1.

Medium 1 in the region where $r < a$ in spherical coordinates is a perfect dielectric of permittivity ε_1. Medium 2 in the region where $r > a$ is free space. The electric field in medium 1 is given by

$$\mathbf{E}_1 = E_0 \hat{z}.$$

Find the electric field in medium 2.

2.

Describe the duality theorem and show an example of using it.

3.

Describe the image theory for electric current above a perfect electric conductor (PEC).

4.

Describe the image theory for magnetic current above a perfect electric conductor (PEC).

5.

Derive the gauge condition from the Maxwell's equations.

6.

Determine whether equi-phase and equi-amplitude planes can be orthogonal to each other in a lossless medium, and discuss the reason.

7.

The reflection and the transmission of a plane wave can be analyzed graphically by drawing K

vectors in K-domain. Suppose the wave number ($k = \omega\sqrt{\mu\varepsilon}$) of medium 1 in the region where $z > 0$ is smaller than the one of medium 2 in the region where $z < 0$. Discuss how to draw two K surfaces (two half circles) and three K vectors in K-domain.

8.

The reflection and the transmission of a plane wave can be analyzed graphically by drawing K vectors in K-domain. Suppose the wave number ($k = \omega\sqrt{\mu\varepsilon}$) of medium 1 in the region where $z > 0$ is larger than the one of medium 2 in the region where $z < 0$. Discuss the critical angle using K vectors in K-domain.

9.

Discuss the concept of polarization currents and derive the electric polarization current density for replacing a dielectric material with vacuum.

10.

Describe the Green's first and second identities