REV-01
MSP/21/26

2023/01

SET A

M.Sc. PHYSICS
FIRST SEMESTER
ELECTRODYNAMICS
MSP – 104 IDMN
[USE OMR SHEET FOR OBJECTIVE PART]

Duration: 1:30 hrs. **Full Marks: 35**

(**Objective**)

Time: 15 mins. **Marks: 10**

Choose the correct answer from the following: ***1X10=10***

1. The electric field for a point charge goes as (in spherical polar coordinates)
   a. $1/r$ b. $1/r^2$
   c. $1/r^3$ d. $1/r^4$

2. Physically, the electric field is
   a. force per unit charge b. force per unit length
   c. force per unit current d. force per unit area

3. Choose the correct statement.
   a. Field lines begin on positive charges. b. Field lines begin on negative charges.
   c. Field lines can terminate in midair. d. Field lines can cross each other.

4. If σ is the charge per unit surface, then over an area A, the total charge would be
   a. σ b. σA
   c. σ^2 d. σ/A

5. The flux of an electric field through a surface is
   a. $\int \vec{E} \cdot d\vec{a}$ b. $\int \vec{E} \times d\vec{a}$
   c. $\int E^2 da$ d. None of these

6. The curl of an electrostatic field is
   a. ρ/ϵ_0 b. ρ
   c. $\epsilon_0 \rho$ d. 0

7. Magnetic force in a charge , moving with velocity in a magnetic field, is the Lorentz force, and it is expressed as
   a. $\vec{F}_{mag} = Q(\vec{v} \times \vec{B})$ b. $\vec{F}_{mag} = (\vec{v} \times \vec{B})$
   c. $\vec{F}_{mag} = Q\vec{v}$ d. $\vec{F}_{mag} = Q\vec{B}$

8. $\nabla \cdot \vec{B} = ?$
   a. Q b. I
   c. μ_0 d. 0

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9. The continuity equation reads as

a. $\nabla \cdot \vec{j} = \frac{\partial \rho}{\partial t}$

b. $\nabla \cdot \vec{j} = -\frac{\partial \rho}{\partial t}$

c. $\nabla \cdot \vec{j} = \frac{\rho}{t}$

d. $\nabla \cdot \vec{j} = \rho$

10. $\nabla \times \vec{B} = ?$

a. $\vec{j}$

b. $\mu_0 \vec{j}$

c. $\mu_0^2 \vec{j}$

d. $\mu_0^3 \vec{j}$

Descriptive

Marks: 25

Time : 1 hr.15 mins.

[Answer question no.1 & any two (2) from the rest]

1. Draw the field lines for **1.25×4 =5**
   i. a charge q
   ii. a charge 2q
   iii. two equal charges separated by some distance.
   iv. two equal and opposite charges separated by some distance.

2. i. Find the electric field (magnitude and direction) a distance z above the midpoint between two equal charges, q, a distance d apart. **5+5=10**
   ii. Find the electric field (magnitude and direction) a distance z above the midpoint between two equal but opposite charges, $q, -q$, a distance d apart.

3. i. A long cylinder carries a charge density that is proportional to the distance from the axis: $\rho = ks$, for some constant k. Find the electric field inside this cylinder. **4+3+3 =10**
   ii. Suppose the electric field in some region is found to be $\vec{E} = kr^3\hat{r}$, in spherical coordinates (k is some constant).
   (a) Find the charge density ρ.
   (b) Find the total charge contained in a sphere of radius R, centered at the origin.

   Hint: $\left[\nabla . \mathbf{V} = \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 v_r) + \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, v_\theta) + \frac{1}{r\sin\theta}\frac{\partial v_\phi}{\partial\phi}\right]$

4. i. Show that magnetic forces do not work. **2.5×4 =10**
   ii. Find the magnetic field at the center of a square loop, which carries a steady current I. Let R be the distance from center to side.
   iii. Find the field at the center of regular n-sided polygon, carrying a steady current I. Again, let R be the distance from the center to any side.
   iv. Deduce the result for the field at the center of a circular loop, in the limit $n \to \infty$.

   $$\left[\text{Hint: } B = \frac{\mu_0 I}{4\pi s}(\sin\theta_2 - \sin\theta_1)\right]$$

5. i. Write down the Maxwell's equations in free space. **4+6=10**
   ii. Show that Electric field satisfies the three-dimensional wave equation.[Identity: $\nabla \times (\nabla \times E) = \nabla(\nabla \cdot E) - \nabla^2 E$]

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