Learning Objectives 2.1 and 2.2: I can recall the definition of scalar fields, vector fields, phasors, and Euler's identity. I can explain the basic terms and quantities used to describe electromagnetic fields.

Show your work. Write a **Documentation** line at the end (**None** if you did not collaborate).

1. **Euler's identity.**

   (a) Starting from $e^{j\theta} = \cos\theta + j\sin\theta$, derive $\cos\theta = \dfrac{e^{j\theta} + e^{-j\theta}}{2}$.

   (b) Write $e^{j\pi/3}$ in rectangular form, and find its magnitude.

   $e^{j\pi/3}$ =

   magnitude =

   (c) Write $2e^{-j\pi/4}$ in rectangular form.

   $2e^{-j\pi/4}$ =

2. **Phasors.** Use the cosine reference, $v(t) = \text{Re}\left[\widetilde{V}e^{j\omega t}\right]$.

   (a) Find the phasor of $v(t) = 10\cos\left(2\pi \times 60\,t - 45^\circ\right)$ V.

   $\widetilde{V}$ = [ ]

   (b) Find the phasor of $i(t) = 2\sin\left(\omega t + 30^\circ\right)$ A.

   $\widetilde{I}$ = [ ]

   (c) Use phasors to write $3\cos\omega t + 4\sin\omega t$ as a single cosine.

   $v(t)$ = [ ]

   (d) Find the phasor of dv/dt for the voltage in part (a).

   phasor = [ ]

3. **A sinusoidal wave.** A wave on a line is $y(x,t) = 0.5\cos\left(2\pi \times 10^8\, t - 2.094\, x\right)$, with x in meters.

   (a) Find the frequency, wavelength, and phase velocity.

   f = ____

   λ = ____

   v_p = ____

   (b) In which direction does the wave travel? Show it by writing the argument of the cosine as a function of $x - v_p t$ or $x + v_p t$.

4. **Field quantities and materials.** Use $\epsilon_0 = 8.854 \times 10^{-12}$ F/m, $\mu_0 = 4\pi \times 10^{-7}$ H/m, and $e = 1.602 \times 10^{-19}$ C.

   (a) An electric field of 1 kV/m exists in polyethylene, $\epsilon_r = 2.25$. Find the electric flux density, and the magnitude of the force on an electron in the field.

   $D =$ ____

   $F =$ ____

   (b) A field of 0.01 V/m drives current in copper, $\sigma = 5.8 \times 10^7$ S/m. Find the current density.

   $J =$ ____

   (c) A magnetic field intensity of 100 A/m exists in air. Find the magnetic flux density.

   $B =$ ____

   (d) Show that $c = 1/\sqrt{\mu_0 \epsilon_0}$ gives the speed of light, and explain in one sentence what it says about the relationship between the electric and magnetic properties of free space and light.

Documentation: _____