(PART-B : Descriptive)

Time : 2 hrs. 40 min. **Marks : 50**

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

1. Derive an expression for frequency of plasma oscillation. In presence of thermal motion, the plasma oscillations propagate. Hence, write down the dispersion relation of electron plasma wave. 8+2=10
2. **a.** Find an expression for the grad-B drift of a gyrating particle in a nonuniform magnetic field. Also discuss the trajectory of the charged particles. 4+2+4 =10

   b. An electron and an ion of masses m_e and m_i respectively are subjected to a constant and uniform magnetic field $\vec{B}$. Show that the kinetic energy acquired by an electron in time τ is m_i/m_e times greater than the kinetic energy acquired by an ion. Assume, the average time τ between two collisions is the same for electrons and ions.
3. **a.** In a magnetic mirror, the trajectory of a charged particle makes an angle θ_0 with the magnetic field line. Show that the mirror ratio R_m is given by $\frac{1}{R_m} = \frac{B_0}{B_m} = \sin^2\theta_m$. 8+2 =10

   Here $B_0$is the strength of the magnetic field at the centre and $B_m$is the strength of the magnetic field at the throat of the magnetic mirror system.

   b. A plasma with an isotropic velocity distribution is placed in a magnetic mirror trap with mirror ratio $R_m = 2$. Find the value of pitch angle θ_m.
4. **a.** What do you mean by Debye shielding length of plasma? Compute the Debye length of earth's ionosphere with typical value of temperature $T = 10^3\ K$ and number density $n = 10^{12}\ m^{-3}$ 3+2+5 =10

   b. Starting from electromagnetic field tensor $F^{\mu\nu}$, derive Maxwell's second equation.
5. **a.** What is the power radiated by a point charge? 4+6=10

   b. Show that the power radiated from a electric dipole varies as the fourth power of the frequency.
6. **a.** Explain retarded potentials? 6+4 =10

   b. Obtain the expressions for the famous Liénard- Wiechert potentials.
7. **a.** Discuss the reflection and transmission of the electromagnetic waves at oblique incidence and obtain the Snell's law. 5+5=10

   b. Describe the theory of propagation of electromagnetic waves inside a rectangular waveguide of uniform cross section.
8. **a.** What are the static and dynamic Maxwells equations? Derive the equation of continuity. 3+3+4 =10

   b. Write a short note on Cherenkov radiation.

   c. Prove the uniqueness theorems in electrostatics.

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REV-00 2018/06
MSP/57/62

M. Sc. PHYSICS
SECOND SEMESTER
ELECTROMAGNETICS & PLASMA PHYSICS
MSP-201

(Use Separate Answer Scripts for Objective & Descriptive)

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

(PART-A : Objective)

Time : 20 min. **Marks : 20**

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

1. A charged particle in a constant and uniform electric field $\vec{E}$ where |B|=0 describes a
   - **a.** motion with constant velocity
   - **b.** uniformly accelerated motion
   - **c.** gyrated motion with constant radius
   - **d.** periodic motion with constant amplitude.
2. If λ_D is the Debye length and L is the dimension of plasma, then which of the following represents the criterion of an ionized gas to behave as plasma?
   - **a.** $\lambda_D \ll L$
   - **b.** $\lambda_D \gg L$
   - **c.** $\lambda_D \approx L$
   - **d.** $\lambda_D = \sqrt{L}$
3. The cyclotron frequency of electron in a homogeneous magnetic field of 0.1 Tesla is
   - **a.** $\omega_c = 1.76 \times 10^{10}$ Hz
   - **b.** $\omega_c = 1.758 \times 10^{12}$ Hz
   - **c.** $\omega_c = 1.758 \times 10^{9}$ Hz
   - **d.** $\omega_c = 1.76 \times 10^{11}$ Hz
4. The $\vec{E} \times \vec{B}$ drift velocity for the motion of a non-relativistic charged particle in the presence of crossed electric (E) and magnetic (B) fields which are constant in time and uniform in space is expressed as
   - **a.** $\vec{v_E} = \frac{\vec{E}.\vec{B}}{B^2}$
   - **b.** $\vec{v_E} = \frac{q}{m}\frac{\vec{E}\times\vec{B}}{B^2}$
   - **c.** $\vec{v_E} = \frac{mv_\parallel^2}{2}\frac{\vec{E}\times\vec{B}}{B^2}$
   - **d.** $\vec{v_E} = \frac{\vec{E}\times\vec{B}}{B^2}$
5. Drift of a gyrating particle in crossed gravitational and magnetic fields depends on the ratio
   - **a.** $\frac{mv_\parallel^2}{q}$
   - **b.** $\frac{2mv_\perp^2}{q}$
   - **c.** $\frac{m}{q}$
   - **d.** $\frac{q}{m}$

6. For an electron plasma wave, if v_{th} is thermal velocity of electrons the phase velocity v_{ph} is always greater than or equal to

a. $\sqrt{3/2}\, v_{th}$
b. $\sqrt{1/3}\, v_{th}$
c. $2v_{th}$
d. v_{th}^2

7. The magnitude of the magnetic moment $|\vec{\mu}|$ associated with the circulating current of charged particle in a uniform magnetostatic field $\vec{B}$ can be expressed as

a. $|\vec{\mu}| = \frac{1}{2} m\omega_c$
b. $|\vec{\mu}| = \frac{1}{2}\omega_c r_c$
c. $|\vec{\mu}| = \frac{|q|}{2}\omega_c r_c^2$
d. $|\vec{\mu}| = \frac{|q|}{2}\omega_c r_c^2$

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

a. $N_D \propto \sqrt{\lambda_D}$
b. $N_D \propto \lambda_D^3$
c. $N_D \propto 1/\lambda_n^3$
d. $N_D \propto \lambda_D$

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

10. Relativistic version of continuity equation is expressed as, where J^μ is the current density

a. $\partial_\mu J^\mu = -\frac{\rho}{\epsilon_0}$
b. $\partial_\mu J^\mu = 0$
c. $\partial_\mu^2 J^\mu = 0$
d. $\partial_\mu J^\mu = -\mu_0\epsilon_0$

11. Accelerating electric charges produce

a. Electric field
b. Electromagnetic waves
c. Electric and magnetic field
d. None of these

12. The fields which survives at large distances from the source is called

a. Radiation zone
b. Electromagnetic field
c. Both Radiation zone and Electromagnetic field
d. None of these

13. The energy transported by an electromagnetic wave is called the

a. Power b. Poynting vector c. Energy flux d. Intensity

Contd...

14. The phase velocity of and ordinary wave is given by

a. $v = \frac{\omega}{\kappa}$
b. $v = \frac{d\omega}{d\kappa}$
c. $v = \frac{2\omega}{\kappa}$
d. None of these

15. Choose the incorrect option

a. $v = \frac{c}{n}$
b. $v = \frac{\sqrt{\epsilon\mu}}{\sqrt{\varepsilon_0\mu_0}}$
c. $v = \frac{\sqrt{\epsilon\mu}}{\sqrt{\varepsilon_0\mu_0}}$
d. $v = \frac{1}{\sqrt{\epsilon\mu}}$

16. Opt out the incorrect option

a. $\vec{k} \times \vec{E} = \omega \vec{B}$
b. $\vec{E} = \frac{\omega}{k}\vec{B}$
c. $k^2 = \frac{c^2}{v^2}$
d. $\vec{E} = C\,\vec{B}$

17. Electromagnetic field is

a. conservative
b. discontinuous
c. non- conservative
d. none of these

18. The potential inside an enclosure completely surrounded by conducting material, provided there is no charge within the conductor is

a. unity
b. zero
c. constant
d. undefined

19. 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

20. The tangential component of electric field at the boundary must be

a. continuous
b. undefined
c. discontinuous
d. Fourth power of wavelength

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P.T.O.