Chapter–10
Wave Optics
Class – XII
Subject – Physics

10.1. Monochromatic light of wavelength 589 nm is incident from air on awater surface. What are the wavelength, frequency and speed of
- **(a) reflected, and**
- **(b) Refracted light? Refractive index of water is 1.33.**

Sol.

Given:
λ = 589 nm
n = 1.33

a) For Reflected light all parameters will be same. So

λ = 589 nm
f = c / λ = 5.09 x 10^{14} Hz
c = 3 x 10^{8} m / s

b) For refracted light, frequency will be same.
speed, v = c / n = 2.26 x 10^{8} m / s
λ = v / f = 444 nm

10.2. What is the shape of the wave front 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 wave front of light from a distant star intercepted by the Earth.**

Sol.

a) Spherical
b) Plane
c) Plane

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 × 108 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?**

Sol.

a) v = c / n
$= 3 \times 10^8 / 1.5$
$= 2 \times 10^8$ m / s
b) No, it is not independent. Violet will travel slower than red.

10.4. **In a Young's double-slit experiment, the slits are separated by0.28 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.**

Sol.

Given:
d = 0.28 mm

D = 1.4 m
Fringe spacing = 1.2 cm

We know
$D\lambda / d = 1.2 \times 10^{-2}$
Calculation yields
$\lambda = 600$ nm

10.5. **In Young's double-slit experiment using monochromatic light ofwavelength λ, 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?**

Sol.

We know,

Intensity I = 4I'cos2Θ / 2

Θ = 0 at central maxima
So I' = Io / 4
At path difference = λ/3
Phase difference
Θ'= (2π / λ).path difference = 2π / 3
Thus intensity,
I"= 4I'cos2(2π / 3) (1 / 2)
= I'

or I" = K/4

10.6. **In a double-slit experiment the angular width of a fringe is found tobe 0.2° on a screen placed 1 m away. The wavelength of light used is 600 nm. What will be the angular width of the fringe if the entire experimental apparatus is immersed in water? Take refractive index of water to be 4/3.**

Sol.

Given:
D = 1 m
Angular width = 0.2
λ = 600 nm
μ = 4 / 3

Angular separation = 0.2 = λ / d
Which gives
d = 3 micro meters
Using water,
μ = 4 / 3
v = c / n
= 2.25×10^8 m / s
f = c / λ
= 5×10^{14} Hz
λ' = v / f
= 450 nm
Therefore,
β' = λ'D / d
= 0.15

10.7. **What is the Brewster angle for air to glass transition? (Refractiveindex of glass = 1.5.)**

Sol.

Brewster angle,

$\tan^{-1}(1.5) = 56.31^o$

10.8. Light of wavelength 5000 Å falls on a plane reflecting surface. Whatare the wavelength and frequency of the reflected light? For what angle of incidence is the reflected ray normal to the incident ray?

Sol.

Given:

λ = 5000 angstroms

Wavelength will be same for the reflected light.

Frequency = c / λ

= 6×10^{14} Hz

Reflected ray will be normal to the incident ray for angle of incidence = 45^o.

10.9. Estimate the distance for which ray optics is good approximationfor an aperture of 4 mm and wavelength 400 nm.

Sol.

Given:

λ = 400 nm

a = 4 mm

Using the formula

$Z_F = a^2 / \lambda$

$= 40$ m