系所組別：電機工程學系甲組

考試科目：電磁學

考試日期：0222，節次：2

※ 考生請注意：本試題可使用計算機。 請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

※ 本試題卷共五題，第一題為簡答題，並非名詞英譯中，必須將觀念敘述出來。其餘四題為計算題，依計算過程和結果的正確性，酌量給分。

※ 一些可能用到的常數和公式：intrinsic impedance of free space = $120\pi\ \Omega$, $\tanh^{-1} x = \frac{1}{2}\ln\frac{1+x}{1-x}$ for $x^2 < 1$

1. Answer the following questions.

   (a) [9 分] Why is the phase velocity of the electromagnetic wave in a medium given by $1/\sqrt{\mu\varepsilon}$? where μ and ε are the permeability and permittivity of the medium, respectively. Why is the group velocity of electromagnetic waves always not greater than the phase volocities? Discuss the dispersion phenomena and its cause for electromagnetic waves in a lossy medium.

   (b) [5 分] What are the TE, TM, TEM, and hybrid modes in metallic or optical waveguides?

   (c) [5 分] Define the radiation resistance of an antenna. What is a radiation pattern? What is an antenna array?

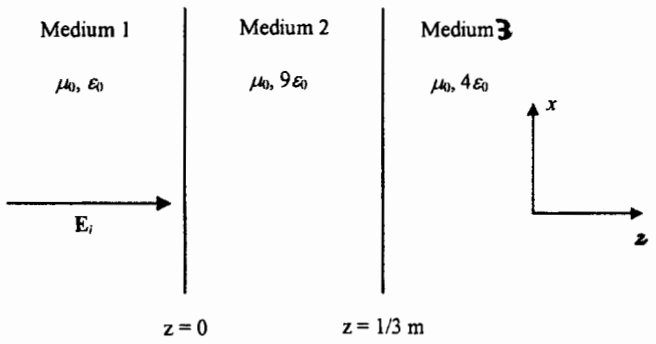
   (d) [6 分] Discuss how polarization current and magnetization current arise in a material medium. How are they taken into account in Maxwell's equations?

2. [18 分] Write the expressions for the electric- and magnetic-field intensities of a sinusoidally time-varying uniform plane wave propagating in free space and having the following characteristics: (a) $f = 100$ MHz; (b) direction of propagation in the +z-direction; and (c) polarization is right circular with the electric field in the $z = 0$ plane at $t = 0$ having an x-component equal to E_0 and a y-component equal to $0.75E_0$.

3. [22 分] In the following figure, medium 3 extends to infinity so that no reflected (-) wave exists in that medium. For a uniform plane wave having the electric field

$$\mathbf{E}_i = E_0 \cos\left(3\times10^8 \pi t - \pi z\right)\mathbf{a}_x \quad \text{V/m}$$

incident from medium 1 onto the interface $z = 0$, obtain the expressions for the expressions for phasor electric- and magnetic-field components in all three medium. What are the reflection and transmission coefficients for the system?



(背面仍有題目,請繼續作答)

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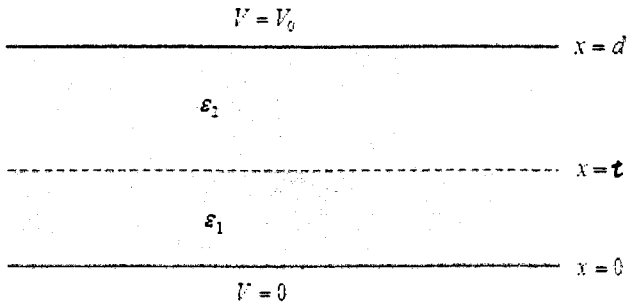
4. [14 分] The region between the two plates shown below is filled with two perfect dielectric media having permittivities ε_1 for $0 < x < t$ and ε_2 for $t < x < d$. (a) Find the solutions for the potentials in the two regions $0 < x < t$ and $t < x < d$. (b) Find the capacitance per unit area of the plates.



5. [11分] (A) The following diagram represents a loaded lossy transmittion with complex characteristin impedence $\bar{Z}_0$ and complex propagation constant $\bar{\gamma}$. Starting with the line voltage $\bar{V}(d) = \bar{V}^+ e^{\bar{\gamma}d} + \bar{V}^- e^{-\bar{\gamma}d}$ and line current $\bar{I}(d) = \frac{1}{\bar{Z}_0}\left[\bar{V}^+ e^{\bar{\gamma}d} - \bar{V}^- e^{-\bar{\gamma}d}\right]$, find the voltage reflection coefficient at any d and prove that the input impedance at $d = l$ is given by $\bar{Z}_{\text{in}} = \bar{Z}_0 \frac{\bar{Z}_R + \bar{Z}_0 \tanh \bar{\gamma} l}{\bar{Z}_R \tanh \bar{\gamma} l + \bar{Z}_0}$.

[10分] (B) Let the length of the transmission line be $l = 50$ m. The input impedance is measured at a frequency of 100 MHz for two cases: with the output short-circuited, it is $(10 + j49)\ \Omega$, and with the output open circuited, it is $(10 - j49)\ \Omega$. Find: (a) the characteristic impedance of the line; (b) the attenuation constant of the line; and (c) the phase velocity in the line, assuming its approximate value to be 1.75×10^8 m/s.