Code: AE14 **DECEMBER 2008** **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. When the separation between two charges increases, the electric potential energy of charges

(A) increases. **(B)** decreases.
(C) remains the same. **(D)** may increase or decreases.

b. Which one of the following conditions will not guarantee a distortionless Transmission Line?

(A) R=0, G=0 **(B)** LG=RC
(C) $R >> \omega L, G >> \omega C$ **(D)** $R << \omega L, G << \omega C$

c. A uniform plane wave in air is incident normally on an infinitely thick slab. If the refractive index of the glass slab is 1.5, then the percentage of the incident power that is reflected from the air-glass interface is

(A) 0% **(B)** 4%
(C) 20% **(D)** 10%

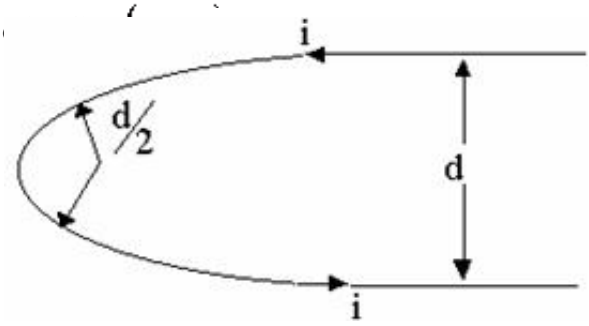
d. Some unknown material has a conductivity of 10^6 mho/m, and a permeability of $4\pi \times 10^{-7}$ H/m. The skin depth for the material at 1 GHz is

(A) 15.9 μm **(B)** 20.9 μm
(C) 25.9 μm **(D)** 30.9 μm

e. An electromagnetic wave is incident obliquely at the surface of a dielectric medium $2(\mu_2, \epsilon_2)$ from dielectric medium $1(\mu_1, \epsilon_1)$. The angle of incidence and the critical angle are θ_i and θ_c respectively. The phenomenon of total reflection occurs when

(A) $\epsilon_1 > \epsilon_2$ and $\theta_i < \theta_c$ **(B)** $\epsilon_1 < \epsilon_2$ and $\theta_i > \theta_c$
(C) $\epsilon_1 < \epsilon_2$ and $\theta_i < \theta_c$ **(D)** $\epsilon_1 > \epsilon_2$ and $\theta_i > \theta_c$

f. Find the magnetic field at the point P due to a current carrying conductor as shown in the figure. The curve portion is a semicircle



(A) $\frac{\mu_o i}{2\pi d}$ **(B)** $\frac{\mu_o i}{2d}\left(1+\frac{4}{\pi}\right)$

(C) $\frac{1}{2}\frac{\mu_o i}{2\pi d}$ **(D)** $\frac{\mu_o i}{2d}\left(1+\frac{2}{\pi}\right)$

g. Poisson's equation is

(A) $\nabla^2 V = \frac{-\rho}{\epsilon}$ **(B)** $\nabla^2 V = -4\pi\sigma$

(C) $\nabla^2 V = -4\pi\rho$ **(D)** $\nabla^2 V = 0$

h. The radio wave is incident on layer of ionosphere at an angle of 30° with the vertical. If the critical frequency is 1.2 MHz, the maximum usable frequency (MUF) is

(A) 1.2 MHz **(B)** 2.4 MHz

(C) 0.6 MHz **(D)** 1.386 MHz

i. A transmission line with a characteristic impedance Z_1 is connected to a transmission line with characteristic impedance Z_2. If the system is being driven by a generator connected to the first line, then the overall transmission coefficient will be

(A) $\frac{2Z_1}{Z_1+Z_2}$ **(B)** $\frac{Z_1}{Z_1+Z_2}$

(C) $\frac{2Z_2}{Z_1+Z_2}$ **(D)** $\frac{Z_2}{Z_1+Z_2}$

j. A rectangular waveguide has dimension $1.0\,\text{cm} \times 0.5\,\text{cm}$, its cutoff frequency for the dominant mode is

(A) 5 GHz **(B)** 10 GHz

(C) 15 GHz **(D)** 20 GHz

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

Q.2 a. Determine the electric potential energy of a uniformly charged sphere of radius R. **(8)**

b. Find the electric field at a point P on the perpendicular bisector of a uniformly charged rod. The length of the rod is L, the charge on it is Q and the distance of P from the centre of the rod is a. **(8)**

Q.3 a. Prove that a uniform plane wave is transverse in nature and $\frac{|\bar{E}|}{|\bar{H}|} = \sqrt{\frac{\mu}{\epsilon}}$. **(12)**

b. Derive expression for attenuation constant (α) and phase constant (β) for lossless transmission lines. **(4)**

Q.4 a. Explain critical frequency and maximum usable frequency. Determine the value of frequency at which an Electromagnetic wave must be propagated for D-region having refractive index of 0.5. (given N=400 electrons/cc for D-region).
(8)

b. Derive the wave equations from Maxwell's equation for free space, lossless charge free region. **(8)**

Q.5 a. Find the magnetic field at a distance r from a long straight wire carrying a steady current I. **(5)**

b. Find the magnetic field due to an infinite uniform surface current $k\hat{i}$ covering the x – y plane. **(5)**

c. Evaluate $\oint_s \bar{B} \cdot d\bar{s}$ for a cubical box bounded by x = 0 & x = 1, y = 0 & y = 1, z = 0 & z = 1 and the magnetic field is given by $\vec{B} = (x+2)\hat{a}_x + (1-3y)\hat{a}_y + 2z\hat{a}_z$. **(6)**

Q.6 a. An electromagnetic wave travel in free space with the electric component $E_S = 100e^{j(0.866\,y+0.5z)}\,\hat{a}_x\ V/m$. Determine

(i) ω and λ
(ii) the magnetic field component.
(iii) time average power in wave. **(3+3+4)**

b. In a loss less medium for which $\eta = 60\pi$, $\mu_0 = 1$ and H = 0.1 Cos $(\omega t - z)\ \hat{a}_x$ +0.5 Sin $(\omega t - z)\hat{a}_y$. Calculate electric field intensity. **(6)**

Q.7 a. What is stub matching? Outline the solution for the single stub matching problem. **(8)**

b. A 30m long loss less transmission line with $Z_o = 50\Omega$ operating at 2 MHz is terminated with a load $Z_L = 60 + j40\Omega$. If $v = 0.6\ c$ on the line, find

(i) the reflection coefficient, (K).

(ii) the voltage standing wave ratio, (S). **(4+4)**

Q.8 a. Discuss the propagation characteristics of a rectangular wave guide propagating under TM mode and hence explain propagation constant, guide wavelength and cut off frequency. **(10)**

b. A rectangular wave guide has the following characteristics: b = 1.5 cm, a = 3 cm, $\mu_r = 1$, $\epsilon_r = 2.25$

(i) Calculate the cutoff frequency for TE_{10}, TE_{20} and TM_{11} modes.

(ii) Calculate the guide wavelength and characteristic impedance, Z_o at 4.0 GHz for TE_{10} modes. **(6)**

Q.9 a. Establish the expression for normalised E-field and H-field pattern for a half wave dipole. **(4+4)**

b. A magnetic field strength of $5\mu A/m$ is required at a point on $\theta = \pi/2$, 2 Km from an antenna in air. Neglecting ohmic loss how much power must antenna transmit if it is

(i) a hertzian dipole of length $\lambda/25$.

(ii) A half wave dipole. **(4+4)**