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SARDAR PATEL UNIVERSITY

BSc Examination 2022

Semester: VI

Subject: Physics Course: US06CPHY24

Electrodynamics and Plasma Physics

Date: 27-6-22, Monday

Time: 10.00 am to 12.00 pm

Total Marks: 70

INSTRUCTIONS:

- 1 Attempt all questions.
- 2 The symbols have their usual meaning.
- 3 Figures to the right indicate full marks.

Q-1 Multiple Choice Questions: [Attempt all]

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- (1) The charge density inside a conductor is _____.
(a) Zero (b) Positive
(c) Negative (d) Infinite
- (2) The general solution of one-dimensional Laplace's equation $\frac{d^2V}{dx^2} = 0$ is _____.
(a) $V(x) = \text{constant}$ (b) $V(x) = mx + b$
(c) $V(x) = \log x$ (d) $V(x) = ax^2 + bx + c$
- (3) $\nabla^2 V = -\frac{\rho}{\epsilon_0}$ is called _____.
(a) Newton's equation (b) Laplace's equation
(c) Poisson's equation (d) Maxwell's equation
- (4) Iron (Fe) is _____ material.
(a) Ferromagnetic (b) Polarized
(c) Diamagnetic (d) Nonpolarized
- (5) The torque on a magnetic dipole is given as _____.
(a) $N = m \cdot P$ (b) $N = m \cdot B$
(c) $N = m \times P$ (d) $N = m \times B$
- (6) The auxiliary field is _____.
(a) $H = \frac{1}{\mu_0}(B - M)$ (b) $H = \frac{1}{\mu_0}B - M$
(c) $H = \mu_0(B - M)$ (d) $H = \mu_0B - M$
- (7) For $E = 0$ and uniform B , the trajectory of a charged particle moving with any arbitrary velocity v_z along B is _____ in the space.
(a) Circular (b) Straight line
(c) Helix (d) Elliptical

- (8) The magnetic mirror was first proposed by _____ as a mechanism for the acceleration of cosmic rays.
- (a) Newton (b) Einstein
(c) Robert Hooke (d) Enrico Fermi
- (9) The neutral fluid will interact with the ions and electrons only through _____.
- (a) Pressure (b) Collision
(c) Mixing (d) Reaction
- (10) For ion waves, the group velocity is _____ the phase velocity.
- (a) Less than (b) Greater than
(c) Equal (d) None of these

Q-2 Fill in the blanks (1) to (4), and state True or False (5) to (8):

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- (1) If there is some cavity in the conductor and some charge exists in this cavity then the field in the cavity will _____. (be zero / not be zero)
- (2) Some materials acquire magnetization opposite to B are called _____.
(Diamagnets / Paramagnets)
- (3) The conversion factor of temperature used in the plasma physics is
 $1eV = \underline{\hspace{2cm}}$ (1160 °K / 11600 °K).
- (4) $\frac{dG}{dt} = \frac{\partial G}{\partial t} + (\mathbf{u} \cdot \nabla)G$ is called _____. (Convective derivative / temperature derivative)
- (5) The induced dipole moment in dielectric is proportional to the E . (True / False)
- (6) A magnetic dipole never experiences a torque in a magnetic field. (True / False)
- (7) The magnetic moment of the gyrating particle is $\mu = \frac{\frac{1}{2}mv_{\perp}^2}{B}$ (True / False)
- (8) $\rho \left[\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla)\mathbf{u} \right] = -\nabla p + \rho \nu \nabla^2 \mathbf{u}$ is called Navier-Stokes equation. (True / False)

Q-3 Short Answer Questions. (Attempt any ten)

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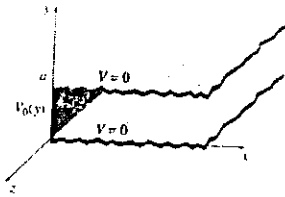
- (1) Define electric polarization.
- (2) Write Laplace's equation in Cartesian coordinate system (in three dimensions).
- (3) Find the capacitance of two concentric spherical metal shells, with radii a and b .
- (4) Discuss Ohm's law.
- (5) Define Magnetization.
- (6) Write equations of electrodynamics before Maxwell.
- (7) Define Plasma.
- (8) Give three conditions that an ionized gas must satisfy to be called a plasma.
- (9) Discuss the loss cone for magnetic mirror.
- (10) Which phenomenon is called Langmuir's Paradox?

- (11) Write a note on equation of continuity.
 (12) What is the difference between plasma oscillations and ion waves?

Q-4 Long Answer Questions. (Attempt any four)

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- (1) Define conductor and discuss basic properties of conductor in detail.
 (2) Two infinite grounded metal plates lie parallel to the xz plane, one at $y = 0$, the other at $y = a$ as shown in the figure. The left end, at $x = 0$, is closed off with an infinite strip insulated from the two plates and maintained at a specific potential $V_0(y)$. Find the potential inside this "slot".



- (3) Define magnetic dipole. Show that as the effect of a magnetic field on atomic orbits, a change in the dipole moment is

$$\Delta \mathbf{m} = -\frac{e^2 R^2}{4m_e} \mathbf{B}.$$

- (4) Write a note on inductance and derive Neumann formula for mutual inductance

$$M_{21} = \frac{\mu_0}{4\pi} \oint \oint \frac{d\mathbf{l}_1 \cdot d\mathbf{l}_2}{r}.$$

- (5) Discuss Debye's shielding and obtain expression for Debye length

$$\lambda_D \equiv \left(\frac{\epsilon_0 K T_e}{n e^2} \right)^{\frac{1}{2}}.$$

- (6) Discuss motion of a single charged particle in the uniform magnetic field \mathbf{B} . Obtain the expression for the Larmor radius.

- (7) Write fluid equation and discuss fluid drift parallel to magnetic field \mathbf{B} . Derive expression for diamagnetic drift:

$$\mathbf{v}_D = -\frac{\nabla p \times \mathbf{B}}{qnB^2}.$$

- (8) Define plasma frequency and derive expression for the plasma frequency:

$$\omega_p = \left(\frac{n_0 e^2}{m \epsilon_0} \right)^{\frac{1}{2}}.$$

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