 \cdot 6579$

or $C = \mathbf{41 \cdot 14°}$

Sol.14. A ray of light PA incident at an angle of 70° on the horizontal surface X_1 Y_1 gets refracted along AB into the glass slab at angle of refraction r (say) and then comes to incident at the point B on the vertical surface Y_1 Y_2 The ray of light will graze along the surface Y_1 Y_2, if the angle of incidence at point B on the vertical surface Y_1 Y2 equals the critical angle C for the glass-air interface [Fig. 2.42].

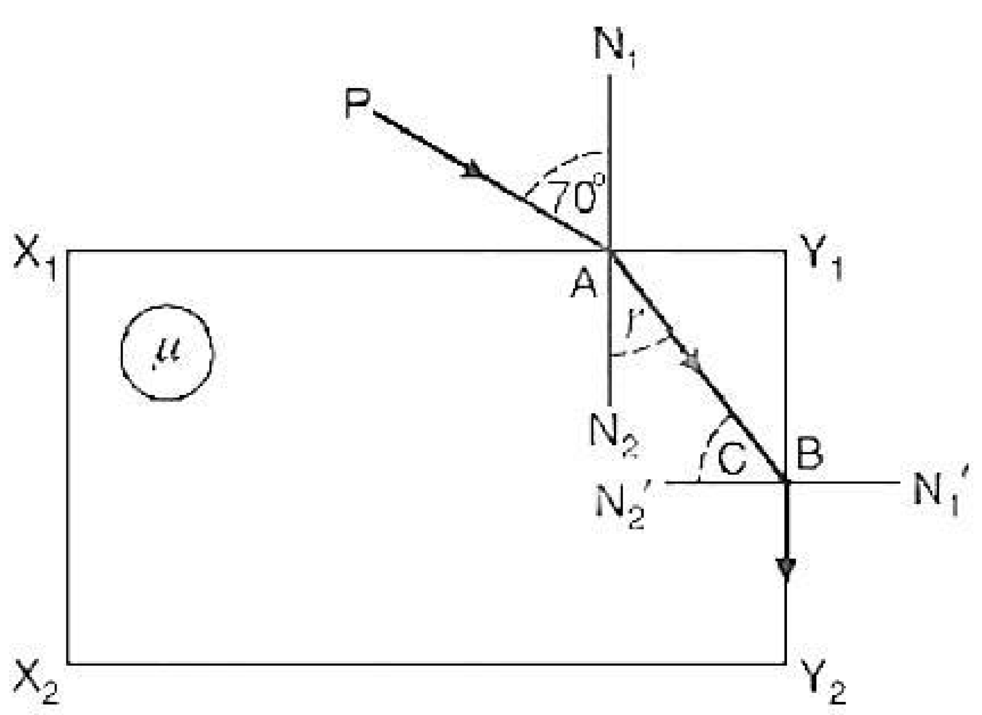

Fig. 2.42

Since $N_1 N_2$ and $N_1' N_2'$ are perpendicular to each other,

$$r + C = 90° \quad \text{or} \quad r = 90° - C$$

For refraction at point A, we have

$$\frac{\sin 70°}{\sin r} = \mu \quad \text{or} \quad \sin r = \frac{\sin 70°}{\mu}$$

$$\text{or } \sin(90° - C) = \frac{\sin 70°}{\mu}$$

$$\text{or} \quad \cos C = \frac{\sin 70°}{\mu} \quad \text{...}(i)$$

Also, for refraction at point B, we have

$$\frac{\sin 70°}{\sin r} = \mu \quad \text{or} \quad \sin r = \frac{\sin 70°}{\mu}$$

$$\text{or } \sin(90° - C) = \frac{\sin 70°}{\mu}$$

$$\text{or} \quad \cos C = \frac{\sin 70°}{\mu}$$

Also, for refraction at point B, we have

$$\frac{1}{\sin C} = \mu$$

$$\text{or} \quad \sin C = \frac{1}{\mu} \quad \text{...}(ii)$$

Dividing the equation (*ii*) by the equation (*i*), we have

$$\frac{\sin C}{\cos C} = \frac{1}{\mu} \times \frac{\mu}{\sin 70°}$$

$$\text{or} \quad \tan C = \frac{1}{\sin 70°} = \frac{1}{0{\cdot}9397} = 1{\cdot}0642$$

$$\text{or} \quad C = \mathbf{46° \, 47'}$$

$$\text{Now,} \quad \mu = \frac{1}{\sin C} = \frac{1}{\sin 46°47'} = \frac{1}{0{\cdot}7287} = \mathbf{1{\cdot}372}$$