23-17. Using Eq. (23-65) for the TE case:

$$R_{\text{TE}} = \left| \frac{\cos\theta - \sqrt{(n_R^2 - n_I^2 - \sin^2\theta) + i\,(2\,n_R n_I)}}{\cos\theta - \sqrt{(n_R^2 - n_I^2 - \sin^2\theta) + i\,(2\,n_R n_I)}} \right|^2$$

and for the TM case,

$$R_{\text{TM}} = \left| \frac{-\left[n_R^2 - n_I^2 + i\,(2\,n_R n_I)\right]\cos\theta + \left(n_R^2 - n_I^2 - \sin^2\theta\right) + i\,(2\,n_R n_I)}{\left[n_R^2 - n_I^2 + i\,(2\,n_R n_I)\right]\cos\theta + \left(n_R^2 - n_I^2 - \sin^2\theta\right) + i\,(2\,n_R n_I)} \right|^2$$

The given parameters are $n_R = 2.485$ and $n_I = 1.381$. The free computer algebra system Maxima with the TeXmacs front end, can be used to determine the reflectances. Below I show the syntax used and give a table with the output.

```
(%i1) (nR:2.484,nI:1.381,k:%pi/180)$
(%i2) for j from 0 step 10 thru 90 do (RTE[j]:float(abs((cos(k*j)-sqrt(nR^2-nI^2-
      sin(k*j)*sin(k*j)+%i*2*nR*nI))/(cos(k*j)+sqrt(nR^2-nI^2-
      sin(k*j)*sin(k*j)+%i*2*nR*nI)))^2),RTM[j]:float(abs(((-nR^2-nI^2+2*%i*nR*nI)*cos(k*j)+sqrt(nR^2-nI^2-
      sin(k*j)*sin(k*j)+%i*2*nR*nI))/((nR^2-nI^2+2*%i*nR*nI)*cos(k*j)+sqrt(nR^2-nI^2-
      sin(k*j)*sin(k*j)+%i*2*nR*nI)))^2))
  (%o3) done
(%i4) for j from 0 step 10 thru 90 do display(RTE[j],RTM[j])
```

θ	0°	30°	50°	70°	90°
R_{TE}	29.3	34.5	45.4	65.7	100
R_{TM}	29.3	24.2	14.9	5.4	100

23-18. Using the Maxima program from the last problem with the input values $n_R = 1.5$ and $n_I = 5.3$ I find,

θ	R_{TE}	R_{TM}
0°	82.5%	82.5%
30°	84.7%	80.1%
60°	90.9%	69.5%

23-19. Given $n_I = 5.3$ at $\lambda = 589.3\,\text{nm}$. (a) $\alpha = 4\pi n_I/\lambda = 4\pi\,(5.3)/(589.3\,\text{nm}) = 0.113\,\text{nm}^{-1}$

(b) $I = I_0 e^{-\alpha s}$. For $I = 0.01\,I_0$, $e^{-\alpha s} = 0.01 \Rightarrow s = (-1/\alpha)\ln(0.01) = 40.75\,\text{nm} = 0.069\,\lambda$

23-21. (a) The penetration depth is

$$|z|_{1/e} = \frac{1}{\alpha} = \frac{\lambda}{2\pi}\frac{1}{\sqrt{\sin^2\theta/n^2 - 1}} = \frac{0.546\,\mu\text{m}}{2\pi}\frac{1}{\sqrt{\sin^2(45°)/(1/1.6)^2 - 1}} = 0.164\,\mu\text{m}$$

(b) Since irradiance is proportional to the square of the field amplitude and with $\alpha = \frac{1}{|z|_{1/e}} = 6.089\,\mu\text{m}^{-1}$,

$$\frac{I}{I_0} = e^{-2\alpha|z|} = e^{-2(6.089\,\mu\text{m}^{-1})(1\mu\text{m})} = 5.1 \times 10^{-6}$$

25-1. (a) Consider,

$$K \equiv n^2 = (n_R + i\,n_I)^2 = n_R^2 - n_I^2 + 2\,i\,n_I n_R = K_R + i\,K_I$$
$$K_R = n_R^2 - n_I^2,\; K_I = 2\,n_I n_R$$

Solving these two relations for n_R and n_I proceeds as,

$$K_I = 2\,n_I n_R = 2\,n_I \sqrt{K_R^2 + n_I^2}$$
$$K_I^2 = 4\,n_I^2\,(K_R^2 + n_I^2)$$
$$4\,n_I^4 + 4K_R^2 n_I^2 - K_I^2 = 0$$
$$n_I^2 = \frac{-4\,K_R \pm \sqrt{16\,K_R^2 + 16\,K_I^2}}{8} = \frac{-K_R \pm \sqrt{K_R^2 + K_I^2}}{2}$$

To make $n_I^2 > 0$, choose the $+$ sign. Thus,

$$n_I = \left[\frac{-K_R + \sqrt{K_R^2 + K_I^2}}{2}\right]^{1/2}$$

$$n_R^2 = K_R + n_I^2 = \frac{2\,K_R}{2} + \frac{-K_R + \sqrt{K_R^2 + K_I^2}}{2} = \frac{K_R + \sqrt{K_R^2 + K_I^2}}{2}$$

$$n_R = \left[\frac{K_R + \sqrt{K_R^2 + K_I^2}}{2}\right]^{1/2}$$

(b) If $K_I \approx K_R$,

$$n_R = \left[\frac{K_I + \sqrt{2\,K_I^2}}{2}\right]^{1/2} = \sqrt{K_I}\left(\frac{1 + \sqrt{2}}{2}\right)^{1/2} = 1.099\,\sqrt{K_I}$$

$$n_I = \left[\frac{-K_I + \sqrt{2\,K_I^2}}{2}\right]^{1/2} = \sqrt{K_I}\left(\frac{-1 + \sqrt{2}}{2}\right)^{1/2} = 0.455\,\sqrt{K_I}$$

25-4. Given

$n = 1$ electron/atom $\quad N = \frac{N_A\,\rho}{M} = \frac{(6.02 \times 10^{26})\,(2.70 \times 10^3)}{26.982}\,\mathrm{m}^{-3} = 6.027 \times 10^{28}\,\mathrm{m}^{-3} \quad \sigma_0 = 3.54 \times 10^7/\Omega\text{-m}$

(a) $\sigma_0 = \frac{N\,e^2}{m\,\gamma} \Rightarrow \gamma = \frac{N\,e^2}{m\,\sigma_0} = \frac{(6.027 \times 10^{28})\,(1.602 \times 10^{-19})^2}{(9.109 \times 10^{-31})\,(3.54 \times 10^7)}\mathrm{s}^{-1} = 4.80 \times 10^{13}\,s^{-1}$

(b) $\omega_p^2 = \frac{N\,e^2}{m\,\varepsilon_0} = \frac{(6.027 \times 10^{28})\,e^2}{m\,\varepsilon_0} = 1.918 \times 10^{32}\,\mathrm{s}^{-2} \Rightarrow \omega_p = 1.38 \times 10^{16}\,\mathrm{s}^{-1}$

(c) At $\lambda = 550\,\mathrm{nm}, \omega = 2\,\pi\,f = 2\,\pi\,c/\lambda = 3.425 \times 10^{15}\,\mathrm{Hz}$. Now,

$$n_R^2 - n_I^2 \equiv K_R = 1 - \frac{\omega_p^2}{\omega^2 + \gamma^2} = -15.347 \quad 2\,n_I n_R \equiv K_I = \frac{\gamma}{\omega}\left(\frac{\omega_p^2}{\omega^2 + \gamma^2}\right) = 0.2291$$

Solving these simultaneously as in problem 25-1 gives,

$$n_R = \left[\frac{K_R + \sqrt{K_R^2 + K_I^2}}{2}\right]^{1/2} = 0.0292 \quad n_I = \frac{K_I}{2\,n_R} = 3.92$$

25-7. (a) $\delta_{\mathrm{Al}} = \left(\frac{2}{\sigma\,\mu_0\,\omega}\right)^{1/2} = \left(\frac{2}{3.54 \times 10^7\,(4\,\pi \times 10^{-7})\,2\,\pi \times 6 \times 10^4}\right)^{1/2}\mathrm{m} = 0.345\,\mathrm{mm}$

(b) $\delta_{\mathrm{s.w.}} = \left(\frac{3.54 \times 10^7}{4.3}\right) \times \delta_{\mathrm{Al}} = 0.991\,\mathrm{m} \approx 1\,\mathrm{m}$

25-8. $\delta_{\mathrm{Ag}} = \left(\frac{\lambda}{\sigma\,\mu_0\,\pi\,c}\right)^{1/2} = \left(\frac{0.1}{3\times 10^7 (4\,\pi\times 10^{-7})\,\pi\,(3\times 10^8)}\right)^{1/2} \mathrm{m} = 1.68\times 10^{-6}\,\mathrm{m} = 1.68\,\mu\mathrm{m}$

As long as the silver coating is thicker than this the silver-plated brass component would work.

25-9. (a) $I = I_0\,e^{-\alpha x} \Rightarrow (I/I_0) = (1/4) = e^{-\alpha x} = e^{-\alpha(3.42\,\mathrm{m})} \Rightarrow 3.42\,\alpha = \ln(4) \Rightarrow \alpha = 0.405\,\mathrm{m}^{-1}$

(b) $(I/I_0) = (1/100) = e^{-(0.405\,\mathrm{m}^{-1})x} \Rightarrow (0.405\,\mathrm{m}^{-1}) = \ln(100) \Rightarrow x = 11.37\,\mathrm{m}$