[25] No. of Printed Pages: 2

Sardar Patel University
Vallabh Vidyanagar
M Sc. II Sem. Examination
Subject: PS02CPHY03 Electrodynamics and Plasma Physics
Day & Date: Friday, 24 April 2015 Time: 10:30am to 1:30pm

Max. marks 70

Note: Symbols have their usual meaning.

I Choose the best possible answer from the choices given below each questions (8x1=8)

1. Poynting vector is expressed as

(A) $\vec{E}\cdot\vec{H}$ (B) $\vec{E}\times\vec{H}$ (C) $\mu\vec{E}\times\vec{H}$ (D) $\frac{1}{\mu}\ \vec{E}\times H$

2. The electric field component of an electromagnetic wave in free space is given by $\vec{E} = 30\cos(4x-\omega t)\hat{y}$ V/m. The wave is propagating along

(A) x-y plane (B) x-direction (C) y-direction (D) x-z plane

3. The expression $\varepsilon_0[\vec{r}\times(\vec{E}\times\vec{B})]$ for electromagnetic fields corresponds to

(A) Energy flow (B) Field momentum
(C) Angular momentum of the em field (D) Lorentz guage condition

4. For an EM wave propagating through a good conducting medium will have,

(A) its magnetic field lags behind the electric field by 45°
(B) its electric field lags behind the magnetic field by 45°
(C) its magnetic field and the electric field in phase
(D) its magnetic field equal to zero

5. The equations $\nabla^2 E-\sigma\mu\frac{\partial E}{\partial t}-\varepsilon\mu\frac{\partial^2 E}{\partial t^2}=0$ and $\nabla^2 H-\sigma\mu\frac{\partial H}{\partial t}-\varepsilon\mu\frac{\partial^2 H}{\partial t^2}=0$ represent wave equations governing the electromagnetic fields E and H in

(A) A homogeneous dielectric medium (B) A homogeneous conducting medium
(C) Vacuum (D) A Plasma medium.

6. A rectangular waveguide of dimension a = 4cm and b= 2cm, is operating at 10GHz frequency. The dominant mode and its cutoff frequency is given by

(A) (TE_{11}, 10 GHz) (B) (TE_{10}, 3.75 GHz)
(C) (TE_{01}, 3.75 GHz) (D) (TM_{11}, 3.0 GHz)

7. The zeroth moment of the Boltzmann equation of the kinetic theory of plasma represents

(A) Momentum balance equation (B) Energy conservation equation
(C) Heat flow (D) Continuity equation

8. In the case of a planar sheath, the mach number, $m^2 > 1$ is called the

(A) Debye condition (B) Sagdeev condition
(C) Bohm Sheath criterion (D) Landau damping criterion

II Attempt any seven of the following short answer questions. **(7x2=14)**

1. Define a right circularly polarized plane wave.
2. Define skin depth and write an expression for the same. Find the skin depth at a frequency of 1.6 MHz in Aluminium. [given: $\sigma_{Al} = 38.2MS/m$, $\mu_r = 1.0$]
3. Give the physical interpretation of Landau damping.
4. What are Lienard-Wiechert potentials? How are they computed?
5. For the coordinates of a radiating moving point charge, show that $\vec{\nabla} \times \vec{v} = -\vec{a} \times \vec{\nabla} t_r$.
6. Show that the rate of electromagnetic energy radiated by a point source is $(1 - \hat{r} \cdot \vec{\beta})$ times the rate of radiation energy received by an observer at $\vec{r}$.
7. Define cut off frequency of a wave guide and give an expression for the cutoff wavelength of the dominant TE and TM waves in a rectangular wave guide.
8. Explain how the Cerenkov radiation is different from the synchrotron radiation.
9. Describe advantages of the kinetic theory over fluid dynamics for the study of plasma.

III A Write all the four Maxwell's equations in integral form and derive the boundary conditions satisfied by the $\vec{E}, \vec{B}, \vec{D}$ *and* $\vec{H}$. (6)

B State and prove the Poynting theorem. (6)

OR

B. The electric component of an electromagnetic wave propagating along z- direction is given by $\vec{E}(z,t) = A\sin(\omega t - kz)\hat{x}$. Calculate the corresponding magnetic field component and then compute the instantaneous power flow per unit area along x-y plane. (6)

IV A. Discuss with the help of mathematics, reflection of electromagnetic waves at a conducting surface. (6)

B. A plane wave traveling in the +z direction in free space is normally incident at z = 0 on a conducting surface for which $\sigma = 61.7MS/m$, $\mu_r = 1.0$. The free space electric field component of the wave at the interface is given by $\vec{E}(0,t) = 1.0\sin(2\pi ft)\hat{y}$ V/m where f = 1.5 MHz. find $\vec{H}(z,t)$ for z > 0. (6)

OR

B. Define reflection and transmission coefficient of a plane wave incident normally at the interface of two dielectric media. (6)

V A. What is the essential difference between a wave guide and a resonator? Explain the different modes of propagation in wave guide and excitations in a resonator. (6)

B. Obtain the field components of a small loop antenna and obtain an expression for the radiation resistance of a small loop antenna. (6)

OR

B. The electric field component of the radiation emitted by a moving point charge particle is given by $\vec{E}_R = \frac{q}{4\pi\varepsilon_0 r\ \xi^3}\hat{n} \times [(\hat{n} - \vec{\beta}) \times \dot{\vec{\beta}}]$, where $\hat{n}$ is the unit vector along the propagation direction. Deduce it for the case of a slowly moving charge particle and derive the Larmor formula. (6)

VI A. Derive the sheath equation in plasma and obtain the Bohm-Sheath criterion. (6)

B. Derive the Abraham – Lorentz formula and explain its physical interpretation. (6)

OR

B. Discuss in detail the problem of controlled fusion and derive the Lawson criterion. (6)

—X—