

End-sem: Fields & Waves (ECE230), Winter 2022

Total marks: 40

*Vector quantities must be represented with an overhead arrow. Vector calculus operations must be written correctly. Dot and cross products must be written properly. In case of any of these mistakes it will be awarded 1 out of 2 points or no/0/0. If you have a number of such mistakes in a single question, you will awarded upon the total mark in the question.

Q1. Let's talk about some Sci-fi. Suppose, magnetic monopoles are about to be experimentally discovered and you are asked to reformulate electromagnetism!

(a) How would you modify Maxwell's 4 equations? Your answers must be accompanied by solid mathematical/physical reasoning.

(b) How many potentials would there be in your new formalism? (each potential should be accompanied by definition in terms of vector calculus notations, just like you have already done in the course).

[8 + 4] = 12 points

Q2. Find the gradient of the following function: $f(x, y, z) = x^2 y^3 z^4$. [2 points]

Q3. Find the curl of the following function: $\vec{f}(x, y, z) = x^2 \hat{x} + 3xz^2 \hat{y} - 2xz \hat{z}$. [3 points]

Q4. Derive the equation of continuity. What physical law does this equation represent? [2 + 1 = 3 points]

Q5. Suppose an electromagnetic wave traveling in air strikes normally on the surface of planar glass plate (refractive index 1.5). What would be the reflection coefficient and transmission coefficient? [2 + 2 = 4 points]

Q6. Consider a lossless transmission line has a distributed inductance of $227nH/m$ and distributed capacitance of $90.9pF/m$ and has been connected to a signal generator of frequency $14\pi \times 10^8$ Hz.

(a) How much is the characteristic impedance of the line?

(b) What would be the speed of the voltage wave propagating in this line?

(c) What would be the propagation constant of the wave?

(d) If the transmission line is terminated with a load $Z_L = 30\Omega$, how much would be voltage reflection coefficient at the load?

(e) Under the same condition as part (d), what is the VSWR?

[2 + 2 + 2 + 2 + 2] = 10 points

Q7. Consider a uniform, x -polarized plane wave of frequency $3GHz$ is propagating along z -direction in a nonmagnetic medium ($\mu_0 = 4\pi \times 10^{-7}H/m$) with conductivity $7.2 \times 10^4 S/m$ and permittivity $24 \times 10^{-12}F/m$.

(a) Write down the effective permittivity of the medium.

(b) How much is the ratio $\frac{E}{H}$ for this wave?

(c) How much is the propagation constant of the EM wave?

[2 + 2 + 2 = 6 points]