Solution to HW#2

February 6, 2007

15-2 Brewster’s Law:

\[ \theta_p = \tan^{-1}\left(\frac{n_2}{n_1}\right) \]

From air to diamond (external):

\[ \theta_p = \tan^{-1}\left(\frac{n_{\text{diamond}}}{n_{\text{air}}}\right) = 67.5^\circ \]

From diamond to air (internal):

\[ \theta_p = \tan^{-1}\left(\frac{n_{\text{air}}}{n_{\text{diamond}}}\right) = 22.5^\circ \]

15-4 For a HWP,

\[ \frac{2\pi}{\lambda} \Delta n d = 2m\pi + \pi \]

\[ m = 100, \lambda = 514.5\text{nm}, \Delta n = |n_1 - n_2| = 0.005, \]

\[ d \text{ can be calculated to be } 0.01034\text{m}. \]

15-8 The angular offset between successive polarizers is \( \theta = 90^\circ / N \). Applying the law of Malus N times in succession,

\[ I_T = I_0 (\cos^2 \theta)^N = I_0 [\cos(\pi / 2N)]^{2N} = 0.96I_0 \]

Use your favorite Math program to find N=61.
15-10  See the following figure, At the diagonal interface:

$E_p$ component from $n_\parallel$ to $n_\perp$: $1.4864 \sin 45° = 1.6584 \sin \theta_R$ or $\theta_R = 39.329°$

$E_s$ component from $n_\perp$ to $n_\parallel$: $1.6584 \sin 45° = 1.4864 \sin \theta'_R$ or $\theta'_R = 52.086°$

On exit:

Upper ray: $\theta_1 = 45 - \theta_R = 5.671°$; $1.6584 \sin 5.671° = \sin \theta_2$ or $\theta_2 = 9.432°$

Lower ray: $\theta_3 = \theta'_R - 45 = 7.086°$; $1.4864 \sin 7.086° = \sin \theta_4$ or $\theta_4 = 10.566°$

Deviation: $\theta_2 + \theta_4 = 9.432 + 10.566 = 19.997°$

15-15  The rotation of polarized light in an optically active medium is proportional to the inverse of the square of the wavelength: $\beta = \rho L d \propto 1/\lambda^2$

a) For the given parameter, the concentration of the solution is

$$d = \frac{\beta}{pL} = \frac{1.23}{20.5 \times 1.2} = 0.05 g/cc$$

b) Given the stated wavelength dependence,

$$\frac{\beta_{\text{red}}}{\beta_{\text{violet}}} = \frac{\lambda_{\text{violet}}^2}{\lambda_{\text{red}}^2}$$

$$\beta_{\text{violet}} = \beta_{\text{red}} \frac{\lambda_{\text{red}}^2}{\lambda_{\text{violet}}^2} = 15°(700^2/400^2) = 46°$$