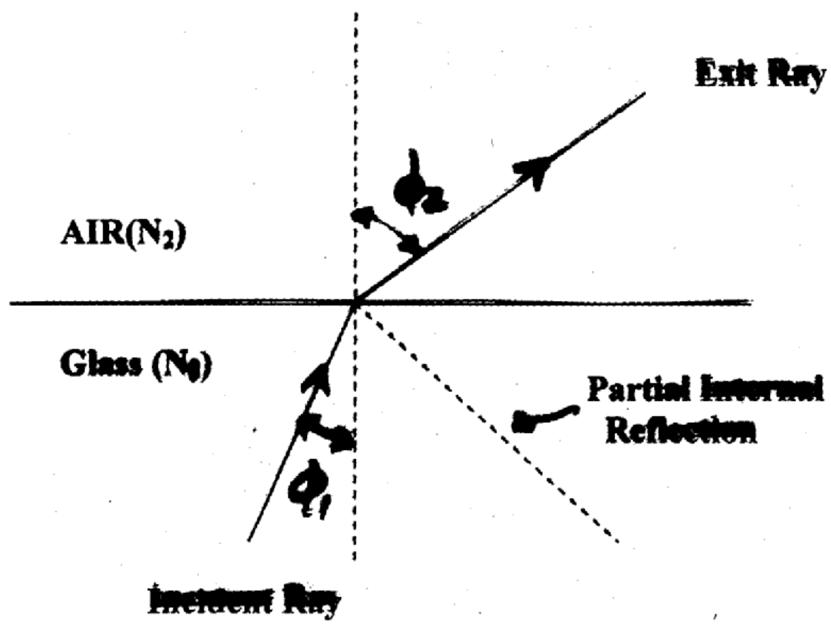
Unit - 1

Basics
of
Transmission of Light

RAY THEORY TRANSMISSION

REF INDEX $\mu = \dfrac{\text{VELOCITY OF LIGHT IN VACCUM}}{\text{VELOCITY OF LIGHT IN THE MEDIUM}}$

- THE DENSER THE MEDIUM, THE LOWER IS THE VELOCITY OF LIGHT



$N_2 < N_1$

SNELL'S LAW   N1 SIN ϕ_1= N2 SIN ϕ_2

CRITICAL ANGLE(ϕ_C) ANGLE OF INCIDENCE FOR WHICH ANGLE OF REFRACTION IS 90^0

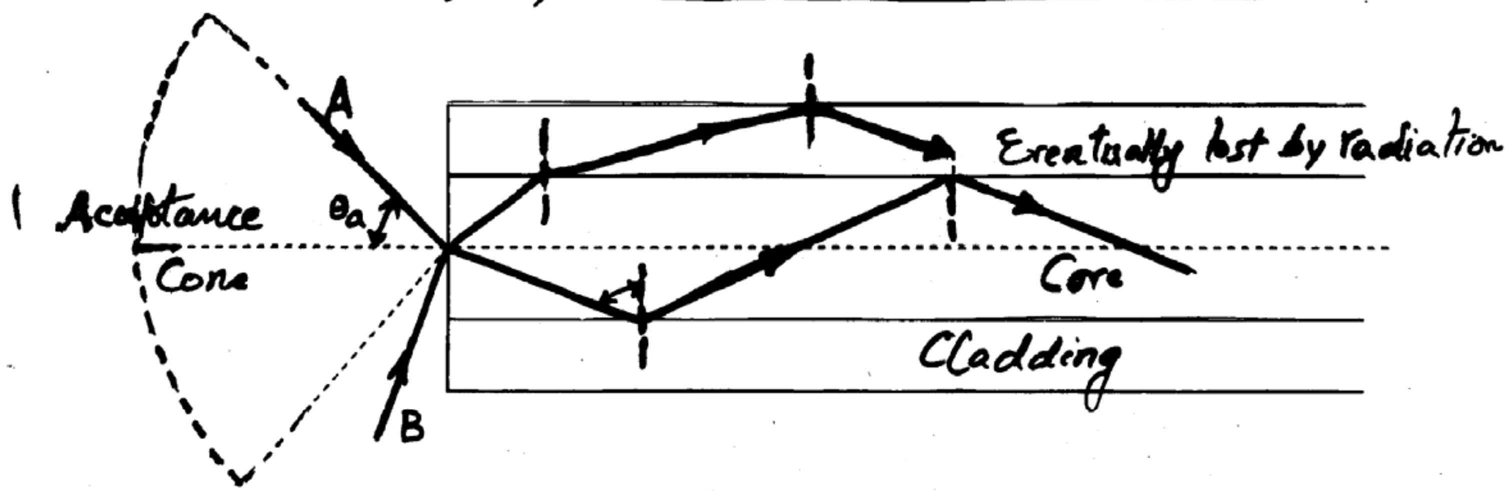
NI SIN ϕ_C = N2

N1/N2= 1/SIN ϕ_C OR SIN ϕ_C = N2/N1

AT ANGLE OF INCIDENCE, GREATER THAN ϕ_{C}, THE LIGHT IS REFLECTED BACK INTO THE ORGINATING DIELECTRIC MEDIUM (η = 99.9%)

$\rightarrow$ TOTAL INTERNAL REFLECTION .

ACCEPTANCE ANGLE ($\theta\alpha$) - LIGHT LAUNCHED INTO AN OPT. FIBER

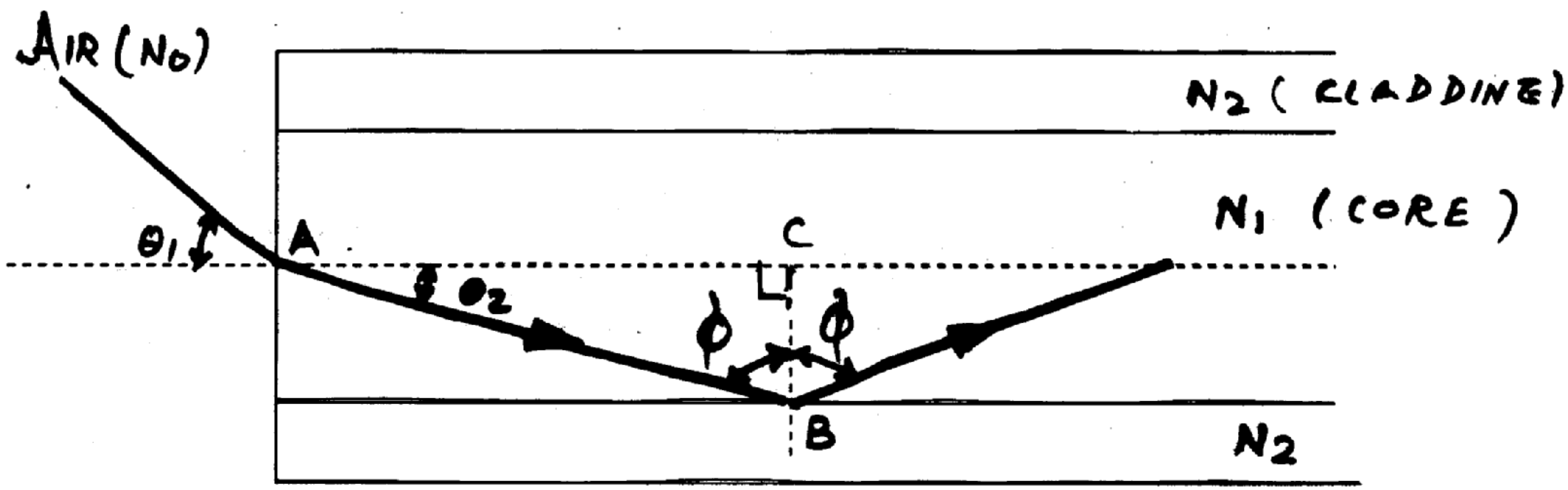


- NOT ALL RAYS ENTERING THE FIBER CORE WLL CONTINUE TO BE PROPAGATED DOWN ITS LENGTH.

-RAYS TO BE TRANSMITTED BY TIR WITHIN THE FIBER CORE MUST BE INCIDENT ON THE FIBER CORE WITHIN THE ACCEPTANCE CONE(HALF ANGLE= ϕ_a)

$\phi_{a=}$ MAXIMUM ACCEPTANCE ANGLE FOR THE FIBER.

NUMERICAL APERTURE (NA)

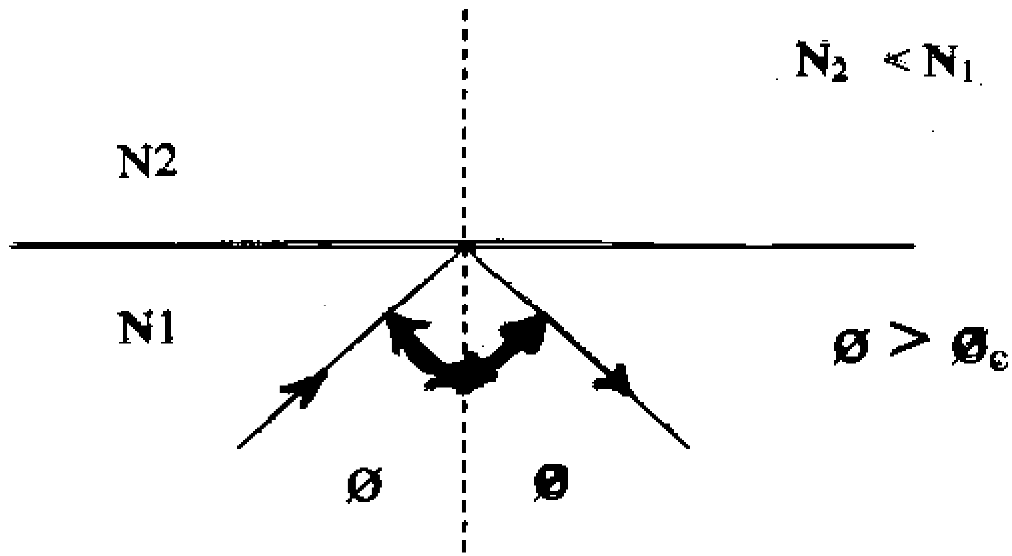


THREE MEDIA- CORE/ CLADDING/ AIR

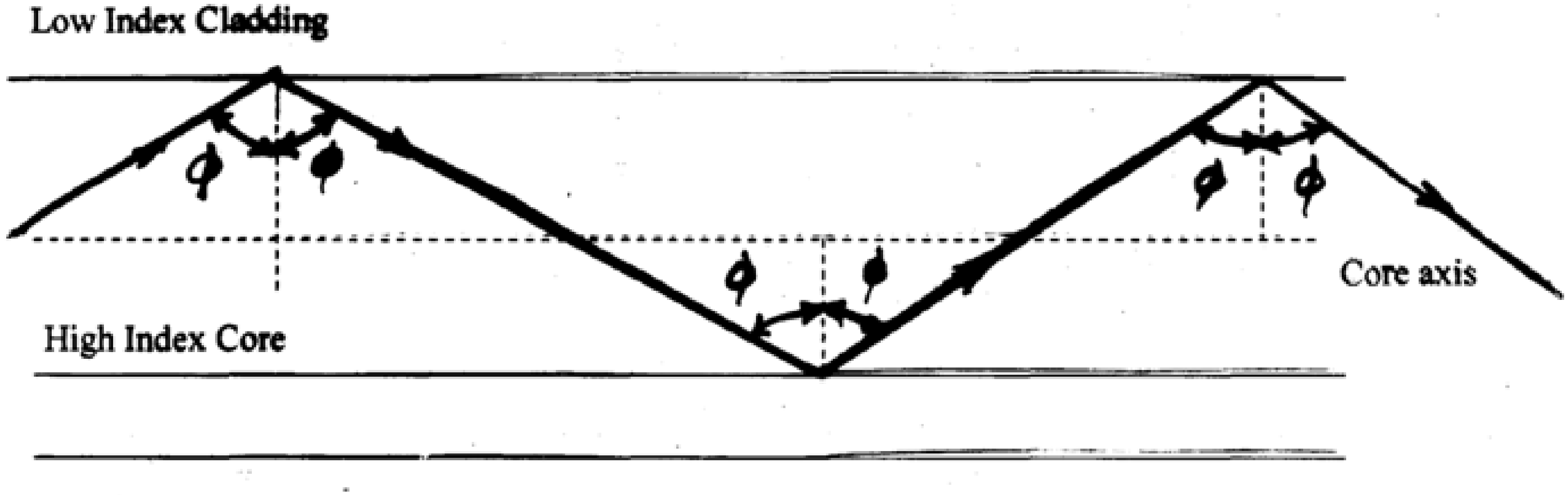
$\theta_1 < \theta_a$ (ACCEPANCE ANGLE)

$N_2 < N_1$

TOTAL INTERNAL REFLECTION (TIR)



- TIR OCCURS WHEN ANGLE OF INCIDENCE EXCEEDS THE CRITICAL ANGLE.
- LIGHT TRAVELS DOWN AN OPTICAL FIBER AT A SHALLOW ANGLE (LESS THAN $9O^0$ -ϕc)VIA A SERIES OF TOTAL INTERNAL REFLECTIONS



TRANSMISSION OF LIGHT RAY IN A PERFECT OPTICAL FIBER

IMPERFECTIONS AT THE CORE CLADDING INTERFACE WOULD RESULT IN LOSSES OF THE LIGHT RAY INTO THE CLADDING

$N_0 \, SIN\theta_1 = N_1 SIN \, \theta_2$--------1

INΔ ABC $\phi = \pi/2 - \theta_2$ OR $\theta_2 = (\pi/2 - \phi)$

WHERE $\phi > \phi_C$

EQUATION (1) BECOMES $N_0 \, SIN \, \theta_1 = N_1 SIN \, \theta_2 = N_1 SIN \, (\pi/2 - \phi)$

i.e. $N_0 \, SIN \, \theta_1 = N_1 \, COS \, \phi$

USING $SIN^2 \phi + COS^2 \phi = 1$

$N_0 \, SIN \, \theta_1 = N_1 (1 - SIN^2 \phi)^{1/2}$

LIMITING CASE FOR TIR

$\phi = \phi_C$, $\theta_1 = \theta_a$, SIN $\phi_C = N_2/N_1$

$N_0 \, SIN\theta_a = N_1 (1 - N_2^2/N_1^2)^{½} = (N_1^2 - N_2^2)^{½}$

$NA = N_0 \, SIN \, \theta_a = (N_1^2 - N_2^2)^{½} = \sin\theta_a$

(SINCE N_0 = 1 FOR AIR)

THE OPTICAL RAY WILL BE PROPAGATED ALONG THE FIBER FOR $0 \leq \theta_1 \leq \theta_a$

NA IS INDEPENDENT OF THE FIBER CORE DIA

LET $\Delta = N_1^{2-}N_2^2/2N_1^2$ = RELATIVE REF. INDEX DIFF. BETWEEN CORE & CLADDING.

HENCE NA = $N_1 (2 \Delta)^{½}$