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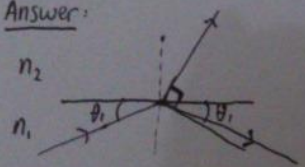
2.7 Light travelling in air strikes a glass plate at an angle $\theta_1 = 33°$, where θ_1 is measured between the incoming ray and the glass surface. Upon striking glass, part of the beam is reflected and part is refracted. If the refracted and reflected beams make an angle of 90° with each other, what is the refractive index of the glass? What is the critical angle for this glass?

Answer:



$n_1 \sin \phi_1 = n_2 \sin \phi_2$

$\Rightarrow n_1 = n_{air} = 1$

$\Rightarrow \phi_1 = 90° - 33° = 57°$

$\Rightarrow \phi_2 = 33°$

$\sin 57° = n_2 \sin 33°$

$n_2 = \frac{\sin 57°}{\sin 33°} = 1.54$

So, the refractive index of the glass is 1.54

$\sin \phi_c = \frac{n_1}{n_2}$

$\phi_c = 40.5$

So, the critical angle for the glass is 40.5

2.9 A 45°-45°-90° prism is immersed in alcohol (n=1.45). What is the minimum refractive inde the prism must have if a ray incident normally on one of the short faces is to be totally reflected at a long face of the prism?

Answer:

n_1 : the index refraction of the prism

n_2 : the index refraction of alcohol = 1.45

θ_1 : the angle of incidence with the long face = 45°

$\theta_2 = 90°$

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

$n_1 \times \frac{1}{2}\sqrt{2} = 1.45 \times 1$

$n_1 = 2.05 \rightarrow \therefore$ So, the minimum refractive index of the prism is 2.05

2.12 Calculate the numerical aperture of a step-index fiber having $n_1 = 1.48$ and $n_2 = 1.46$. What is the maximum entrance angle θ_{omax} for the fiber if the outer medium is air with $n = 1.00$?

Answer:

$NA = \sqrt{(n_1^2 - n_2^2)} = \sqrt{(1.48)^2 - (1.46)^2} = 0.242$

$\theta_{o\,max} = \sin^{-1} NA$

$= \sin^{-1} 0.242$

$= 14°$

2.19 (a) Determine the normalized frequency at 820 nm for a step-index fiber having a 25 μm core radius, $n_1 = 1.48$, and $n_2 = 1.46$.

(b) How many modes propagate in this fiber at 820 nm?

(c) How many modes propagate in this fiber at 1320 nm?

(d) How many modes propagate in this fiber at 1550 nm?

(e) What percent of the optical power flows in the cladding in each case?

Answer:

(a) The normalized frequency is:

$$V = \frac{2\pi}{\lambda} a (NA) \rightarrow NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$NA = 0.242$$

$$V = \frac{2\pi \times 25 \times 10^{-6} \times 0.242}{820 \times 10^{-9}} = 46.33$$

(b) $M_{820} = \frac{V^2}{2} \approx 1073$

(c) $V = \frac{2\pi \times 25 \times 10^{-6} \times 0.242}{1320 \times 10^{-9}} = 28.7833$

(d) $V = \frac{2\pi \times 25 \times 10^{-6} \times 0.242}{1550 \times 10^{-9}} = 24.512$

$$M_{1550} = \frac{V^2}{2} \approx 300$$