AMIETE – ET (OLD SCHEME)

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

DECEMBER 2009

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 the best alternative in the following: (2x10)

a. The Gauss law for electrostatics can be mathematically represented as

(A) $\mathbf{D} \cdot d\mathbf{S} = Q_{enc}$ **(B)** $\int \psi \cdot d\mathbf{S} = Q_{enc}$
(C) $\psi = Q_{enc}$ **(D)** $\mathbf{D} = Q_{enc}$

b. A Gaussian surface within a metallic spherical shell of inner and outer radii R_1 and R_2, contains charge Q placed at the center. The normal component of D at the Gaussian surface will be

(A) Zero **(B)** $Q/(4\pi R_1^2)$
(C) $Q/(4\pi R_2^2)$ **(D)** $Q/[4\pi(R_1 - R_2)^2]$

c. The electrons in a cathode ray tube of TV is deflected by a force equal to

(A) QE **(B)** $Q(v \times B)$
(C) $Q(E + v \times B)$ **(D)** None of these

d. A parallel plate capacitor has plate area A, separated by a distance d, and contains dielectric of permittivity ε. When a voltage $V_0 \sin \omega t$ is applied to its plate, the magnitude of displacement current $\mathbf{J}_D$ and conduction current $\mathbf{J}_c$ are

(A) $\mathbf{J}_D > \mathbf{J}_c$ **(B)** $\mathbf{J}_D < \mathbf{J}_c$
(C) $\mathbf{J}_D = \mathbf{J}_c$ **(D)** $\mathbf{J}_D = \mathbf{0}$

e. Which one of the following is not Maxwell equation?

(A) $\nabla . D = \rho$ **(B)** $\nabla \times E = \frac{-\partial B}{\partial t}$
(C) $\nabla \times H = J + \frac{\partial D}{\partial t}$ **(D)** $\nabla . J = \frac{-\partial \rho}{\partial t}$

f. An electromagnetic wave has electric field component along y –direction and magnetic field component along x – direction. The electromagnetic wave is propagating along

(A) +z –direction **(B)** –z –direction
(C) +x –direction **(D)** +y –direction

g. A line of length *l* has characteristic impedance Z_0. The line is cut into two halves. The value of characteristic impedance become

(A) $Z_0/2$ **(B)** $Z_0/4$

(C) $2Z_0$ **(D)** Z_0

h. In the outline of Smith Chart shown in Fig.1, the normalized impedance 0+j0 Ω corresponds to

(A) O
(B) A
(C) B
(D) C

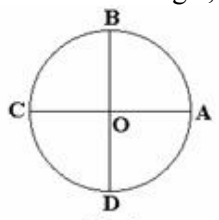

Fig.1

i. Antenna 1 has radiation resistance twice that of antenna 2. It implies that

(A) Antenna 2 delivers double power than antenna 1.
(B) Antenna 2 delivers half power than antenna 1.
(C) Antenna 2 delivers quarter power than antenna 1.
(D) Antenna 2 delivers equal power as antenna 1.

j. A car driver is listening to AM radio at 10 MHz. He, on his way moves into a tunnel of 5m x 5m dimension. He will

(A) receive radio signals uninterrupted.
(B) receive radio signals with disturbances.
(C) receive radio signals with resonating sounds.
(D) not receive any signals.

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

Q.2 a. Derive an expression for energy stored in the static electric field containing 'n' point charges. **(8)**

b. The volume charge density of a given charge distribution is given by $\rho = \rho_0(a/r)$ in spherical coordinates. Determine the electric flux density and field intensity at any point and also, find V from the field E_r if $V = 0$ at $r = 0$. **(8)**

Q.3 a. State Maxwell's equations and explain their physical significance. **(8)**

b. Given $\mathbf{E} = E_m \sin(\omega t - \beta z)\hat{a}_y$ in free space, find **D**, **B** and **H**. **(8)**

Q.4 a. The electric field Intensity distribution is given by $\bar{E}(r,\theta,\phi) = \frac{E_0 \sin\theta}{r}\cos(\omega t - \beta r)\hat{a}_\theta$. Determine
(i) Magnetic flux density $(\bar{B})$ (ii) Poynting's vector $(\bar{P})$
(iii) Characteristic Impedance (η) **(8)**

b. A uniform plane wave strikes the interface between the two dielectrics at right angles. Find reflection coefficient and transmission coefficient. **(8)**

Q.5 a. State and explain Ampere's Circuital Law. What are certain procedures and observations to be followed for the application of this law? **(8)**

b. The volume current density distribution in cylindrical co-ordinates is given by

$$J(r,\phi,z)=\begin{cases}0, & 0<r\le a\\ J_0\left(\frac{r}{a}\right)\hat{a}_z, & a\le r\le b\\ 0, & b\le r<\infty\end{cases}$$

$= 0, \quad b < r < \infty$

where a and b are inner and outer radii of cylinders. Determine the magnetic field Intensity in various regions. **(8)**

Q.6 a. Derive the basic transmission line equation. Also, explain the lossless and distortion less Transmission Lines. **(8)**

b. A transmission line of characteristic impedance 50 ohm is terminated by a resistor 100 ohm. What will be the VSWR in the line? Calculate the impedance at the voltage maximum and minimum position. **(8)**

Q.7 a. Derive the wave equation for a TE wave and obtain all the field component in rectangular waveguide. **(8)**

b. An air filled rectangular waveguide of inside dimensions 7 cm x 3.5 cm operates in the dominant TE_{10} mode **(8)**

(i) Find the cutoff frequency
(ii) Determine the phase velocity of the wave in the guide at a frequency of 3.5 GHz
(iii) Determine the guided wavelength at the same frequency.

Q.8 a. Calculate the total power radiation by a $\lambda/2$ antenna and hence determine its radiation resistance. **(8)**

b. Draw group patterns for an array of two antennas carrying current of equal amplitude for **(8)**

(i) $d = \lambda/2, \ \alpha = 0$ (ii) $d = \lambda/2, \ \alpha = \pi$
(iii) $d = \lambda/4, \ \alpha = -\pi/2$ (iv) $d = \lambda, \ \alpha = 0$

Q.9 a. Describe the mechanism of sky wave propagation. Explain the Terms critical frequency maximum usable freq, virtual height and skip distance. **(8)**

b. Find the shortest distance from the load and the length both in centimeters of a shorted stub connected in parallel to a 300 ohms lossless air dielectric line in order to match a load $\mathbf{Z_R} = (600 + j300)$ ohms at 600MHz. The matching stub is the same type of line as the main Line. **(8)**