8.2 A plane wave in air with an electric field amplitude of 20 V/m is incident normally upon the surface of a lossless, nonmagnetic medium with $\varepsilon_r = 25$. Determine the following:

(a) The reflection and transmission coefficients.

(b) The standing-wave ratio in the air medium.

(c) The average power densities of the incident, reflected, and transmitted waves.

Solution:

(a)

$$\eta_1 = \eta_0 = 120\pi \quad (\Omega), \qquad \eta_2 = \frac{\eta_0}{\sqrt{\varepsilon_r}} = \frac{120\pi}{5} = 24\pi \quad (\Omega).$$

From Eqs. (8.8a) and (8.9),

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = \frac{24\pi - 120\pi}{24\pi + 120\pi} = \frac{-96}{144} = -0.67,$$
$$\tau = 1 + \Gamma = 1 - 0.67 = 0.33.$$

(b)

$$S = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1 + 0.67}{1 - 0.67} = 5.$$

(c) According to Eqs. (8.19) and (8.20),

$$S_{av}^{i} = \frac{|E_0^i|^2}{2\eta_0} = \frac{400}{2 \times 120\pi} = 0.52 \text{ W/m}^2,$$
$$S_{av}^{r} = |\Gamma|^2 S_{av}^{i} = (0.67)^2 \times 0.52 = 0.24 \text{ W/m}^2,$$
$$S_{av}^{t} = |\tau|^2 \frac{|E_0^i|^2}{2\eta_2} = |\tau|^2 \frac{\eta_1}{\eta_2} S_{av}^{i} = (0.33)^2 \times \frac{120\pi}{24\pi} \times 0.52 = 0.28 \text{ W/m}^2.$$