# EE3109 Applied Electromagnetics
# 2024/25 Semester B
# Week 2 Tutorial Questions

1. Given $\mathbf{E}(t) = A_0 \sin(\omega t - \beta z + \phi)\,\hat{\mathbf{x}}$, find $\mathbf{H}(t)$ using phasors.

2. Given $\mathbf{H}(t) = A_0 \cos(\omega t - kx - ky + \phi)\,\hat{\mathbf{z}}$, find $\mathbf{E}(t)$ using phasors.

3. When observed at large distances from their sources, the electric and magnetic fields by many current and charge distributions can be approximated as spherically symmetric waves whose amplitudes vary inversely with distance. Consider the following spherical wave in source-free, free space:
$$\mathbf{E} = \frac{E_0}{r}\sin(\omega t - \beta r)\hat{\mathbf{a}}_{\boldsymbol{\theta}}$$
   (a) Use Maxwell's curl-**E** equation to find the corresponding magnetic field intensity **H**.
   (b) Substitute the **H** found in (a) into Maxwell's curl-**H** equation to find the values of β that allows **E** to satisfy Maxwell's curl equations for large values of *r* (far-field approximation).
   (c) What other component of **E** must also be present at small values of *r* in order to satisfy Maxwell's equations?

4. A homogenous dielectric with dielectric constant $\varepsilon_r = 8$ and conductivity σ is placed between the plates of a parallel-plate capacitor. Determine the value σ at which the conduction and displacement currents in the dielectric are equal at: (a) f = 1kHz, (b) f = 100MHz

5. The parallel-plate capacitor shown in Fig. 1 is filled with a lossy dielectric material of relative permittivity $\varepsilon_r$ and conductivity $\sigma$. The separation between the plates is $d$ and each plate is of area $A$. The capacitor is connected to a time-varying voltage source $V(t)$
   (a) Obtain an expression for $I_c$, the conduction current flowing between the plates inside the capacitor, in terms of the given quantities.
   (b) Obtain an expression for $I_d$, the displacement current flowing inside the capacitor.
   (c) Based on your expressions for parts (a) and (b), give an equivalent circuit representation for the capacitor.
   (d) Evaluate the values of the circuit elements for $A = 4cm^2$, $d = 0.5$ [cm], $\varepsilon_r = 4$, $\sigma = 2.5$ [S/m] and $V(t) = 10\cos(3\pi \times 10^3 t)$ [V]

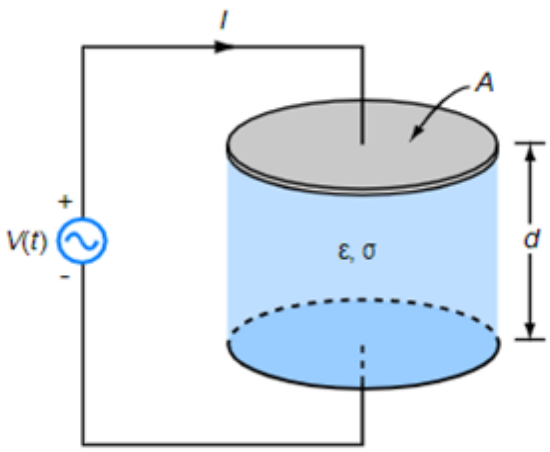


Fig. 1. Parallel-plate capacitor containing a lossy dielectric

6. If the current density in a conducting medium is given by $\mathbf{J}(x, y, z; t) = (\hat{\mathbf{x}}z - \hat{\mathbf{y}}4y^2 + \hat{\mathbf{z}}2x)\cos\omega t$, determine the corresponding charge distribution $\rho_v(x, y, z; t)$.

7. The magnetic field in a given dielectric medium is given by $\mathbf{H} = 6\cos 2z \sin(2 \times 10^7 t - 0.1x)\ \hat{\mathbf{y}}$ [A/m], where x and z are in meters. Determine:
   (a) The electric field **E**,
   (b) The displacement current density $\mathbf{J_d}$, and
   (c) The charge density $\rho_v$.

Source for questions: Ulaby Ch6 Q16,20,27.