JUNE 2008

Code: AE14 **Subject: ELECTROMAGNETICS AND RADIATION**
Time: 3 Hours **Max. Marks: 100**

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x10)

a. Field due to infinitely long line charge along z-axis varies with

(A) ϕ **(B)** z
(C) ρ **(D)** both ϕ and z

b. Which one of the following is correct?

(A) $\overline{\nabla} \cdot \overline{E} = \rho_v$ **(B)** $\overline{\nabla} \cdot \overline{E} = \rho_v / \epsilon_o$
(C) $\overline{\nabla} \cdot \overline{E} = -\rho_v$ **(D)** $\overline{\nabla} \cdot \overline{E} = \epsilon_o \rho_v$

c. When a magnetic flux cuts across 200 turns at the rate of 2 Wb/s, the induced voltage is

(A) 400 V **(B)** 100 V
(C) 600 V **(D)** 0 V

d. When an EM wave is incident on a dielectric, it is

(A) fully transmitted
(B) fully reflected
(C) partially transmitted and partially reflected
(D) none of these.

e. If a line is terminated in an open circuit, the VSWR is

(A) 0 **(B)** 1
(C) ∞ **(D)** –1

f. A hollow rectangular waveguide acts as a

(A) High pass filter **(B)** Low pass filter

(C) Band pass filter **(D)** Low frequency radiator

g. For a 300 Ω antenna operating with 5A of current, the radiated power is

(A) 7500 W **(B)** 750 W
(C) 75 W **(D)** 7500 mW

h. If a current element is z-directed, vector magnetic potential is

(A) x-directed **(B)** y-directed
(C) θ-directed **(D)** z-directed

i. Divergence theorem is applicable for

(A) static field only
(B) time varying fields only
(C) both static and time varying fields
(D) electric fields only

j. Depth of penetration in free space is

(A) α **(B)** $1/\alpha$
(C) 0 **(D)** ∞

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Prove that energy density stored in an electric field of magnitude **E** is proportional to $\mathbf{E}^2$. **(8)**

b. A circular ring of radius 'a' carries a uniform charge ρ_L C/m and is placed on xy-plane with the axis the same as the z-axis

(i) Find $\overline{E}(0,0,h)$
(ii) What value of h gives maximum value of $\overline{E}$?
(iii) If the total charge on the ring is Q, find $\overline{E}$ as 'a' tends to 0. **(8)**

Q.3 a. Derive an expression for the magnetic field due to an infinite plane sheet of uniform surface current density. **(8)**

b. A circular loop located on $x^2 + y^2 = 9,\ z = 0$ carries a direct current of 10A along $\hat{a}\phi$. Determine $\overline{H}$ at (0, 0, 4) and (0, 0, −4). **(8)**

Q.4 a. State and explain Maxwell's equation in their Integral and differential forms. Derive the corresponding equations for fields varying harmonically with time. **(8)**

b. A conducting bar P can slide freely over two conducting rails as shown in Fig.1. Calculate the

induced voltage in the bar

(i) If the bar is stationed at y = 8 cm and $\bar{B} = 4\cos 10^6 t\,\hat{a}_z$ mWb/m^2.

(ii) If the bar slides at a velocity $\bar{v} = 20\,\hat{a}_y$ m/s and $\bar{B} = 4\,\hat{a}_z$ mWb/m^2.

(iii) If the bar slides at a velocity $\bar{v} = 20\,\hat{a}_y$ m/s and $\bar{B} = 4\cos\left(10^6 t - y\right)\hat{a}_z$ mWb/m^2. **(8)**

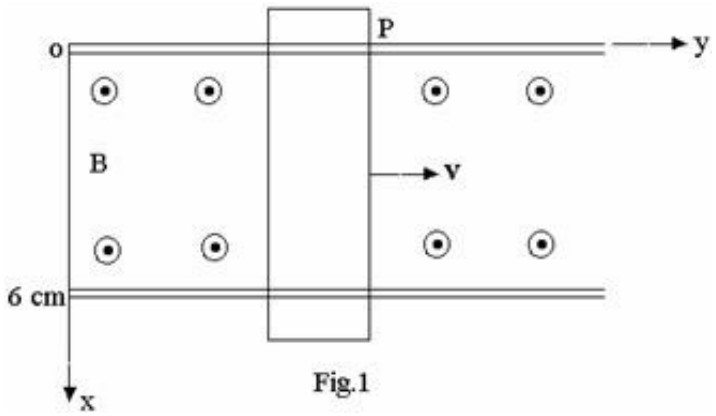

Fig.1

Q.5 a. State and prove Poynting theorem. Explain the physical interpretation of each terms in it. **(8)**

b. Given a uniform plane wave in air as

$\overline{E_i} = 40\cos(\omega t - \beta z)\,\hat{a}_x + 30\sin(\omega t - \beta z)\,\hat{a}_y$ V/m

(i) Find $\overline{H_i}$.

(ii) If the wave encounters a perfectly conducting plate normal to the z-axis at z = 0, find the reflected wave $\overline{E_r}$ and $\overline{H_r}$.

(iii) What are the total $\bar{E}$ and $\bar{H}$ fields for $z \le 0$?

(iv) Calculate the time-average Poynting vectors for $z \le 0$ and $z \ge 0$. **(8)**

Q.6 a. Discuss the derivation of the transmission-line equations from field equations by considering a parallel-plate line. Also model the line as a distributed circuit. **(8)**

b. A distortionless line has $z_o = 60\Omega, \alpha = 20$ mNp/m, v = 0.6 c, where c is the speed of light in vacuum. Find R, L, G, C and λ at 100 MHz frequency. **(8)**

Q.7 a. Explain the Terms-dominant mode, cut-off frequency, guide wavelength and characteristic Impedance. Discuss them for both TE and TM modes. **(8)**

b. Consider a parallel-plate waveguide as shown in Fig.2. Find the power reflection coefficients for $TE_{1,0}$ and $TM_{1,0}$ waves at frequency f = 5000 MHz incident on the junction from free space side. **(8)**

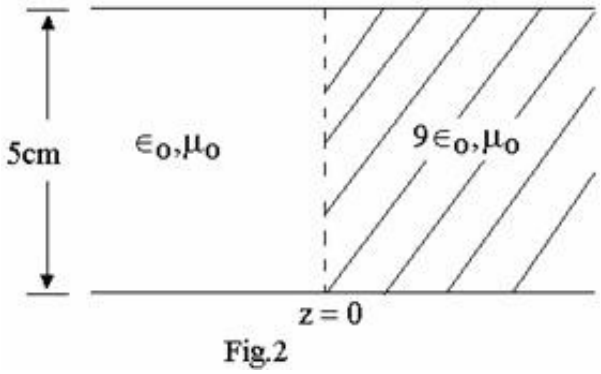

Fig.2

Q.8 a. Discuss the concept of unit and group patterns and their multiplications to obtain the resultant pattern of an array. **(8)**

b. The radiation intensity of an antenna is given by,

$$U(\theta,\phi)=\begin{cases}2\sin\theta\sin^3\phi, & 0\le\theta\le\pi, \quad 0\le\phi\le\pi,\\ 0, & \text{otherwise}.\end{cases}$$

Determine the directivity of the antenna. **(8)**

Q.9 a. What is skip distance and maximum usable frequency, estimate the maximum usable frequency (MUF) for a critical frequency of 1 MHz and an angle of 30°. **(4+4+2)**

b. State the different layers of Ionosphere. Which layer disappears at night, also explain why the ground wave propagation called medium wave propagation?
(4+2)