Two Phase Fresnel Equations from the Hansen Paper.
(W. N. Hansen, JOSA 58, 380-390 (1968))
Chem 243, R. Corn.

Variables:

$n_1(\omega)$	real refractive index for phase 1
$n_2(\omega)$	complex refractive index for phase 2
$\varepsilon_1(\omega)$	real dielectric constant for phase 1
$\varepsilon_2(\omega)$	complex dielectric constant for phase 2
$r_s(\omega,\theta)$	complex Fresnel coefficient for s-polarized light
$r_p(\omega,\theta)$	complex Fresnel coefficient for p-polarized light
$\delta_s(\omega,\theta)$	phase shift for the reflected s-polarized light (=arg(r_s))
$\delta_p(\omega,\theta)$	phase shift for the reflected p-polarized light (=arg(r_p))
$R_s(\omega,\theta)$	Reflection coefficient for s-polarized light
$R_p(\omega,\theta)$	Reflection coefficient for p-polarized light

Two phase Fresnel Calculation: (incident angle is denoted as θ or θ_1)

$$\xi_1(\omega,\theta) = n_1 \cos\theta_1$$

$$\xi_2(\omega,\theta) = n_2 \cos\theta_2 = \left(n_2^2 - n_1^2 \sin^2\theta_1\right)^{1/2}$$

ξ_2 can be complex!

$$r_s = |r_s| e^{i\delta_s} = \frac{\xi_1 - \xi_2}{\xi_1 + \xi_2}$$

$$r_p = |r_p| e^{i\delta_p} = \frac{\varepsilon_2\xi_1 - \varepsilon_1\xi_2}{\varepsilon_2\xi_1 + \varepsilon_1\xi_2}$$

$$R_s = |r_s|^2$$

$$R_p = |r_p|^2$$

Try to make plots of R_s, R_p, δ_s and δ_p versus incident angle $\theta = 0°$ to $90°$ where you can input n_1 and n_2 (remember that n_2 is complex).

Hansen Two Phase Calculation: Interfacial Electric Fields.

The average electric fields at an interface have components in the x, y and z directions, Where z is normal to the interface, x is in the plane of incidence, and y is perpendicular to the plane of incidence. S-polarized light has only an Ey component; p-polarized light has an Ez and an Ex component.

Fields can be calculated either just above the interface (in phase 1) or just below the interface (in phase 2).

Just above the interface:

$$\left\langle E_y^2 \right\rangle = \left[\tfrac{1}{2}\left(1 + R_s\right) + R_s^{\frac{1}{2}} \cos\delta_s\right]\left\langle E_{in}^2 \right\rangle$$

$$\left\langle E_z^2 \right\rangle = \sin^2\theta\left[\tfrac{1}{2}\left(1 + R_p\right) + R_p^{\frac{1}{2}} \cos\delta_p\right]\left\langle E_{in}^2 \right\rangle$$

$$\left\langle E_x^2 \right\rangle = \cos^2\theta\left[\tfrac{1}{2}\left(1 + R_p\right) - R_p^{\frac{1}{2}} \cos\delta_p\right]\left\langle E_{in}^2 \right\rangle$$

where the complex Fresnel reflection coefficients r_s and r_p are:

$$r_s = R_s^{\frac{1}{2}} \exp(i\delta_s)$$

$$r_p = R_p^{\frac{1}{2}} \exp(i\delta_p)$$

If we let $E_{in} = 1$, then $\langle E_{in}^2 \rangle = ½$.

Just below the interface:

$$\left\langle E_y^2 \right\rangle = \tfrac{1}{2}\left|t_s\right|^2\left\langle E_{in}^2 \right\rangle$$

$$\left\langle E_z^2 \right\rangle = \tfrac{1}{2}\left|\frac{n_1 \sin\theta}{n_2} t_p\right|^2\left\langle E_{in}^2 \right\rangle$$

$$\left\langle E_x^2 \right\rangle = \tfrac{1}{2}\left|\frac{\xi_2}{n_2} t_p\right|^2\left\langle E_{in}^2 \right\rangle$$

where the complex Fresnel transmission coefficients t_s and t_p are:

$$t_s = \frac{2\xi_1}{\xi_1 + \xi_2}$$

$$t_p = \frac{n_1}{n_2}\left[\frac{2\varepsilon_2\xi_1}{\varepsilon_2\xi_1 + \varepsilon_1\xi_2}\right]$$

Remember that n_2 can be complex!