1. Above are contours and surfaces that can be used in the analysis of currents, fluxes and fields for an infinitely-long co-axial transmission line. Below the contours are eight integrals, some of which could be used to calculate the parameters listed in the table below. For the parameter listed in the table, indicate which contour or surface you would need to integrate over, and which integral you would need to use, to calculate that parameter.

<table>
<thead>
<tr>
<th>Parameter to be calculated</th>
<th>Contour or Surface</th>
<th>Integral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current on inner conductor</td>
<td>S₁</td>
<td>b)</td>
</tr>
<tr>
<td>Flux produced</td>
<td>S₃</td>
<td>f)</td>
</tr>
<tr>
<td>Magnetic Field</td>
<td>C₁</td>
<td>d)</td>
</tr>
<tr>
<td>Electric Field</td>
<td>S₂</td>
<td>g)</td>
</tr>
</tbody>
</table>
2. Two antennas are positioned in an infinite, lossy material as shown, where the unit of distance is meters. The incidence angle for the 30 MHz plane wave is -25°. If the lower antenna receives a signal that is 2.68 dB lower in magnitude and 277° retarded in phase with respect to the upper antenna, calculate the complex wave number for the wave.
\[ \gamma = 0.1 + j0.5\pi \]

3. The electric field of an electromagnetic wave
\[ \vec{E} = E_0 \cos\left(6 \times 10^8 \pi t - 2\pi z + \theta\right) \hat{a}_y \] is the sum of two electric fields \( \vec{E}_1 \) and \( \vec{E}_2 \) where
\[ \vec{E}_1 = 3 \cos\left(6 \times 10^8 \pi t - 2\pi z - 200\pi\right) \hat{a}_y \] and \[ \vec{E}_2 = 5 \cos\left(6 \times 10^8 \pi t - 2\pi z - \frac{\pi}{4}\right) \hat{a}_y \]

Find \( E_0 \) and \( \theta \).
\[ E_0 = 7.431 \quad \theta = -28.41^\circ \]

4. The capacitor shown has a dielectric between its plates that varies with \( y \) (\( y=0 \) on bottom plate). Specifically, \( \varepsilon_r(y) = \frac{2d}{y + d} \)

where \( d \) is the distance between the plates (\( d = 2 \times 10^{-4} \) m in this problem). Given that the area of the plates is \( 1 \times 10^{-5} \) m\(^2\), calculate the capacitance.
\[ C = 0.589 \text{ pico Farads} \]

5. The vector electric and magnetic fields of a TEM wave at a particular point in space are given below:
\[ \vec{E} = (12\hat{a}_x + 15\hat{a}_z) \cos(2\pi \times 10^8 t + 54^\circ - 4\pi y) \]
\[ \vec{H} = (5\hat{a}_x - 4\hat{a}_z) \cos(2\pi \times 10^8 t + 38^\circ - 4\pi y) \]

What is the magnitude of the time-average Poynting Vector (give units)?
\[ \left| \vec{S} \right|_{\text{avg}} = 59.1 \]

What is the velocity of propagation for this wave?
\[ \text{velocity} = 5 \times 10^7 \text{ m/s} \]

6. In order to test a material’s dielectric properties, it is placed between the plates of a parallel-plate capacitor. The area of the plates is 50 mm\(^2\) (5 x 10\(^{-2}\) m\(^2\)), and the
separation between the plates is 1 mm. When a voltage of $5\cos(\pi \times 10^7 t)$ Volts is applied across the capacitor, the current through the capacitor is measured to be $0.4866\cos(\pi \times 10^7 t+89.706^\circ)$ Amps. Given the above information:

a) What is the relative permittivity of the material?

$$\varepsilon_r = 7$$

b) What is the conductivity of the material?

$$\sigma = 10^{-5} \text{ Siemens/m}$$

c) What is the loss tangent?

Loss tangent = 0.00514

7. This problem relates to a parallel-plate transmission line that is to work on a circuit board that has a thickness of 2.5 mm.

a) If the relative permittivity of the circuit board material is 2.5, what must the width of the line be to achieve a characteristic impedance of 100Ω?

$$w = 5.957 \times 10^{-3} m$$

b) If a 3 Volt signal is sent on the transmission line, what is the magnitude of the electric and magnetic fields between the conductors?

$$|\vec{E}| = 1200 \text{ Volts/m} \quad |\vec{H}| = 5.036 \text{ Amps/m}$$

c) What is the power (Watts) associated with sending a 3 Volt signal down this transmission line? What is the magnitude of the Poynting vector (Watts/m²) between the conductors?

Power = 0.09 Watts

8. A light source is placed in a dielectric as shown. How far in the $x$ direction can an observer just above the interface go and still see the light? As shown, the dielectric has a relative permittivity of 30.

$$x_{\text{max}} = 0.928 \text{ m}$$