

Quiz 2: Fields & Waves (ECE230), Winter 2023

Duration: 1hr 15mins, Total: 20 points (Attempt all questions)

**Vector quantities must be represented with an overhead arrow, vector calculus operators must be written correctly, dot and cross products must be written properly. In case of any of these mistake -1 will be awarded for each count of mistake. If you have n number of such mistakes in a single question, -n will awarded upto the total marks in the question.

NO credit will be given to the answers that do not accompany proper explanation.

Any case of copying/cheating will be dealt as per institute guidelines.

Q1. Consider a material with $\sigma = 2\epsilon$.

(a) What is the effective complex permittivity of the material?

(b) What are the real and imaginary parts of the permittivity?

[2 + 2 = 4 marks]

Q2. Consider the general form of the frequency dependent relative permittivity of a medium: $\epsilon_r(\omega) = 1 + \frac{Nq^2}{m\epsilon_0} \sum_j \frac{f_j}{\omega_j^2 - \omega^2 + i\omega\gamma_j}$

(a) How does the above expression get modified if we assume that all the electrons have same natural frequency of oscillation and same damping constant?

(b) Under the assumption made in part (a) and considering just one molecule per volume, what would be the real and imaginary parts of ϵ_r as functions of frequency of the applied electric field.

2 + (2 + 2) = 6 points

Q3. Under certain conditions, the relative permittivity of a metal can be written as: $\epsilon_r(\omega) = \left(1 - \frac{\omega_p^2}{\omega^2}\right)$. Plot $\epsilon_r(\omega)$ as a function of frequency. All the important points must be shown on the graph for full credit.

4 points

Q4. Write down the 4 Maxwell's equations for electromagnetic fields in differential form.

4 points

Q5. Starting with Ampere's law, obtain Ampere-Maxwell's law with proper explanations.

2 points