Q1/ A light ray is incident on a mirror surface at an angle of 30 degrees with the normal. Calculate the angle of reflection?

Sol: Incident angle (θ_1) = 30 degrees

According to the law of reflection, the angle of reflection is equal to the angle of incidence. Therefore, the angle of reflection is also 30 degrees.

Q2/Light traveling through an optical fiber (n=1.44) reaches the end of the fiber and exits into air. If the angle of incidence on the end of the fiber is 30º, what is the angle of refraction outside the fiber?

Sol:

Since the light is now traveling from the fiber into air, we will call the fiber material 1 and air material 2.

Thus, $\mathbf{n_1 = 1.44, n_2 = 1.00, and\ \theta_1 = 30^o}$. Snell's Law then becomes:

$$(1.44) \sin 30^o = 1.00 \sin \theta_2.$$

$$\sin \theta_2 = (1.44/1.00) \sin 30^o = 1.44\ (0.500) = 0.720$$

$$\theta_2 = \sin^{-1} (0.720) = 46^o.$$

Notice that this time, the angle of refraction is larger than the angle of incidence. The light is bending away from the normal as it enters a rarer material.

Q3/ A light ray traveling in air strikes the surface of water (refractive index = 1.33) at an angle of 45 degrees with the normal. Determine the angle of refraction and the angle of reflection.

Sol:

Given: Incident angle (θ_1) = 45 ^{o}

Refractive index of water (n_2) = 1.33

Using Snell's law: $n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$

Substituting the known values:

$1.0 * \sin 45^o = 1.33 * \sin \theta_2$

Rearranging the equation and solving for

$\sin \theta_2 = (1.0 * \sin 45^o) / 1.33$

$\theta_2 = \sin^{-1} ((1.0 * \sin 45^o) / 1.33)$

$\theta_2 = 32.117^o$

Q4/ The primary mirror of the orbiting Hubble Space Telescope has a diameter of 2.4 m. Being in orbit, this telescope avoids the degrading effects of atmospheric distortion on its resolution. What is the angle between two just-resolvable point light sources (perhaps two stars)? Assume an average light wavelength of 550 nm.

Sol:

The Rayleigh criterion for the minimum resolvable angle is given by Equation**:**

$$\theta = 1.22\,\lambda/D$$

$\theta = 1.22\ (500 \times 10^{-9}\ \text{m} / 2.4\ \text{m}) \longrightarrow \theta \approx 2.80 \times 10^{-7}\ \text{rad.}$

Q5/Calculate the numerical aperture for a fiber cable of which n_{core} =1.5 and $n_{cladding}$ =1.48. The launching takes place from air.

Sol:

$$NA = \sqrt{n_{core}^2 - n_{cladding}^2}$$

$$NA = \sqrt{1.5^2 - 1.48^2}$$

$$NA = 0.244$$