

CITY UNIVERSITY OF HONG KONG

Module code & title : EE 2114 Applied Electromagnetics

Session : Semester B 1996-97

Time allowed : Two hours

This paper has FIVE pages. (Including this page)

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1. This paper consists of **THREE** questions in **Section A** and **THREE** questions in **Section B**.
 2. Answer **ANY TWO** questions in each section. Each section has 50 percent marks.
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Materials, aids & instruments permitted to be used during examination:

1. Approved calculator
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Special materials (other than standard materials & answer book or supplementary sheets) to be supplied to students:

- (a) Smith Chart
 - (b) Important constants: $\mu_0 = 4\pi \times 10^{-7} \text{ (H/m)}$
 $\epsilon_0 \equiv 8.854 \times 10^{-12} \text{ (F/m)}$
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Section A (50%)

Attempt ANY TWO questions from this Section to get 50 marks.

1. (a) A uniform plane wave propagating in a medium has

$$\vec{E} = 2e^{-\alpha z} \sin(10^8 t - \beta z) \hat{y} \quad (V / m)$$

If the medium is characterized by $\epsilon_r = 1$, $\mu_r = 20$ and $\sigma = 3$ S/m, find α , β and the magnetic field. [15 marks]

- (b) In a nonmagnetic medium,

$$\vec{E} = 4 \sin(2\pi \times 10^7 t - 0.8x) \hat{z} \quad (V / m)$$

find ϵ_r and η . [10 marks]

2. In free space ($z \leq 0$), a plane wave with [25 marks]

$$\vec{H} = 10 \cos(10^8 t - \beta z) \hat{x} \quad (A / m)$$

is incident normally on a lossless medium ($\epsilon = 2\epsilon_0$, $\mu = 8\mu_0$) in region $z \geq 0$.

Determine (i) β and η in the free space and in the lossless medium,

(ii) the reflected wave $\vec{H}_r$ and $\vec{E}_r$,

(iii) the transmitted wave $\vec{H}_t$ and $\vec{E}_t$, and

(iv) the time-average power carried by the incident and transmitted waves.

3. (a) An air line has characteristic impedance of 75Ω and phase constant $\beta=3$ rad/m at 900 MHz. Calculate the inductance per meter and the capacitance per meter of the line. [10 marks]

- (b) A microstrip antenna with input impedance $40 + j 30 \Omega$ is to be matched to a 100Ω lossless microstrip line with a shorted stub. Using a Smith Chart, determine

(i) the shortest distance between the stub and the antenna,

(ii) the stub length,

(iii) the standing wave ratio on each section of the system. [15 marks]

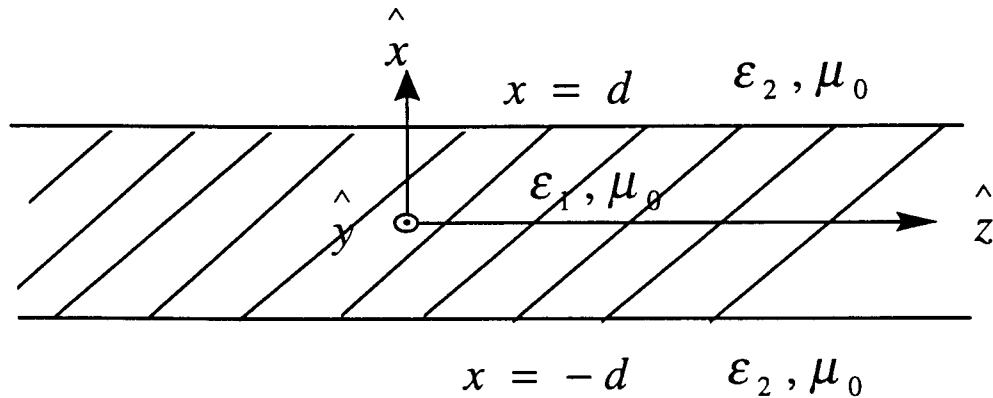
Section B (50%)

Attempt ANY TWO questions from this Section to get 50 marks.

1. A rectangular waveguide of 2 X 1 cm operating at 10 GHz. Assume there is only a TE₁₀ mode in the rectangular waveguide with $\vec{E} = \hat{y} E_0 f(x) e^{-jk_z z}$, find
 - (a) $f(x)$ and the $\vec{H}$ field. [5 marks]
 - (b) the guide wavelength in centimeters, [5 marks]
 - (a) the modal impedance Z_{TE} in ohms, [5 marks]
 - (b) the maximum electric intensity in volts/meter if the guide transmits a peak power of 10 kW. [10 marks]

2. (a) Indicate the term that Maxwell contributed in his Maxwell's Equations. [5 marks]
- (b) Show that the solution of a homogeneous equation in time domain exhibits the characteristics of wave. [5 marks]
- (c) What is the Brewster angle? [5 marks]
- (d) In a source-free region, $\vec{H} = z\hat{y} + y\hat{z}$. Does D vary with time (you have to substantiate your answer)? [5 marks]
- (e) Fill in the blank: The propagation spectrum of an electromagnetic wave in an unbound medium is _____. It becomes _____ in a confined space because of _____. [5 marks]

3. Consider a dielectric slab waveguide that has three layers as shown in the following figure. The central layer has dielectric constant ϵ_1 with two outer layers of dielectric constant ϵ_2 . The permeabilities of all three layers are equal to μ_0 .



Assume that the E field is polarized along the y-direction. Let

$$\vec{E} = \hat{y} E_1 \cos k_x x e^{-jk_z z} \quad \text{for } |x| < d$$

$$\vec{E} = \hat{y} E_0 e^{-\alpha_x |x| - jk_z z} \quad \text{for } |x| > d$$

- Find the $\vec{H}$ fields. [10 marks]
- Find the modes that are allowed to propagate in the waveguide. [5 marks]
- If $d = 3 \times 10^{-6}$ m and $\epsilon_1 = 1.47 \epsilon_0$ and $\epsilon_2 = 1.46 \epsilon_0$, find the angle of incidence θ_i of permitted propagation and the first two cut-off frequencies. [5 marks]
- Discuss the differences between the planar dielectric waveguide and fiber optics. Why the commonly used wavelengths are 1.3 and 1.55 μm ? [5 marks]

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