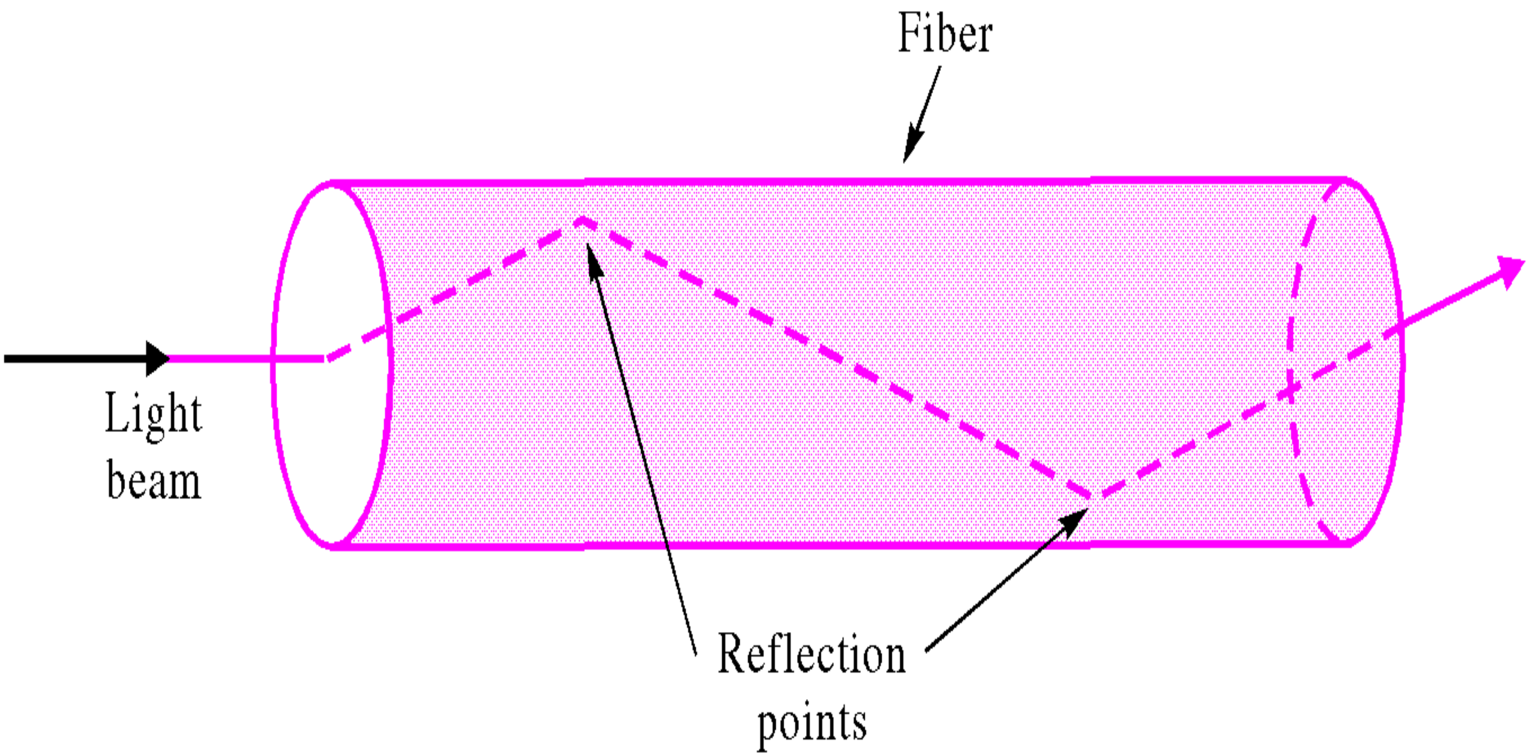
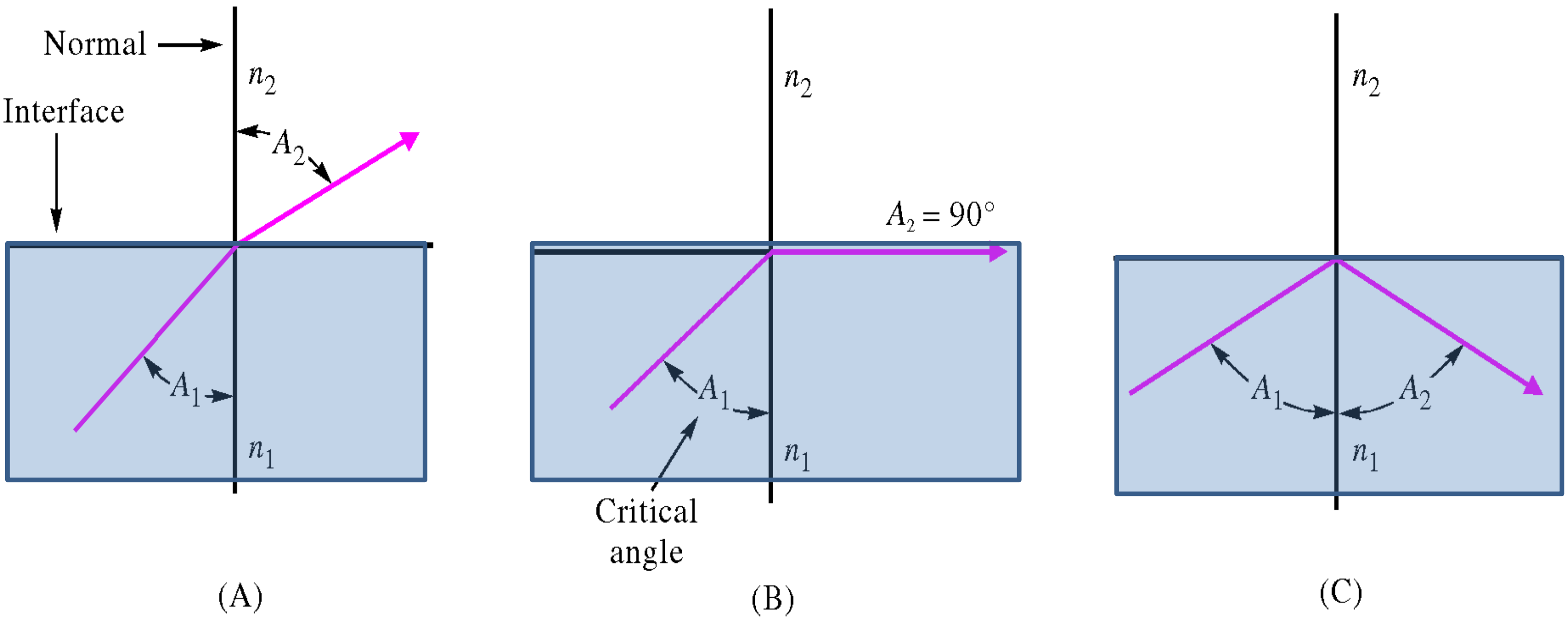
Reflection in Optical Fiber

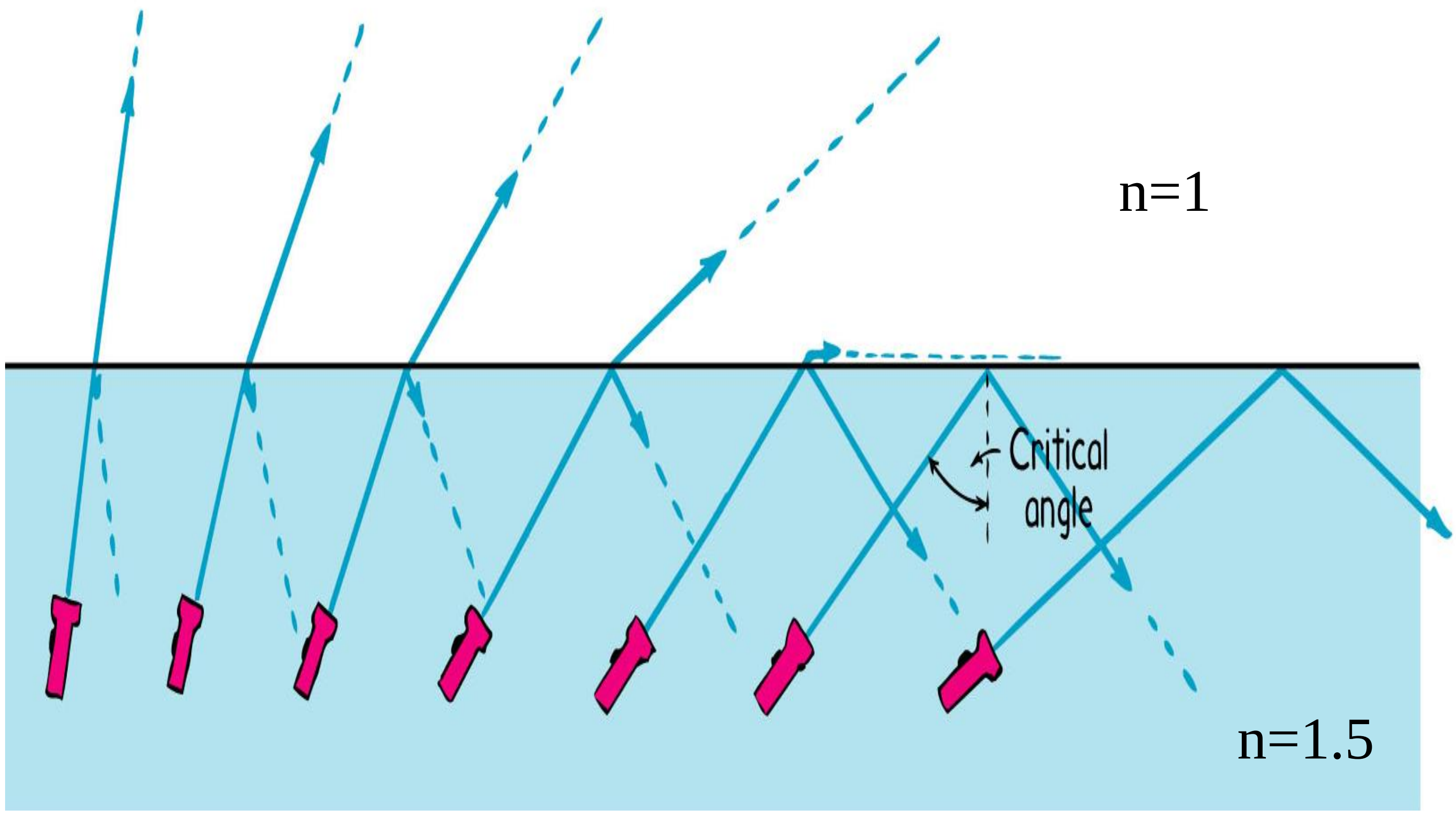


The ***critical angle*** **is the angle of incidence that will produce a** ***90^0 angle of refraction*****.**



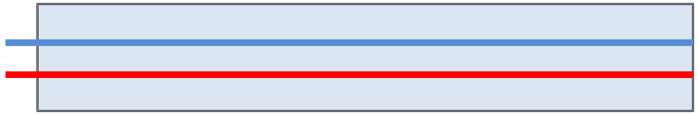
3 specific conditions are shown here. The angle of incidence, A_1 and the angle of refraction, A_2.

Material 1 is more dense than material 2, so n_1 is greater than n_2.

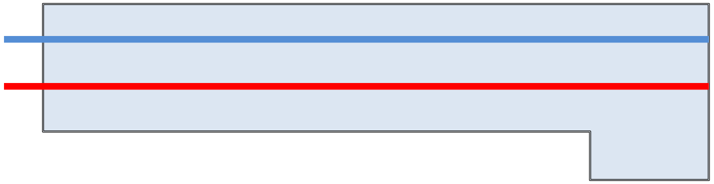

n=1
Critical
angle
n=1.5

Total Internal Reflection in Fiber

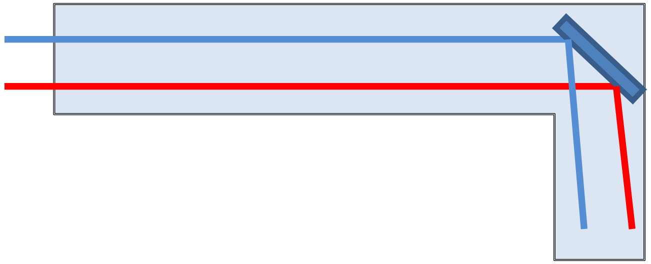
- Straight hallway

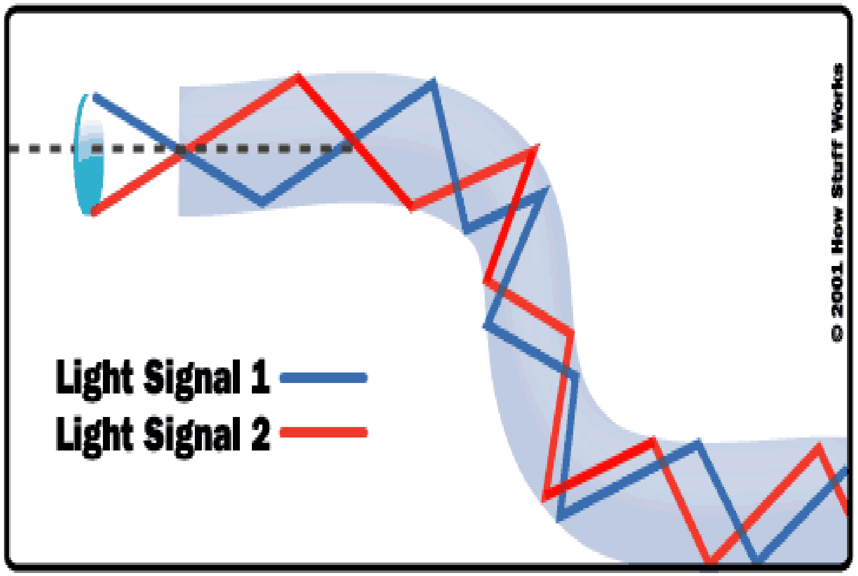


- Bent hallway



- Bent hallway with a mirror

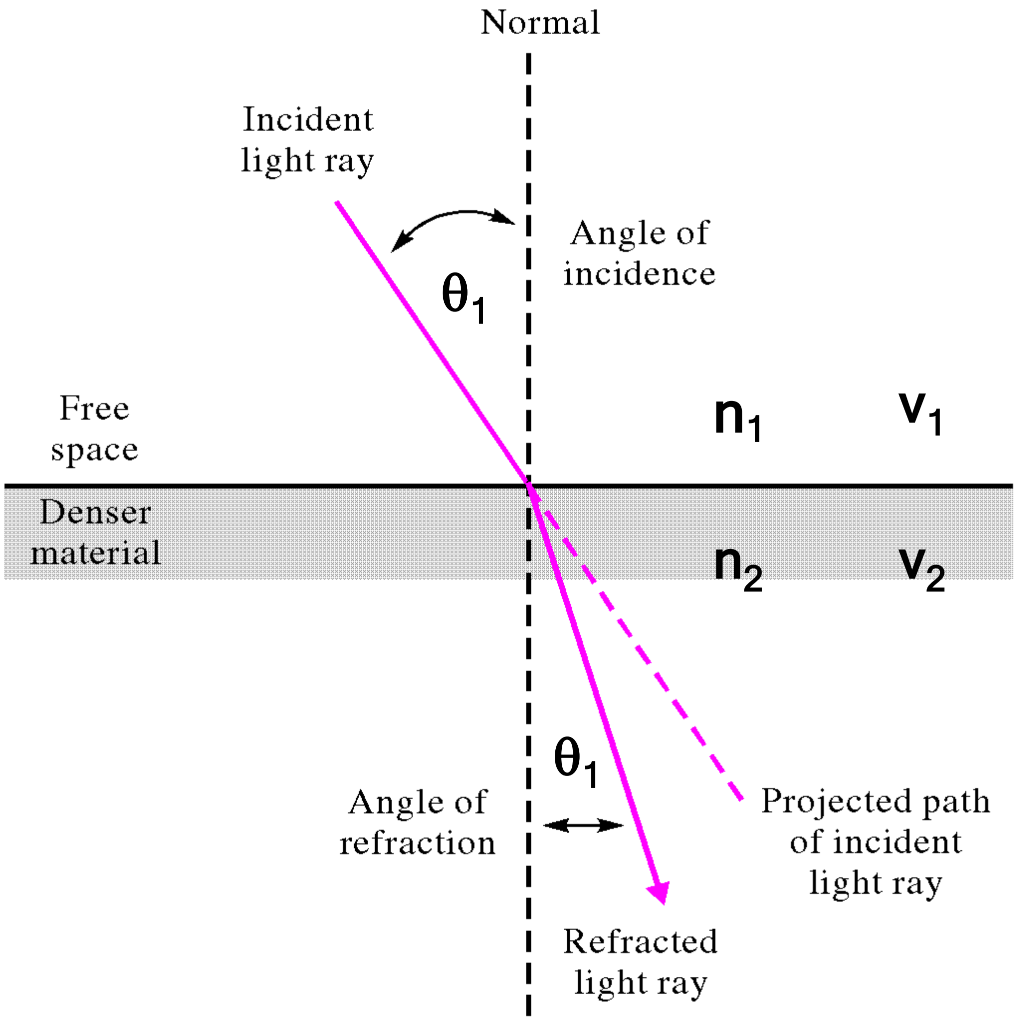




Acceptance Angle

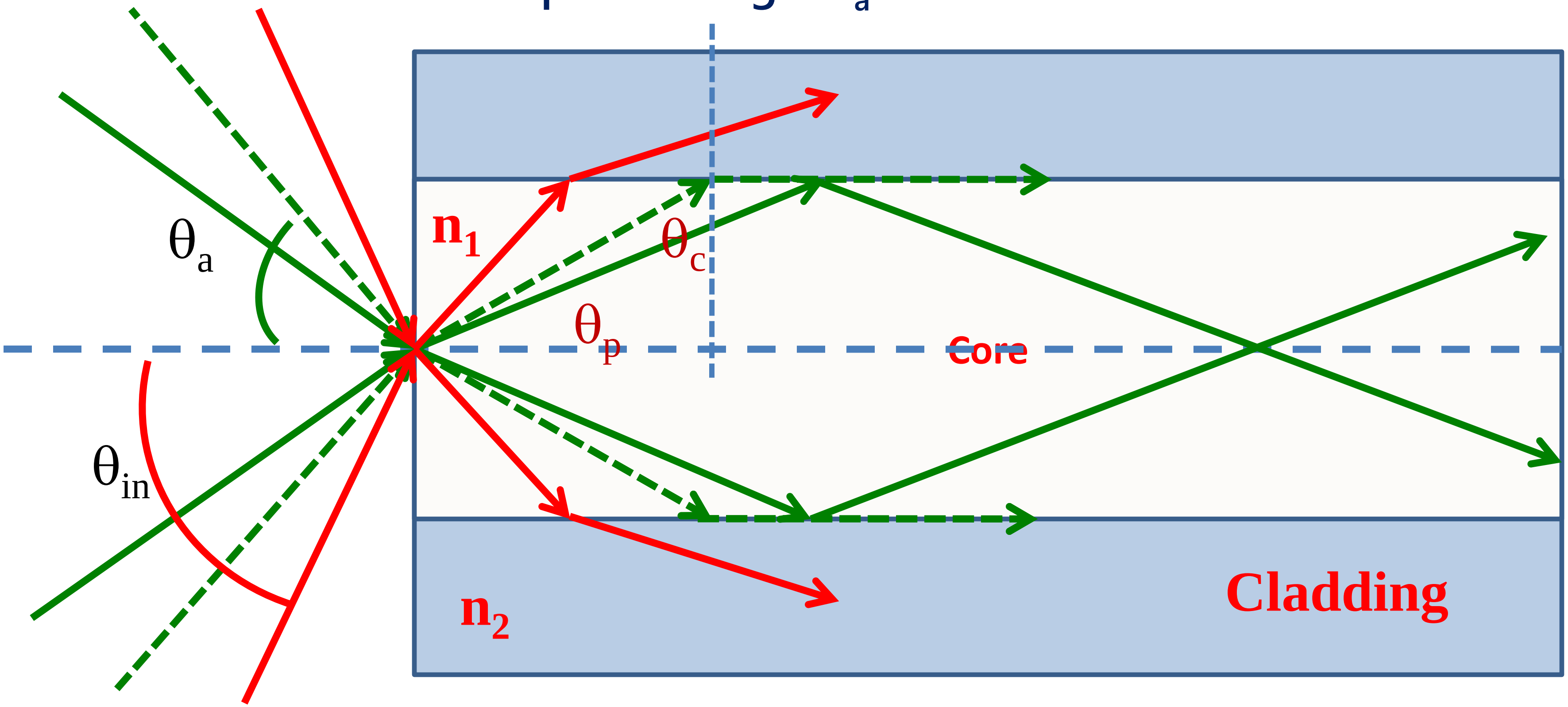
Snell's law states that the ratio of the sines of the angles of incidence and refraction is equivalent to the ratio of phase velocities in the two media, or equivalent to the opposite ratio of the indices of refraction:

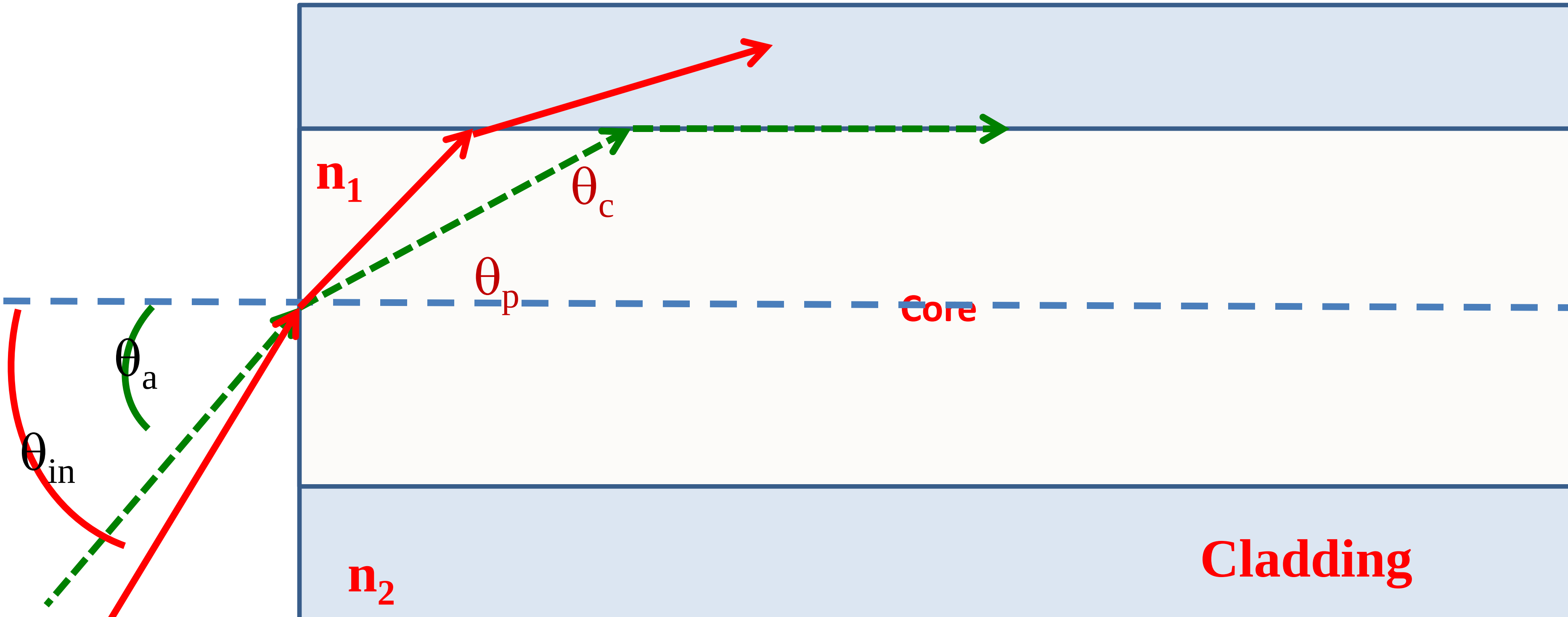
$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1}$$



Acceptance Angle

An Optical Fiber will only propagate light that enters the fiber within a certain cone, known as the acceptance cone of the fiber. The half angle of this cone is called Acceptance angle θ_a





To propagate the light beam down the optical fiber, the light beam at the core and cladding interface must taken an angle less than the critical θc, From Snell's law,

$$n \sin\theta_a = n_1 \sin\alpha_c$$

$$\sin\theta_a = n_1 \sin(90 - \theta_c)$$

$$\sin\theta_a = n_1 \cos\theta_c$$

$$\sin\theta_a = n_1 \sqrt{1 - \sin^2\theta_c}$$

from **core to cladding**

$$n_1 \sin\theta_c = n_2 \sin 90$$

$$\sin\theta_a = n_1 \sqrt{1 - \frac{n_2^{\,2}}{n_1^{\,2}}}$$

$$\sin\theta_a = \sqrt{n_1^{\,2} - n_2^{\,2}}$$

θ_a – Acceptance angle

Numerical Aperture

Numerical Aperture

$$NA = \sin\theta_a$$

$$NA = \sqrt{n_1^{\,2} - n_2^{\,2}}$$

NA describes the ability of an optical fiber to gather light signals from the sources and to preserve them within the fiber

Relative index , Δ

$$\Delta = \frac{n_1 - n_2}{n} = \frac{(n_1 - n_2)(n_1 + n_2)}{n(n_1 + n_2)} = \frac{(n_1^{\,2} - n_2^{\,2})}{n(n_1 + n_2)}$$

Where 'n' average index

$$\Delta = \frac{(n_1^{\,2} - n_2^{\,2})}{2n_1^{\,2}} \longrightarrow (n_1^{\,2} - n_2^{\,2}) = 2n_1^{\,2}\Delta$$

$$\sqrt{n_1^{\,2} - n_2^{\,2}} = n_1\sqrt{2\Delta} \longrightarrow NA = n_1\sqrt{2\Delta}$$