1. Two perfect dielectrics have relative permittivities $\varepsilon_{r1} = 2$ (Region 1) and $\varepsilon_{r2} = 8$ (Region 2). The planar interface between them is the surface

$$x - y + 2z = 5.$$

The origin lies in Region 1. If

$$E_1 = 100\,\hat{a}_x + 200\,\hat{a}_y - 50\,\hat{a}_z \quad (\text{V/m}),$$

find the electric field E_2 in Region 2.

2. A right-circularly polarized plane wave in air is incident at Brewster's angle onto a semi-infinite slab of plexiglas with $\varepsilon'_r = 3.45$ and $\varepsilon''_r = 0$ (lossless).

   (a) Determine the fractions of the incident power that are reflected and transmitted.

   (b) Describe the polarizations of the reflected and transmitted waves.

3. Let Region 1 ($z < 0$) be a uniform dielectric with relative permittivity $\varepsilon_{r1} = 3.2$, and Region 2 ($z > 0$) a dielectric with $\varepsilon_{r2} = 2$. The electric flux density in Region 1 is

$$D_1 = -30\,\hat{a}_x + 50\,\hat{a}_y + 70\,\hat{a}_z \quad \text{nC/m}^2.$$

Take the unit normal from Region 1 into Region 2 as $\hat{n} = \hat{a}_z$. Find:

   (a) The normal component D_{n1}.

   (b) The tangential component D_{t1}.

   (c) The angle θ_1 between D_1 and the normal $\hat{n}$.

   (d) The polarization vector P_1 in Region 1.

4. (a) Define Brewster's angle.

   (b) Light is incident from air ($n_1 = 1.0$) onto diamond ($n_2 = 2.42$). Assume $\mu_1 = \mu_2 = \mu_0$. Using the Fresnel equations for polarization in the plane of incidence (p-polarization):

      (i) Calculate the reflection and transmission amplitudes at normal incidence.

      (ii) Determine Brewster's angle.

      (iii) Find the "crossover" angle, at which the magnitudes of the reflected and transmitted amplitudes are equal.

5. Let the permeability be

$$\mu_A = 5\ \mu\text{H/m} \qquad \text{in region A (where } x < 0),$$

and

$$\mu_B = 20\ \mu\text{H/m} \qquad \text{in region B (where } x > 0).$$

At the boundary $x = 0$ there is a surface current density

$$K = 150\,\hat{a}_y - 200\,\hat{a}_z \quad \text{A/m},$$

and in region A the magnetic field is

$$H_A = 300\,\hat{a}_x - 400\,\hat{a}_y + 500\,\hat{a}_z \quad \text{A/m}.$$

Find the following magnitudes:

(a) $|H_{tA}|$ (tangential component of H in region A),
(b) $|H_{nA}|$ (normal component of H in region A),
(c) $|H_{tB}|$ (tangential component of H in region B),
(d) $|H_{nB}|$ (normal component of H in region B).

6. A uniform plane wave in air partially reflects from the surface of a material whose properties are unknown. Measurements of the electric field in the region in front of the interface yield:

   - Spacing between maxima: 1.5 m,
   - First maximum located at: 0.75 m from the interface,
   - Standing Wave Ratio (SWR) (ratio of amplitude of maximum to minimum): 5.

   Determine the intrinsic impedance, η_u, of the unknown material.

7. A 1-MHz uniform plane wave is normally incident onto a fresh water lake ($\epsilon_r' = 78,\ \epsilon_r'' = 0,\ \mu_r = 1$). Determine the fraction of the incident power that is

   (a) reflected,
   (b) transmitted,
   (c) the amplitude of the electric field that is transmitted into the lake.

8. A uniform plane wave is incident from air onto a glass surface at an angle of 30° from the normal. Assume air has refractive index $n_1 = 1.00$ and the glass has refractive index $n_2 = 1.45$.

   Determine the fraction of the incident power that is reflected and transmitted for:

   (a) p-polarization (electric field in the plane of incidence),
   (b) s-polarization (electric field perpendicular to the plane of incidence).

   State any assumptions you make.