Unit-2

Lecture -8

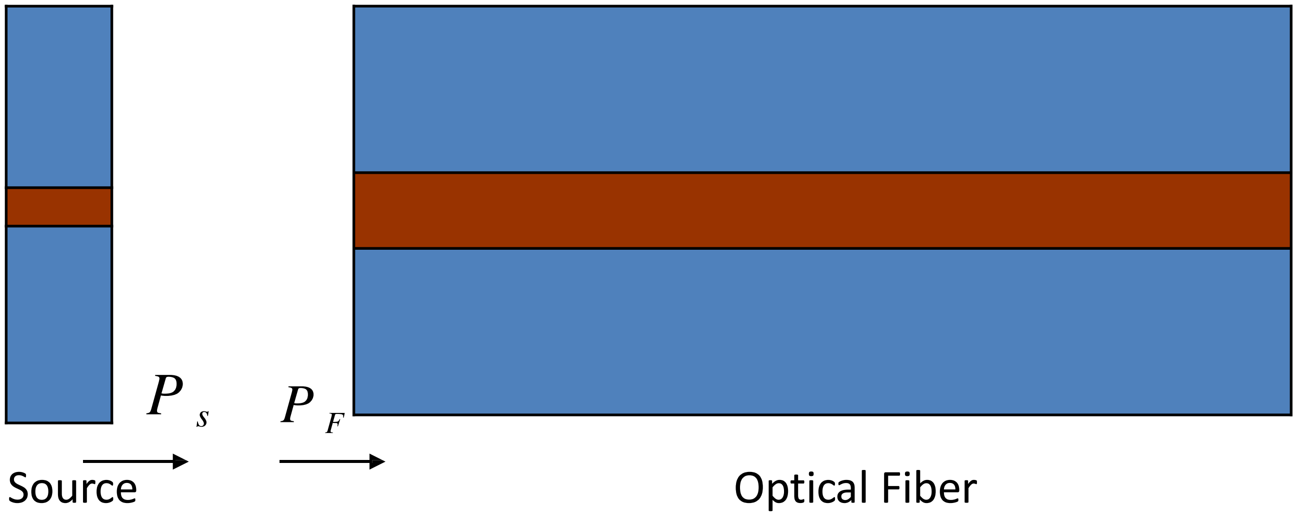
Laser Fiber Connector, Joints, Splicer, Coupling efficiency

Content

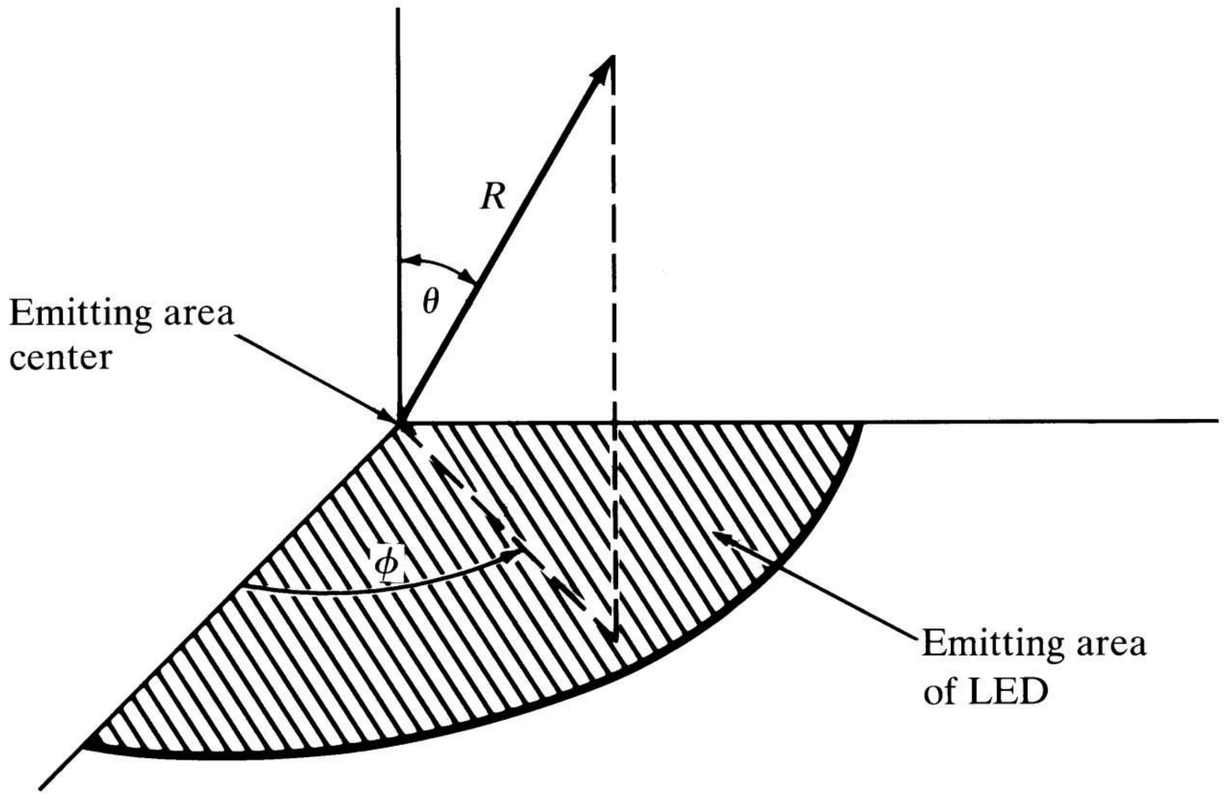
- Launching optical power into a fiber
- Fiber-to-Fiber coupling
- Fiber Splicing and connectors

Coupling Efficiency

$$\eta = \frac{\text{power coupled into the fiber}}{\text{power emitted from the sourse}} = \frac{P_F}{P_s} \qquad [5\text{-}1]$$



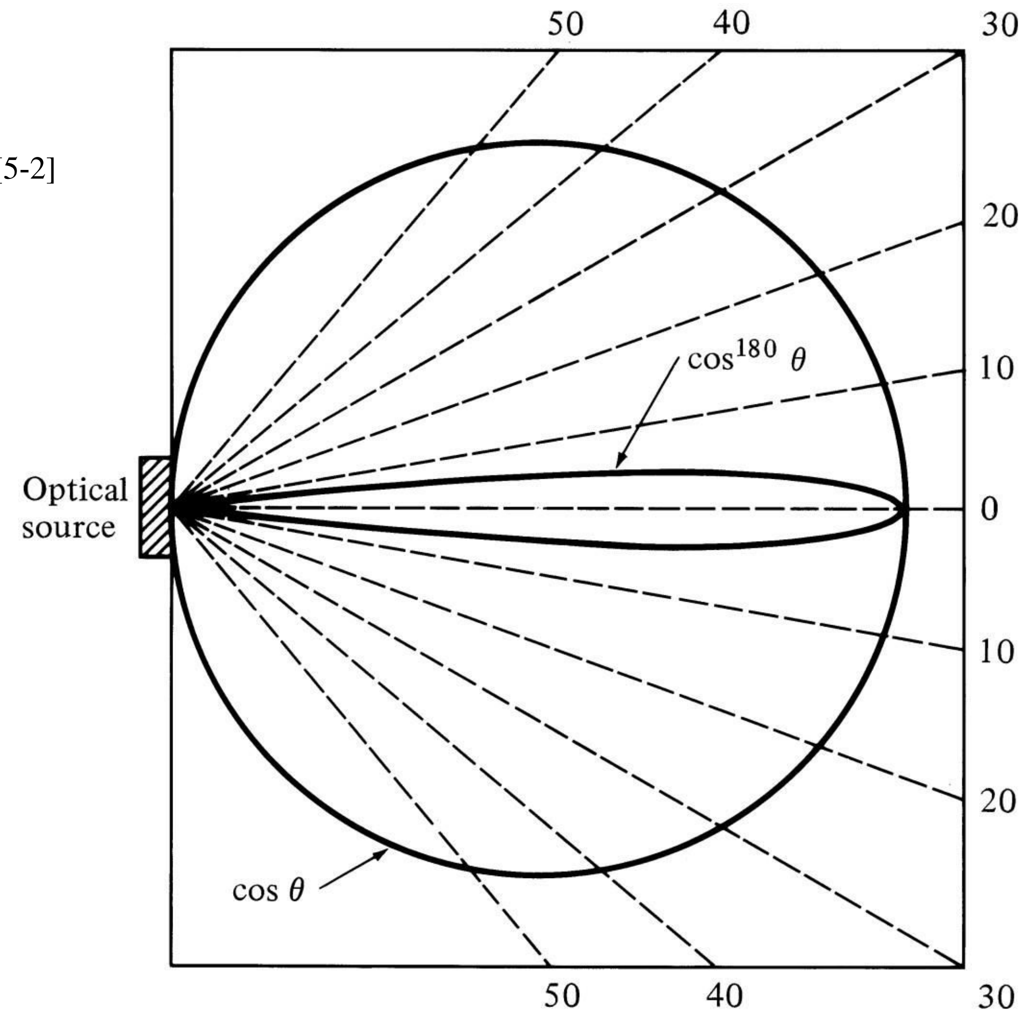
Radiance (Brightness) of the source



- *B*= Optical power radiated from a unit area of the source into a unit solid angle [watts/(square centimeter per stradian)]

Surface emitting LEDs have a Lambertian pattern:

$$B(\theta, \phi) = B_0 \cos\theta$$ [5-2]

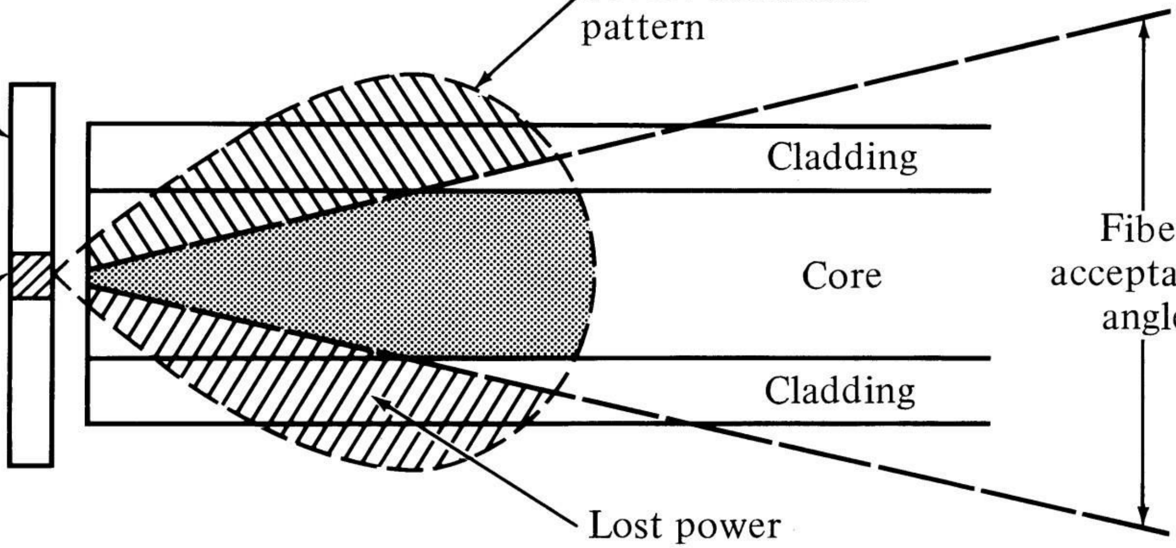


Edge emitting LEDs and laser diodes radiation pattern

$$\frac{1}{B(\theta,\varphi)} = \frac{\sin^2\varphi}{B_0 \cos^T\theta} + \frac{\cos^2\varphi}{B_0 \cos^L\theta} \qquad [5\text{-}3]$$

For edge emitting LEDs, *L*=1

Power Coupled from source to the fiber



A_s and Ω_s : area and solid emission angle of the source

$$P_F = \int_{A_f}\left[\int_{\Omega_f} B(A_s,\Omega_s)\,d\Omega_s\right]dA_s = \qquad [5\text{-}4]$$

A_f and Ω_f : area and solid acceptance angle of fiber

$$= \int_0^{r_m}\int_0^{2\pi}\left[\int_0^{2\pi}\int_0^{\theta_{0\,max}} B(\theta,\varphi)\sin\theta\,d\theta\,d\varphi\right]d\theta_s\,r\,dr$$

Power coupled from LED to the Fiber

$$P = \int_0^{r_s} \int_0^{2\pi} \left(2\pi B_0 \int_0^{\theta_{0\,\max}} \cos\theta \sin\theta d\theta \right) d\theta_s rdr$$

$$= \pi B_0 \int_0^{r_s} \int_0^{2\pi} \sin^2 \theta_{0\,\max} d\theta_s rdr$$

$$= \pi B_0 \int_0^{r_s} \int_0^{2\pi} \mathrm{NA}^2 d\theta_s rdr$$

$$\boxed{P_{\mathrm{LED,step}} = \pi^2 r_s^2 B_0 (\mathrm{NA})^2 \approx 2\pi^2 r_s^2 B_0 n_1^2 \Delta}$$

[5-5]

Power coupling from LED to step-index fiber

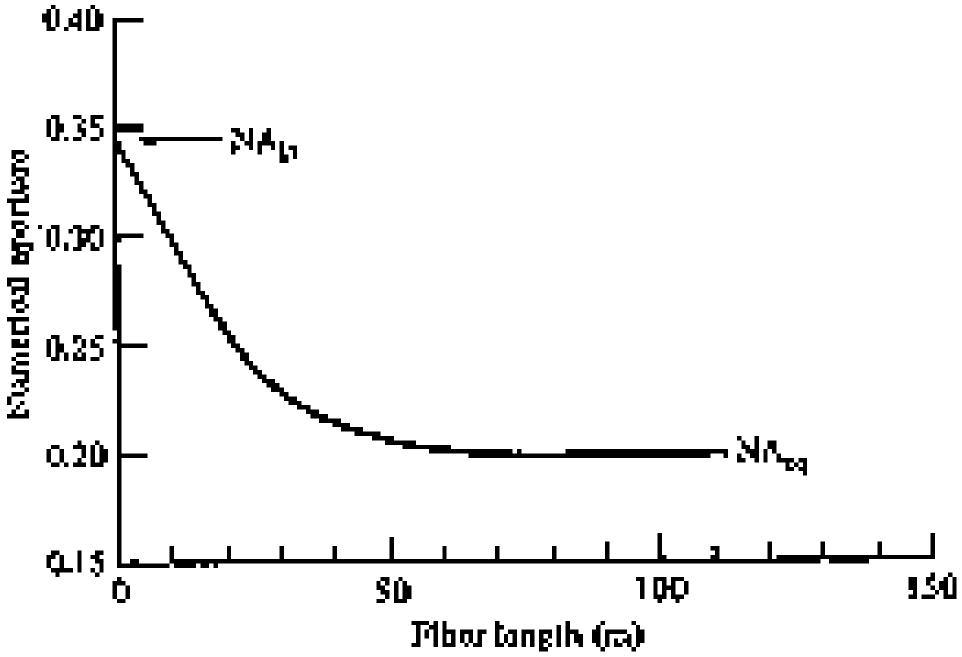
- Total optical power from LED:

$$P_s = A_s \int_0^{2\pi} \int_0^{\pi/2} B(\theta,\varphi) \sin\theta \, d\theta \, d\varphi$$

$$\boxed{P_s = \pi r_s^{\,2}\, 2\pi B_0 \int_0^{\pi/2} \cos\theta \sin\theta \, d\theta = \pi^2 r_s^{\,2} B_0}$$ [5-6]

$$\boxed{P_{\mathrm{LED,step}} = \begin{cases} P_s (\mathrm{NA})^2 & \text{if } r_s \le a \\ \left(\dfrac{a}{r_s}\right)^2 P_s (\mathrm{NA})^2 & \text{if } r_s \ge a \end{cases}}$$ [5-7]

Equilibrium Numerical Aperture



Examples of possible lensing schemes used to improve optical source-to-fiber coupling efficiency

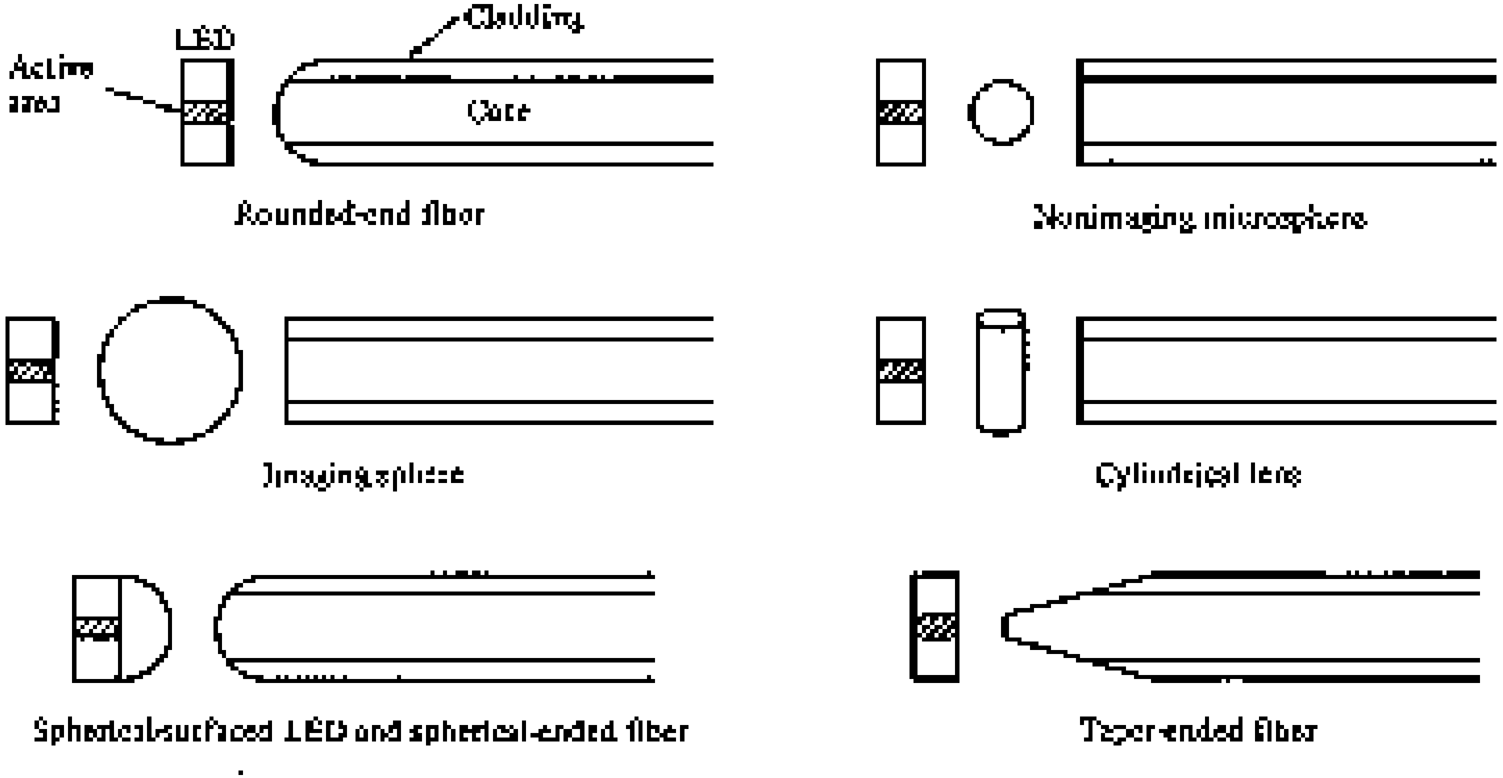


FIGURE 5-5

Laser diode to Fiber Coupling