!REV-01
MSP/01/05

2023/08

M.Sc. PHYSICS
SECOND SEMESTER (SPECIAL REPEAT)
ELECTROMAGNETICS & PLASMA PHYSICS
MSP-201

[USE OMR SHEET FOR OBJECTIVE PART]

Duration: 3 hrs. **Full Marks: 70**

Objective

Time: 30 mins. **Marks: 20**

Choose the correct answer from the following: ***1X20=20***

1. Calculate the charge density when a potential function $x^2 + y^2 + z^2$ is in air (in 10^{-9} order).
   a. $1/6\pi$ b. $6/2\pi$
   c. $12/6\pi$ d. $10/8\pi$
2. Find the electric field of a potential function given by $20 \log x + y$ at the point (1,1,0)
   a. $-20\,i - j$ b. $-i - 20\,j$
   c. $i + j$ d. $(i + j)/20$
3. Mathematically, the functions in Green's theorem will be:
   a. Continuous partial derivatives b. Continuous derivatives
   c. Discrete derivatives d. Discrete partial derivatives
4. The reflection coefficient of a wave with transmission coefficient 0.45 is:
   a. 1.45 b. 0.55
   c. 0.45 d. 0
5. The boundary condition at the surface of incidence obeys_____.
   a. Fresnel Equation b. Snell's law
   c. Gauss's law d. Kepler's law
6. Waveguides can carry:
   a. TE mode b. TM mode
   c. Mixed Mode d. All of these
7. The cut off frequency of the dominant mode in a TE wave in the line having a and b as 2.5 cm and 1 cm respectively is:
   a. 4.5 GHz b. 5 GHz
   c. 7 GHz d. 6 GHz
8. $\emptyset(r,t) = \frac{1}{4\pi\varepsilon_0}\frac{qe}{(Rc - R.v}$ gives the:
   a. Retarded Potential b. Scalar potential
   c. Lienard-Wiechert Potential d. Vector Potential
9. Which of the following will not satisfy the wave equation?
   a. $50e^{i(\omega t - 3z)}$ b. $\sin(\omega(10z + 5t))$
   c. $\sin x \cos t$ d. None of these
10. Find the curl of Electric field when the magnetic field is given as 15t.
    a. -15 b. 15
    c. 1.5 d. 7.5

11. The number of atoms in a Debye sphere N_D is related to the Debye shielding length λ_D as:

a. $N_D \propto \lambda_D$ b. $N_D \propto \sqrt{\lambda_D}$

c. $N_D \propto \lambda_D^3$ d. $N_D \propto 1/\lambda_D^3$

12. A charged particle in a plasma trapped in a magnetic bottle leaks out after a millisecond. What is the total work done by the magnetic field during the time the particle is trapped?

a. Maximum b. Minimum

c. Zero d. Depends on the strength of the magnetic field

13. As a plasma is compressed radially, the plasma number density and the temperature:

a. Increase b. Decrease

c. Remain same d. Become infinite

14. For an ion acoustic wave, the phase velocity v_{ph} and group velocity v_g are related as:

a. $v_{ph} > v_g$ b. $v_{ph} < v_g$

c. $v_{ph} = v_g$ d. $v_{ph} = -v_g$

15. Consider an infinite cylindrical column of conducting fluid plasma with axial current density $J_z(r)\hat{z}$ and a resulting azimuthal magnetic induction $B_\theta(r)\hat{\theta}$. The force which produces radial constriction of the plasma column is the:

a. Centrifugal force b. $q(\vec{v} \times \vec{B})$ force

c. $\nabla\vec{B}$ force d. $\vec{J} \times \vec{B}$ force

16. The gradient drift for a charge particle of mass m and charge q moving in a system with non-uniform magnetic field $\vec{B}$ is: (the symbols have their usual meanings)

a. $\vec{v}_{\nabla B} = \pm \frac{m v_\perp^2}{2qB} \frac{\vec{B} \times \nabla \vec{B}}{B^2}$ b. $\vec{v}_{\nabla B} = \frac{1}{2} m v_\perp^2 \frac{\vec{B} \times \nabla \vec{B}}{B^4}$

c. $\vec{v}_{\nabla B} = \pm \frac{m v_\perp^2}{2qB} \frac{\vec{B} \times \nabla \vec{B}}{B^2}$ d. $\vec{v}_{\nabla B} = \pm \frac{m v_\perp^2}{2qB} \frac{\vec{B} \times \nabla \vec{B}}{B^2}$

17. The Rayleigh scattering intensity for a single particle varies inversely as the:

a. First power of wavelength b. Second power of wavelength

c. Third power of wavelength d. Fourth power of wavelength

18. Rayleigh scattering is strongly dependent upon the:

a. Size of the particle b. Mass of the particle

c. Charge of the particle d. Spin of the particle

19. The zeroth component of a four-vector is:

a. A scalar b. A vector

c. A tensor of rank 2 d. None of these

20. The four momentum of a particle at rest having mass m is:

a. $p^\mu = \begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}$ b. $p^\mu = \begin{pmatrix} mc^2 \\ 0 \\ 0 \\ pc \end{pmatrix}$

c. $p^{\mu} = \begin{pmatrix} mc^2 \\ 0 \\ 0 \\ 0 \end{pmatrix}$

d. $p^{\mu} = \begin{pmatrix} mc^2 \\ p_x c \\ p_y c \\ p_z c \end{pmatrix}$

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Descriptive

Time : 2 hr. 30 mins. Marks : 50

[Answer question no.1 & any four (4) from the rest]

1. a) Suppose $\varphi = 0$ and $A = A_0 \sin(kx - wt)\, j$, where A_0, w, and k are constants. Find E and B. 5+5=10
   b) Derive an expression for $\vec{E} \times \vec{B}$ drift velocity for the motion of non-relativistic charged particles in presence of crossed electric ($\vec{E}$) and magnetic ($\vec{B}$) fields which are constant in time and uniform in space.

2. a) Semi-infinite conducting planes at $\varphi = 0$ and $\varphi = \pi/6$ are separated by an infinitesimal insulating gap as shown in the figure. If $V(\varphi = 0) = 0$ and $V(\varphi = \pi/6) = 100V$. Calculate E in the region between the planes. 5+5=10
   b) Calculate the reflection co-efficient of electromagnetic wave at normal incident.

3. a) Show that the mode TE_{00} cannot occur in a rectangular waveguide. Consider a rectangular wave guide with dimension 2.28 cm×1.01cm. What TM modes will propagate in this wave guide, if the driving frequency is 1.70×10^{10} Hz? 2+3+5=10
   b) Calculate the potential of a point charge moving in a specified trajectory.

4. a) Calculate the Fresnel equations of electromagnetics, considering the electric fields are parallel to the incident plane. 6+4=10
   b) Starting from the Maxwell's equation show that $\frac{\partial E_y}{\partial x} - \frac{\partial E_x}{\partial y} = i\omega B_z$. (symbols have their usual meanings)

5. a) Find the Green's function for the boundary value problem $\frac{d^2y}{dx^2} - k^2 y = f(x)$ with boundary conditions, $y(\pm\infty) = 0$ 5+5=10
   b) Explain briefly the pinch effect in plasma. What are the different types of pinch effect present in plasma?

6. a) Derive an expression for the Debye shielding length. 7+3=10
   b) Compute the Debye length and the number of particles in a Debye sphere of a typical plasma system with electron concentration of 10^{13} cm^{-3} and electron temperature of 1 eV.

7. a) Show that the dispersion relation for electron plasma wave is given by 8+2=10
   $\omega^2 = \omega_p^2 + \frac{3}{2} K_B^2 v_{te}^2$.
   b) Hence demostrate the graphical representation of the variation of plasma frequency ω with wave vector k. (symbols have their usual meanings)

8. a) Write down the expression for frequency of plasma oscillation. How does the thermal motion of the particles effect this oscillation? 3+3+2+2=10
   b) What is a four vector? Write down the expressions for four-velocity vector for a particle at rest.
   c) Write down the expression for the matric tensor of special relativity in Minkowski space.
   d) State the differences between Rayleigh scattering and Thomson scattering of electromagnetic waves.

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