

- 2.2** The wavelength dependence of the refractive index for silica glass can be expressed as

$$n^2(\lambda) = 1 + \sum_{i=1}^3 \frac{a_i \lambda^2}{\lambda^2 - b_i^2}$$

in the range $0.3 < \lambda < 2.5$, where λ is the free-space wavelength in units of μm . The constants are

$$(a_1, a_2, a_3) = (0.50716, 0.59707, 0.69879)$$

and

$$(b_1, b_2, b_3) = (0.04014, 0.11359, 8.81674)$$

- 2.10** Collimated laser light of wavelength 632.8 nm is incident on a mm-scale ruler at grazing incidence (light nearly parallel to ruler axis). The light is diffracted off the mm-spaced lines and strikes a screen 2 m away. Determine the angular deflection δ of the beam (with respect to the original beam direction) for each diffraction order, in terms of the angle α between the original beam direction and the ruler axis. Sketch the pattern of diffracted spots seen on the screen, for $\alpha = 1^\circ$, identifying the diffraction order of each spot and the corresponding vertical position on the screen. If the wavelength of the incident light were unknown, one could use this method to “measure the wavelength of light with a ruler.”
- 2.12** A compact disk can be used to diffract light, because the spirals of data are evenly spaced and act like a diffraction grating of groove spacing $d \approx 1.5 \mu\text{m}$. A CD is oriented at 45° to the direction of an incident He–Ne laser beam ($\lambda = 632.8 \text{ nm}$), and diffracted spots reflected from the CD are observed on a screen parallel to and 30 cm distant from the incident beam. Determine the position of the spots on the screen for all observable diffraction orders.
- 2.14** An LED (light-emitting diode) has an emitting surface of diameter 0.5 mm. Light power of 1.5 mW is collected by a lens with focal length 25 mm and diameter 10 mm, placed 80 mm from the LED. Determine the position, the diameter, and the light intensity for the image of the LED.

3.2 Derive Eqs. (3-28) and (3-29) from Eq. (3-25).

$$d_m = d_0 + \frac{m\lambda_0}{2n_1 \cos \theta} \quad (3-28)$$

$$d_0 = \frac{\lambda_0}{\pi n_1 \cos \theta} \cos^{-1} \left(\frac{n_1 \cos \theta}{\sqrt{n_1^2 - n_2^2}} \right) \quad (3-29)$$

$$\tan \left[\frac{\pi n_1 d \cos \theta}{\lambda_0} - m \frac{\pi}{2} \right] = \frac{\sqrt{1 - \left(\frac{n_2}{n_1} \right)^2 - \cos^2 \theta}}{\cos \theta} \quad (3-25)$$