

8.26 Equation (8.45) was derived for the case where the light incident upon the sending end of the optical fiber extends over the entire acceptance cone shown in Fig. 8-12(b). Suppose the incident light is constrained to a narrower range extending between normal incidence and θ' , where $\theta' < \theta_a$.

- (a) Obtain an expression for the maximum data rate f_p in terms of θ' .
- (b) Evaluate f_p for the fiber of Example 8-5 when $\theta' = 5^\circ$.

Solution:

- (a) For $\theta_i = \theta'$,

$$\begin{aligned}\sin \theta_2 &= \frac{1}{n_f} \sin \theta', \\ l_{\max} &= \frac{l}{\cos \theta_2} = \frac{l}{\sqrt{1 - \sin^2 \theta_2}} = \frac{l}{\sqrt{1 - \left(\frac{\sin \theta'}{n_f}\right)^2}} = \frac{ln_f}{\sqrt{n_f^2 - (\sin \theta')^2}}, \\ t_{\max} &= \frac{l_{\max}}{u_p} = \frac{l_{\max} n_f}{c} = \frac{ln_f^2}{c \sqrt{n_f^2 - (\sin \theta')^2}}, \\ t_{\min} &= \frac{l}{u_p} = l \frac{n_f}{c}, \\ \tau = \Delta t &= t_{\max} - t_{\min} = l \frac{n_f}{c} \left[\frac{n_f}{\sqrt{n_f^2 - (\sin \theta')^2}} - 1 \right], \\ f_p &= \frac{1}{2\tau} = \frac{c}{2ln_f} \left[\frac{n_f}{\sqrt{n_f^2 - (\sin \theta')^2}} - 1 \right]^{-1} \quad (\text{bits/s}).\end{aligned}$$

- (b) For:

$$\begin{aligned}n_f &= 1.52, \\ \theta' &= 5^\circ, \\ l &= 1 \text{ km}, \\ c &= 3 \times 10^8 \text{ m/s}, \\ f_p &= 59.88 \quad (\text{Mb/s}).\end{aligned}$$
