Light Refraction and Refraction

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Home Assignment

short answer type questions

(b) Give three examples of materials that refract light rays. What happens to the speed of the light rays when they enter these materials?

Ans: Three examples of materials that refract light rays are water, glass and diamond. When light rays (travelling in air) enter these materials, their speed decreases according to their densities.

(ii) Define Snell's law of refraction. A ray of light is incident on a glass slab at an angle of incidence of 60°. If the angle of refraction be 32.7°, calculate the refractive index of glass. (Given: sin 60° = 0.866 and sin 32.7° = 0.540).

Ans: Given,

Incident angle $\theta_1 = 60°$

Angle of refraction $\theta_2 = 32.7°$

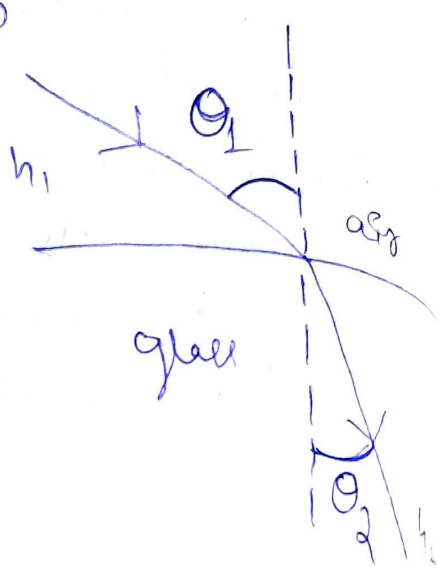
from Snell's law

$n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_2 = \dfrac{n_1 \sin\theta_1}{\sin\theta_2}$

$n_2 = \dfrac{1 \times \sin 60^\circ}{\sin 32.7^\circ}$

$n_2 = \dfrac{0.866}{0.540} = 1.6$



Hence, the refractive index of glass is 1.6.

(b) The speed of light in vacuum and in two different glasses is given in the table below:

Medium	Speed of light
vacuum	3×10^8 m/s
Flint glass	1.86×10^8 m/s
Crown glass	1.97×10^8 m/s

(a) Calculate the absolute refractive indexes of flint glass and crown glass.

Ans. Absolute refractive index of crown glass = Speed of light in vacuum / Speed of light in crown glass

$$= \frac{3 \times 10^8}{1.86 \times 10^8} = 1.61$$

(b) Calculate the relative refractive index for light going from crown glass to flint glass.

Ans. Relative refractive index for light going from crown glass to flint glass = Speed of light in crown glass / Speed of light in flint glass

$$= \frac{1.97 \times 10^8}{1.86 \times 10^8} = 1.059$$

(2) The speed of light in air is 3×10^8 m/s. In medium X its speed is 2×10^8 m/s and in medium Y the speed of light is 2.5×10^8 m/s. Calculate

(a) air n_X

Ans. air n_X = Speed of light in air / Speed of light medium X

air $n_x = \frac{3\times10^8}{2\times10^8} = 1.5$

(b) air n_y

Ans. air n_y = $\frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$

$= \frac{3\times10^8}{2.5\times10^8} = 1.2$

(c) $x n_y$

Sol $x n_y$ = $\frac{\text{Speed of light in medium } x}{\text{Speed of light in medium } y}$

$= \frac{2\times10^8}{2.5\times10^8} = 0.8$

(4) Ans. Refractive index of a medium is the speed of light in a medium of refractive index $\frac{6}{5}$ of its speed in air is 3,00,000 km/s.

Given,

Refractive index of medium = $\frac{6}{5}$

Speed of light in air = 3,00,000 km/s

We know that,
Refractive index of medium
= Speed of light in air / Speed of light in medium

1.2 = 6/5 = 300000 / Speed of light in medium

⇒ Speed of light in medium
= 300000 × 5 / 6 = 250000 km/s

Hence, the speed of light in medium is 250000 km/s.

(15) The refractive index of glass is 1.5. Calculate the speed of light in glass. The speed of light in air is 3×10^8 m/s.

Ans. Refractive index of glass = 1.5
Speed of light in air = 3×10^8 m/s
We know that,
Refractive index of glass =
Speed of light in air / Speed of light in glass

$\Rightarrow 1.5 = \frac{3 \times 10^8}{\text{Speed of light in glass}}$

Speed of light in glass $= \frac{3 \times 10^8}{1.5} = 2 \times 10^8$ m/s

Hence, the speed of light in glass $= 2 \times 10^8$ m/s.

(b) The speed of light in water is 2.25×10^8 m/s. If the speed of light in vacuum be 3×10^8 m/s. Calculate the refractive index of water.

Ans Given,

Speed of light in vacuum $= 3 \times 10^8$ m/s

Speed of light in water $= 2.25 \times 10^8$ m/s

We know that,

Refractive index of water $= \frac{\text{Speed of light in air}}{\text{Speed of light in water}}$

$= \frac{3 \times 10^8}{2.25 \times 10^8} = 1.33$

(17) Light enters from air into diamond which has a refractive index of 2.42. Calculate the speed of light in diamond. The speed of light in air is 3×10^8 m/s.

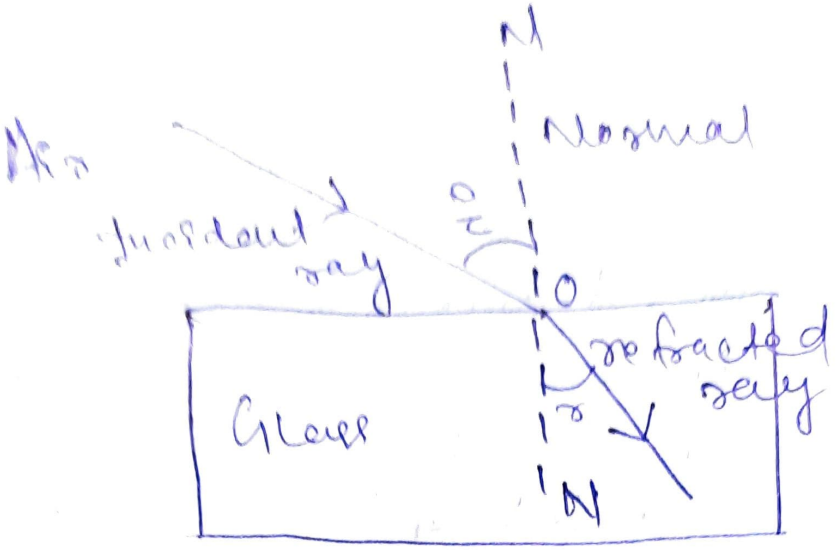
ans. Speed of light in air = 3×10^8 m/s.
Refractive index of diamond = 2.42
We know that,
Refractive index of diamond =
$$\frac{\text{Speed of light in air}}{\text{Speed of light in diamond}}$$

$$2.42 = \frac{3 \times 10^8}{\text{Speed of light in diamond}}$$

Speed of light in diamond
$$= \frac{3 \times 10^8}{2.42} = 1.23 \times 10^8$$
Hence, the speed of light in diamond is 1.23×10^8 m/s.

Long answer type questions.

(18)(a) State and explain the laws of refraction of light with the help of a labelled diagram.



First law :- According to the first law of refraction, the incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

Second law :- According to the second law of refraction, the ratio of sine of angle of incidence is constant to the sine of angle of refraction for a given pair of media.

(b) What is meant by the refractive index of a substance? The ratio of speed of light

In vaccum the speed of light in a medium is called refractive index of that substance.

(c) Light travels through air at 300 million m/s, on entering water it slows to 225 million m/s. Calculate the refractive index of water.

ans. Speed of light in air = 300 million m/s
Speed of light in water = 225 million m/s
We know that,
Refractive index of water =

$$= \frac{\text{Speed of light in air}}{\text{Speed of light in water}}$$

$$= \frac{300 \text{ million m/s}}{225 \text{ million m/s}} = 1.33$$

Hence, the refractive index of water is 1.33.

Multiple choice Questions (MCQs)

(1) The refractive index of four substances P, Q, R and S are 1.50, 1.36, 1.77 and 1.31

respectively. The speed of light is the maximum in the substance :

(a) P (b) Q

(c) R (d) S

Sol. In substance S, the speed of light is maximum because lesser the refractive index, more will be the speed of light.

(20) The refractive indexes of four materials A, B, C and D are 1.33, 1.43, 1.71 and 1.52 respectively. When the light rays pass from air into these materials they refract the maximum in :

(a) material A (b) material B

(c) material C (d) material D

Sol. The refraction of light rays will be maximum in the substance having highest refractive index. Material C has highest refractive index. So, the refraction of light rays is

maximum in material 2.

(21) The refractive index of glass for light going from air to glass is 3/2. The refractive index for light going from glass to air will be :

(a) 1/3 (b) 4/5

(c) 4/6 (d) 5/2

Ans. $a\mu_g = 3/2$

$g\mu_a = \frac{1}{3/2} = \frac{2}{3}$ which is equal to 4/6.

(22) The refractive indices of four substances A, B, C and D are 1.44, 1.52, 1.65 and 1.36 respectively. When the light travelling in air is incident in these media at equal angles, the angle of refraction will be the minimum :

(a) Material A

(b) Material B

(c) Material C

(d) Material D

Ans. When light travelling in air

is incident on these mediums at equal angles, the angle of refraction will be minimum in medium with highest refractive index.

(23) The speed of light in substance x is 1.25×10^8 m/s and that in air is 3×10^8 m/s, the refractive index of this substance will be

(a) 2.4 (b) 0.4
(c) 4.2 (d) 3.75

Sol: Refractive index = Speed of light in air / Speed of light in medium

$= \frac{3 \times 10^8}{1.25 \times 10^8} = 2.4$

(24) The refractive indices of four substances P, Q, R and S are 1.77, 1.50, 2.42 and 1.31 respectively. When the light travelling in air is incident

in three media at equal angles, the angle of refraction will be the maximum?

(a) Substance P (b) Substance Q
(c) Substance R (d) Substance S

Sol The higher the refractive index the more the angle of refraction will be.

21. The refractive index of water is
(a) 1.33 (b) 1.50
(c) 0.42 (d) 1.36

Sol Refractive index of water =
$$\frac{\text{Speed of light in air}}{\text{Speed of light in water}}$$
$$= \frac{3 \times 10^8}{2.25 \times 10^8} = 1.33$$

22. The refractive index of water with respect to air is 4/3. The refractive index of air with respect to water will be
(a) 1.75 (b) 0.50
(c) 0.75 (d) 0.25

Sol Refractive index of air with respect to water = $\frac{1}{\text{Refractive index of water with respect to air}}$

$= \frac{1}{4/3} = 3/4 = 0.75$

(27) Refractive indices of water, sulphuric acid, glass and Carbon disulphide are 1.33, 1.43, 1.53 and 1.63 respectively. The light travel slowest in

(a) sulphuric acid (b) glass
(c) water (d) Carbon disulphide

Sol higher the refractive index, slower the light will travel.

(28) The refractive index of glass with respect to air is 3/2 and the refractive index of water with respect to air is 4/3. The refractive index of glass with respect to air will be :

(a) 1.5 (b) 1.2
(c) 1.42 (d) 1.12

Sol Refractive index of glass with respect to water = Refractive index of glass with respect to air / Refractive index of water with respect to air

$= \frac{3/2}{4/3} = \frac{9}{8} = 1.125$