Question 10.1:

Monochromatic light of wavelength 589 nm is incident from air on a water surface. Wha are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.

Answer

Wavelength of incident monochromatic light,

λ = 589 nm = 589×10^{-9} m

Speed of light in air, $c = 3 \times 10^8$ m/s

Refractive index of water, $\mu = 1.33$

(a) The ray will reflect back in the same medium as that of incident ray. Hence, the wavelength, speed, and frequency of the reflected ray will be the same as that of the incident ray.

Frequency of light is given by the relation,

$$\nu = \frac{c}{\lambda}$$

$$= \frac{3\times 10^8}{589\times 10^{-9}}$$

$$= 5.09\times 10^{14}\,\text{Hz}$$

Hence, the speed, frequency, and wavelength of the reflected light are 3×10^8 m/s, 5.09×10^{14} Hz, and 589 nm respectively.

(b) Frequency of light does not depend on the property of the medium in which it is travelling. Hence, the frequency of the refracted ray in water will be equal to the frequency of the incident or reflected light in air.

$\therefore$ Refracted frequency, $\nu = 5.09 \times 10^{14}$ Hz

Speed of light in water is related to the refractive index of water as:

$$v = \frac{c}{\mu}$$

$$v = \frac{3\times 10^8}{1.33} = 2.26\times 10^8\,\text{m/s}$$

Wavelength of light in water is given by the relation,

$$\lambda = \frac{v}{\nu}$$

$$= \frac{2.26\times10^8}{5.09\times10^{14}}$$

$$= 444.007\times10^{-9}\text{ m}$$

$$= 444.01\text{ nm}$$

Hence, the speed, frequency, and wavelength of refracted light are 2.26×10^8 m/s, 444.01nm, and 5.09×10^{14} Hz respectively.

Question 10.2:

What is the shape of the wavefront in each of the following cases:

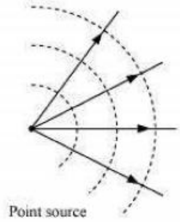
(a) Light diverging from a point source.

(b) Light emerging out of a convex lens when a point source is placed at its focus.

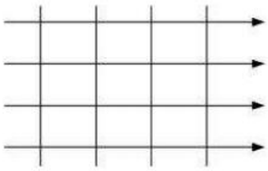
(c) The portion of the wavefront of light from a distant star intercepted by the Earth.

Answer

(a) The shape of the wavefront in case of a light diverging from a point source is spherical. The wavefront emanating from a point source is shown in the given figure.



(b) The shape of the wavefront in case of a light emerging out of a convex lens when a point source is placed at its focus is a parallel grid. This is shown in the given figure.



(c) The portion of the wavefront of light from a distant star intercepted by the Earth is a plane.

Question 10.3:

(a) The refractive index of glass is 1.5. What is the speed of light in glass? Speed of light in vacuum is 3.0×10^8 m s^{-1})

(b) Is the speed of light in glass independent of the colour of light? If not, which of the two colours red and violet travels slower in a glass prism?

Answer

(a) Refractive index of glass, $\mu = 1.5$

Speed of light, $c = 3 \times 10^8$ m/s

Speed of light in glass is given by the relation,

$$v = \frac{c}{\mu}$$

$$= \frac{3\times10^8}{1.5} = 2\times10^8\text{ m/s}$$

Hence, the speed of light in glass is 2×10^8 m/s.

(b) The speed of light in glass is not independent of the colour of light.

The refractive index of a violet component of white light is greater than the refractive index of a red component. Hence, the speed of violet light is less than the speed of red light in glass. Hence, violet light travels slower than red light in a glass prism.

Question 10.4:

In a Young's double-slit experiment, the slits are separated by 0.28 mm and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1.2 cm. Determine the wavelength of light used in the experiment.

Answer

Distance between the slits, d = 0.28 mm = 0.28×10^{-3} m

Distance between the slits and the screen, D = 1.4 m

Distance between the central fringe and the fourth (n = 4) fringe,

u = 1.2 cm = 1.2×10^{-2} m

In case of a constructive interference, we have the relation for the distance between the two fringes as:

$$u = n\lambda \frac{D}{d}$$

Where,

n = Order of fringes = 4

λ = Wavelength of light used

$$\therefore \lambda = \frac{ud}{nD}$$

$$= \frac{1.2\times10^{-2}\times0.28\times10^{-3}}{4\times1.4}$$

$$= 6\times10^{-7}$$

$$= 600 \text{ nm}$$

Hence, the wavelength of the light is 600 nm.

Question 10.5:

In Young's double-slit experiment using monochromatic light of wavelengthλ, the intensity of light 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?

Answer

Let I_1 and I_2 be the intensity of the two light waves. Their resultant intensities can be obtained as:

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