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Sardar patel University
Vallabh Vidyanagar
M Sc. II Sem. Examination
Subject: PS02CPHY03 Electrodynamics and Plasma Physics
Day & Date: Saturday, 9th April 2016 Time: 10:30am to 1:30pm

Note: Symbols have their usual meaning **Max. Marks 70**

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

1. The $\oint \boldsymbol{B}.\boldsymbol{ds} = 0$ indicates

   (a) Gauss-Maxwell law (b) Faraday's law
   (c) Nonexistence of magnetic monopole (d) Ampere's law

2. The electric field component of an electromagnetic wave in free space is given by $\vec{E} = 20\sin(10^8 t - kz)\hat{y}$ V/m . Find the propagation constant, k of the wave.

   (a) 0 .33 rad/m (b) 2.1 rad/m (c) 3.3 rad/m (d) 20.0 rad/m

3. The loss tangent of a medium with reference to the propagation of em wave given by the relation

   (a) $\tan\theta = \sigma\varepsilon^{'}/\varepsilon^{''}\omega$ (b) $\tan\theta = \varepsilon^{'}\omega/\varepsilon^{''}\sigma$
   (c) $\tan\theta = \varepsilon^{'}/\varepsilon^{''} = \dfrac{\sigma}{\omega\varepsilon}$ (d) $\tan\theta = \sigma/\omega$

4. In the case of an electromagnetic wave propagating through a conducting medium, it can be said that

   (a) **E** and **B** fields are in phase (b) **E** lags behind the **B** field
   (c) **B** lags behind **E** field (d) **E** and **B** fields lags behind the Poynting vector

5. A wave guide generally act as

   (a) high pass filter (b) low pass filter
   (c) band pass filter (d) an attenuator

6. The Lawson criterion related to the fusion energy of D-T reaction is given by

   (a) $n\,\tau \le 10^{-14}\,s/cm^3$ (b) $n/\tau < 10^{14}\,cm^3/s$
   (c) $n/\tau \ge 10^{14}\,cm^3/s$ (d) $n\,\tau \ge 10^{14}\,s/cm^3$

7. The Lorentz gauge condition is expressed as

   (a) $\nabla.\boldsymbol{A} = 0$ (b) $\nabla.\boldsymbol{A} + \frac{\partial\varphi}{\partial t} = 0$ (c) $\nabla.\boldsymbol{B} = 0$ (d) $\mathbf{r}.\boldsymbol{A} = 0$

8. Shock waves in cold-ion plasma exist only if the Mach number, m satisfies the condition

   (a) $1 < m < 1.6$ (b) $m = 1.6$
   (c) $m > 1.6$ (d) $0 < m < 1$

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

1. Using relevant Maxwell's equations derive the relaxation time for a charge distribution in a conducting medium.
2. Explain that electromagnetic wave not only carry energy but also carry momentum. Express the momentum density in terms of the Poynting vector.
3. Define cut off frequency of a wave guide and give an expression for the cutoff wavelength of the dominant TM waves in a rectangular wave guide.
4. Explain Ponderomotive force in plasma.
5. What is Bremstrahlung radiation? Draw its angular power distribution?
6. Define retarded time, t_r and get an expression for $\frac{dt_r}{dt}$.
7. Explain the D-T reaction for nuclear fusion energy. Why is it advantageous?
8. What are the boundary conditions satisfied by the electric and magnetic field components of a plane electromagnetic wave incident at the interface of two dielectric media?
9. What is radiation reaction? Explain briefly.

III A. Derive an expression for the electromagnetic field stress tensor. Give its physical interpretation. (6)

B. For the case of normal incidence of electromagnetic plane wave at the interface of a nonconducting medium, obtain equations for reflectance (R) and transmittance (T) and if the refractive indices of the two media $n_1 = 1.0$ and $n_2 = 1.5$ compute R and T. (6)

OR

B. Deduce the wave equation for electric and magnetic field for the case of a plane em wave propagating through conducting medium. In this case show that the wave vector ($\vec{k}$) is complex and obtain its real and imaginary parts. Discuss the case for a very good conducting medium. (6)

IVA. Define scalar and vector potentials. Discuss the gauge degrees of freedom associated with these potentials. Describe the Coulomb and Lorentz gauge conditions and obtain wave equations satisfied by these potentials. (6)

B. Prove that the retarded scalar potential $V(\vec{r},t) = \frac{1}{4\pi\varepsilon_0}\int \frac{\rho(\vec{r}',t_r)}{|\vec{r}-\vec{r}'|} d^3r'$ obeys inhomogeneous wave equation (6)

OR

B. What are Lie'nard-Wiechert potentials. Discuss in detail the power radiated by an accelerated point charge and deduce the Larmor formula. (6)

V A Define TE, TM amd TEM waves. Study the TE waves in a rectangular wave guide and obtain expression for the cutoff frequency. Compute the lowest cutoff frequency for the TE modes for the rectangular wave guide having 1.5 cm x 0.8 cm cross section operatong at a frequency of 50GHz. (6)

B. For an oscillating electric dipole derive the electric and magnetic components of the radiation fields and obtain an expression for the angular power distribution in the case of an electric dipole. Draw its radiation pattern. (6)

OR

B. An electric field strength of $10\mu V/m$ is to be measured at a point 600km perpendicular to a half wave dipole antenna operating in air at 60MHz. Compute the length of the dipole, calculate the current that must fed to the antenna and the average power radiated by the antenna. (6)

VIA) Derive the child –Langmuir law near the sheath of a cold plasma. (6)

B) Explain how the sheaths are formed in plasma contained in a magnetic vessel? Using the Poisson's equation, derive the sheath equation in plasma. (6)

OR

B) Obtain the dispersion formula corresponds to Landau damping using kinetic theory of plasma. Give physical interpretation of the same. (6)

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