Problem 1:

In free space the electric field vector given by \( \vec{E}(z, t) = 10 \cos(2\pi 10^8 t - \beta z)\hat{a}_x \) V/m is incident on a 20 cm diameter receiving antenna dish. Determine the following

(i) amplitude of the electric field,
(ii) Time average Poynting vector
(iii) The power incident on the dish
(iv) Magnetic field vector \( \vec{H} \)

Problem 2:

A thick slab of polystyrene (\( \sigma = 10^{-16} S/m; \varepsilon_r = 2.6 \)) occupies \( z > 0 \). If at the surface of the slab \( z=0 \), the electric field \( \vec{E}(0, t) = 10 \cos(3\pi 10^7 t)\hat{a}_y \)

Determine the following

(i) electric field \( \vec{E}(z,t) \),
(ii) Magnetic field vector \( \vec{H}(z,t) \)
(iii) Time average Poynting vector
(iv) Frequency \( f \)
(v) Wave vector \( \beta \)

Problem 3:

The plane \( z=0 \) separates two lossless, non-magnetic media. Medium 1 (\( z<0 \)) has \( \varepsilon_r = 4 \) and medium 2 (\( z>0 \)) is air. If the incident electric field is given by:

\( \vec{E}_i(z, t) = 10 \cos(\omega t - \beta_1 z)\hat{a}_x \)

Determine the following:

(i) Intrinsic impedances \( \eta_1 \) and \( \eta_2 \)
(ii) the incident fields \( \vec{E}_i(z) \) and \( \vec{H}_i(z) \)
(iii) Reflection and transmission coefficients
(iv) The reflected fields \( \vec{E}_r(z) \) and \( \vec{H}_r(z) \)
(v) the transmitted fields \( \vec{E}_t(z) \) and \( \vec{H}_t(z) \)
(vi) Incident time average power density
(vii) reflected time average power density
(viii) transmitted time average power density

Problem 4:

Calculate the skin depth at 1 GHz for (a) copper, (b) silver, (c) gold, and (c) Nickel.
Problem 5:

The electric field \( \bar{E}_i(z,t) = 10 \cos(2 \pi 10^8 t - \beta_1 z) \hat{a}_x \) V/m is incident from air \((z<0)\) onto a nonmagnetic lossy medium \((z>0)\) characterized by \(\sigma = 10^{-2} \, S/m; \varepsilon_r = 2.0\). Determine the following:

(i) wave vector \(\beta_1\) in air.
(ii) Loss tangent in medium 2
(iii) Intrinsic impedances \(\eta_1\) and \(\eta_2\),
(iv) Reflection and transmission coefficients
(v) The reflected fields \(\bar{E}_r(z)\) and \(\bar{H}_r(z)\)
(vi) the transmitted fields \(\bar{E}_t(z)\) and \(\bar{H}_t(z)\)
(vii) Incident time average power density
(viii) transmitted time average power density

Problem 6: (show all work)

(a) What is the polarization and tilt angle of

\[ \bar{E}_i(z,t) = 10 \cos(\omega t - \beta_1 z) \hat{a}_x + 5 \cos(\omega t - \beta_1 z) \hat{a}_y \]

(b) What is the polarization of the following fields:

(i) \( \bar{E}_i(z,t) = 10 \cos(\omega t - \beta_1 z) \hat{a}_x + 10 \cos(\omega t - \beta_1 z + 270^\circ) \hat{a}_y \)

(ii) \( \bar{E}_i(z,t) = 10 \cos(\omega t - \beta_1 z) \hat{a}_x + 20 \cos(\omega t - \beta_1 z - 270^\circ) \hat{a}_y \)

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductivity (\sigma) (S/m)</th>
<th>(\mu_r)</th>
<th>(\varepsilon_r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>5.8x10^7</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Gold</td>
<td>4.1x10^7</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Silver</td>
<td>6.2x10^7</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Nickel</td>
<td>1.5x10^7</td>
<td>600</td>
<td>1.0</td>
</tr>
</tbody>
</table>