# AMIETE – ET (OLD SCHEME)

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

**JUNE 2010**

**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.**
- **Symbols have their usual meaning.**
- **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.**

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**Q.1 Choose the correct or the best alternative in the following:** **(2×10)**

a. Intrinsic impedance of free space is given as

**(A)** 75 Ω **(B)** 73 Ω
**(C)** 377 Ω **(D)** 300 Ω

b. Which of the following is a scalar quantity?

**(A)** Electric displacement density **(B)** Potential in electric field
**(C)** Electric field strength **(D)** Polarization

c. The magnetic flux density B and a vector magnetic potential A are related as

**(A)** $\vec{B} = \nabla \times \vec{A}$ **(B)** $\vec{A} = \nabla \times \vec{B}$
**(C)** $\vec{B} = \nabla . \vec{A}$ **(D)** $\vec{A} = \nabla . \vec{B}$

d. The following wave doesn't exist in waveguides

**(A)** TM waves **(B)** TE waves
**(C)** TEM waves **(D)** TE and TM waves

e. The Poisson's equation can be represented by

**(A)** $\nabla^2 V = -\rho/\varepsilon_0$ **(B)** $\nabla^2 V = \rho/\varepsilon_0$
**(C)** $\nabla . \vec{E} = \rho/\varepsilon_0$ **(D)** $\vec{E} = -\nabla V$

f. Poynting vector gives the

**(A)** Direction of polarization **(B)** The rate of energy flow
**(C)** Intensity of electric field **(D)** Intensity of magnetic field

g. A dominant wave is characterized by

**(A)** Lowest cut-off wavelength **(B)** Highest cut-off wavelength
**(C)** No attenuation **(D)** Infinite attenuation

h. When a wave travelling in air enters into a waveguide

**(A)** The phase velocity will increase
**(B)** The group velocity will increase
**(C)** The phase velocity will decrease

**(D)** None of the above

i. Propagation of frequencies in UHF range takes place by means of

**(A)** Surface waves **(B)** Space waves
**(C)** Ground waves **(D)** Sky waves

j. The gain of an isotropic antenna is

**(A)** 0 dB **(B)** 3 dB
**(C)** 10 dB **(D)** 12 dB

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

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**Q.2** a. State and derive Gauss's law. Find electric field near an infinite sheet of charge of density $\sigma$ using Gauss's law in integral form. **(8)**

b. Find the energy expended in moving a point charge in an electric field. **(4)**

c. An electric field is given as $E = 6y^2z\,\hat{a}_x + 12\,xyz\,\hat{a}_y + 6xy^2\,\hat{a}_z$ Volt/meter. An incremental path is represented by $\Delta L = -3\,\hat{a}_x + 5\,\hat{a}_y - 2\,\hat{a}_z$ μm. Find the work done in moving a 2 μC charge along this path if the location is at:
(i) $P_A$ (0, 2, 5)
(ii) $P_B$ (1, 1, 1)
(iii) $P_C$ ( – 0.7, –2, –0.3) **(4)**

**Q.3** a. Explain Biot-Savart law. Calculate the magnetic field due to a current carrying thin straight wire of infinite length using Ampere's law. **(8)**

b. Explain the concept of energy stored in a magnetic field. Find the relation describing magnetic energy in terms of current density J and vector potential A. Also find magnetic energy in terms of current I and flux $\psi_m$. **(8)**

**Q.4** a. Write both differential and integral form of Maxwell's equations in matter, as well as in free space. Mention clearly the notations used in the equations. **(8)**

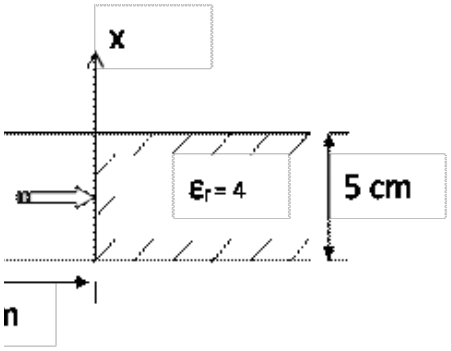
b. At the interface between two perfect dielectric materials, prove the relationship:
$E_2 = \hat{E}_1\,[\sin^2\theta_1 + (\varepsilon_2/\varepsilon_1)^2\cos^2\theta_1]^{1/2}$.
Where $E_1$ and $E_2$ are electric field intensities in dielectric 1 and dielectric 2 respectively and $\varepsilon_1$ and $\varepsilon_2$ are permittivities of these dielectrics. $\theta_1$ is the angle between direction of flux and boundary, in medium 1. **(8)**

**Q.5** a. A 10 GHz plane wave travelling in free space has an amplitude $E_x = 1$ Volt/meter.
(i) Find the phase velocity, the wave length and the propagation constant.
(ii) Determine the characteristic impedance of the medium.
(iii) Find the amplitude and direction of the magnetic field intensity.
(iv) Repeat part (i), if the wave is travelling in a loss less, bounded medium having permeability the same as that of free space but
permittivity four times that of free space. **(8)**

b. Explain the phenomena of reflection and refraction for a uniform wave in conductor with oblique incidence.

**(8)**

**Q.6** a. The region between a pair of parallel perfectly conducting planes of infinite extent in the Y and Z directions is partially filled with a dielectric as shown in figure below. A 30 GHz $TE_{10}$ wave is incident on the air-dielectric interface as shown. Find the VSWR at the interface. **(8)**




b. For a distortion less line with propagation constant $\gamma = 0.04 + j1.5$, having characteristics impedance 80 Ω and frequency of operation 500 MHz. Determine the primary constants R, G, L and C. **(8)**

**Q.7** a. What do you understand by a dominant mode? Calculate the ratio of the area of a circular waveguide to that of a rectangular one, if each is to have the same cut-off wavelength for its dominant mode. **(8)**

b. A line of characteristic impedance 600 Ω is terminated in a load $Z_L$. The VSWR measured on the line is 1.5 and the first maximum occurs at a distance of 20 cm from the load. The line is open wire and supplied from a generator at 300 MHz. Find the value of the load impedance. **(8)**

**Q.8** a. Define the term "directivity" for an antenna. Derive the equation for directivity and compute the directivity of an antenna corresponding to the power density pattern function $f(\theta,\Phi) = \sin^2\theta.\cos^2\theta$ . **(10)**

b. Explain the term "radiation resistance" of an antenna. Calculate the radiation resistance of an antenna in free space having wavelength 10 mm and length 1 cm. **(6)**

**Q.9** Write short notes on the following:

(i) Critical frequency for ionospheric propagation
(ii) Maximum Usable Frequency
(iii) Quarter wave transformer.
(iv) Skin Depth. **(4 × 4)**