Problem 44)

a) To avoid reflection losses at the entrance and exit facets the angle of incidence θ must be equal to the Brewster angle θ_B.

Therefore, $\theta = \theta_B = \tan^{-1} n = \tan^{-1}(1.5) \Rightarrow \theta = 56.31^\circ \Rightarrow \theta' = 33.69^\circ$

Also, the reflection at the bottom must be total internal reflection, that is, $\phi > \phi_c$. Now $n \sin\phi_c = 1 \Rightarrow \phi_c = \sin^{-1}(1/n) = \sin^{-1}(2/3) = 41.81^\circ$.

Therefore, $\phi > 41.81^\circ$.

To determine the range of the Prism angle ψ, use the triangle formed by a transmitted ray and the two sides of the prism. The sum of the angles of this triangle must be 180°, that is,

$$\psi + (90^\circ + \theta') + (90^\circ - \phi) = 180^\circ \Rightarrow \psi = \phi - \theta' \Rightarrow \psi > \phi_c - \theta' = 8.12^\circ.$$

Also, it is necessary that $\psi + (90^\circ + \theta') < 180^\circ \Rightarrow \psi < 56.31^\circ$, otherwise the beam inside the prism will not arrive at the bottom facet. (It will reach the top facet first.) Therefore, $8.12^\circ < \psi < 56.31^\circ$.

b) For s-light the Fresnel reflection coefficient is

$$r_s = \frac{\cos\theta - \sqrt{n^2 - \sin^2\theta}}{\cos\theta + \sqrt{n^2 - \sin^2\theta}} = -0.38 \Rightarrow R_s = |r_s|^2 = 0.15$$

Incident optical power $= P_0$

Transmitted optical power $= P_0(1 - R_s)$ ↙ Note: Reflection loss is the same at entrance and exit facets.

Exiting optical power $= P_0(1-R_s)^2 = 0.85^2 P_0 = 0.72 P_0$

Lost optical power due to reflections at the entrance and exit facets $= 28\%$.

c) Circularly-polarized beam is equal amounts P and S. The half that is p-polarized goes through without losses. The half that is S-polarized loses ~ 28%. Thus the total loss is ~14%