Assignment 6

1. Explain why the sky is blue and the setting sun is red?

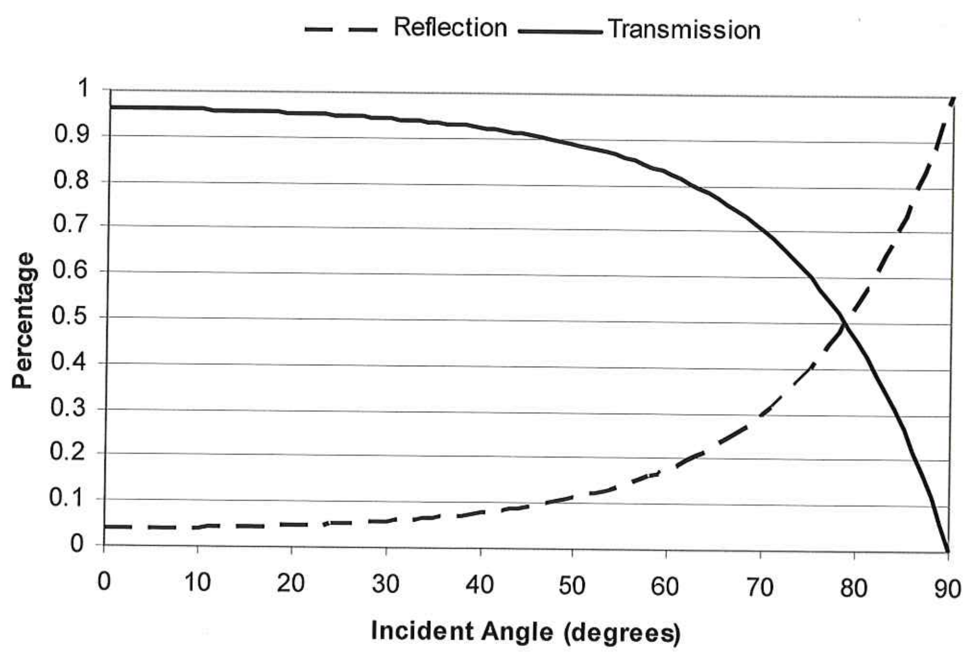
Probability light is scattered $\propto \nu^4$
$\therefore$ blue light from sun is scattered more than red light making sky blue. Light from setting sun travels through more atmosphere than overhead sun at noon causing setting sun to be red.

2. For s polarized light, plot, the reflection and transmission coefficients for incident angle between 0° and 90°.

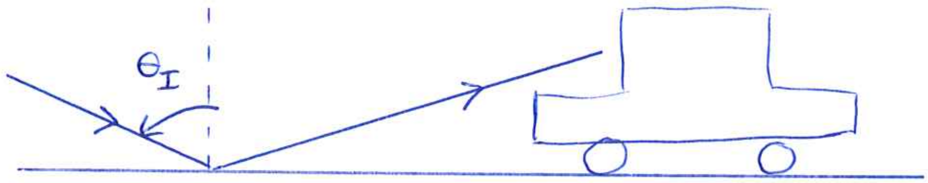
$$R = \left(\frac{1-\beta\alpha}{1+\beta\alpha}\right)^2 \qquad T = \frac{4\alpha\beta}{(1+\beta\alpha)^2} \qquad \beta = \frac{n_2}{n_1} = 1.5$$

$$\alpha = \frac{\sqrt{1-\left(\frac{n_1}{n_2}\sin\theta_I\right)^2}}{\cos\theta_I}$$

Reflection and Transmission for s Polarized Light



3. Explain how Polaroid sunglasses work.



Sun heats road producing layer of warm air near surface. At boundary between warm & cool air, light is reflected and transmitted. P polarized light for which $\theta_I = \theta_{Brewster}$ is not reflected ∴ reflected glare is mainly S polarized. Hence, if driver wears linear polarized glasses that transmit primarily P polarized light, glare is reduced.

4. Calculate Brewster's angle for a light ray travelling in water incident on a glass surface.

$$\tan \theta_B = \frac{n_{glass}}{n_{water}}$$

$$= \frac{1.5}{1.33}$$

$$\theta_B = 48.4^\circ$$

5. Consider an elliptically polarized light wave having the following electric field.

$$\vec{E} = \hat{x} E_1 \cos(kz - \omega t) + \hat{y} E_2 \sin(kz - \omega t)$$

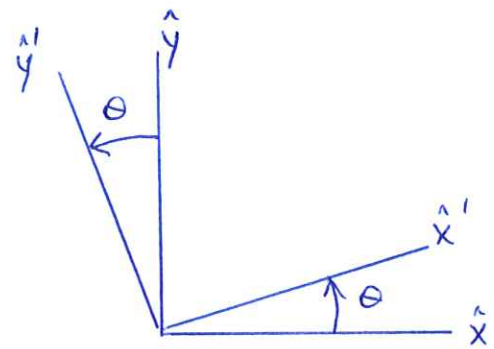
where $E_1 = E_0 \cos\alpha$

$E_2 = E_0 \sin\alpha$

L.P. light $\vec{E} \parallel \hat{x} \Rightarrow E_2 = 0 \Rightarrow \alpha = 0$

C.P. light $E_1 = \pm E_2 \Rightarrow \cos\alpha = \pm \sin\alpha \Rightarrow \alpha = 45^\circ$

Linear Polarizer has transmission axis $\hat{x}'$.



$$\hat{x} = \cos\theta\, \hat{x}' - \sin\theta\, \hat{y}'$$
$$\hat{y} = \sin\theta\, \hat{x}' + \cos\theta\, \hat{y}'$$

Light incident on polarizer has electric field:

$$\vec{E} = (\cos\theta\, \hat{x}' - \sin\theta\, \hat{y}') E_1 \cos(kz - \omega t)$$
$$+ (\sin\theta\, \hat{x}' + \cos\theta\, \hat{y}') E_2 \sin(kz - \omega t)$$
$$= \hat{x}' \left(E_1 \cos\theta \cos(kz - \omega t) + E_2 \sin\theta \sin(kz - \omega t) \right)$$
$$+ \hat{y}' \left(-E_1 \sin\theta \cos(kz - \omega t) + E_2 \cos\theta \sin(kz - \omega t) \right)$$

Light after polarizer has field:

$$\vec{E} = \hat{x}' (E_1 \cos\theta \cos(kz - \omega t) + E_2 \sin\theta \sin(kz - \omega t))$$

Detector Signal $I \propto \langle \vec{E} \cdot \vec{E} \rangle$ ↑ time average over many optical periods

$$I = E_1^2 \cos^2\theta + E_2^2 \sin^2\theta$$

L.P. Incident light $E_2 = 0 \Rightarrow I = E_1^2 \cos^2\theta$

C.P. " " $E_1 = E_2 \Rightarrow I = E_1^2 = \text{constant}$