Major Exam : Electrodynamics (PYL111)

Max. Marks: 40

30.04.2019

- Maximum marks for each question are mentioned in the square brackets.
- If found copying or using your mobile phone during the exam, you will be forced to leave and a disciplinary action will be taken.

Section-I

Q.1. Using divergence theorem, convert $\int_V (\nabla \times \mathbf{v})\, d\tau$ to corresponding surface integral.[5]

OR

Evaluate $\int_V (r^2+2)\vec{\nabla}\cdot\left(\frac{\hat{r}}{r^2}\right)$ by using the identity $\vec{\nabla}\cdot(f\vec{A}) = f(\vec{\nabla}\cdot\vec{A}) + \vec{A}.(\vec{\nabla}f)$.[5]

Q.2. Correct the following statements, if needed, else mark it as 'correct': [5]

(a) Finite spin angular momentum can be accounted for paramagnetic behaviour of a magnetic material.

(b) In a material having both spin and orbital angular momenta finite, spin angular momentum is the dominant one.

(c) Imagine having two wire loops '1' and '2', carrying steady currents I_1 and I_2, respectively. Now if current I_1 is changed it will induce an emf only in loop '1'.

(d) Phase velocity of a wave can be larger than the speed of light without violating causality.

(e) If a wave incident at Brewster's angle has a polarization parallel to the plane of incidence, the reflected wave is completely extinguished.

Q.3 (a) Polarization $\vec{P}$ is defined as the dipole moment per unit volume. State its relation with the electric field and then deduce the expression for the relative permittivity ϵ_r.[3]

(b) Write down the electric field and magnetic field corresponding to a monochromatic plane wave traveling in the z-direction and polarized in the x-direction.[2]

Q.4. A point charge '+q' is situated at a distance 'a' from the centre of a grounded conducting sphere of radius 'R'. To find the potential between the sphere and charge '+q', we can use the method of images. In that case, find the following: [5]

(a) The charge on the image charge

(b) Position of the image charge

OR

When a charged particle approaches a conducting surface, radiation is emitted, associated with the changing electric dipole moment of the charge and its image. If the particle has mass m and charge q, find the total radiated power as a function of its height above the plane.[5]

Section-II

Q.5. A particle of mass m whose total energy is twice its rest mass energy collides with an identical particle at rest. If they stick together, calculate the mass and the velocity of the resulting composite particle.[5]

Q.6. Using the field transformation rules, show that $E^2 - c^2B^2$ is relativistically invariant quantity. If in one inertial frame, $E = E_0$ and $B = 0$ at a point P, find an inertial frame in which $E = 0$ at point P.[5]

Q.7 Write down the field tensor $F^{\mu\nu}$ and dual field tensor $G^{\mu\nu}$ in their matrix form. Show that the 3-space components of $\frac{\partial F^{\mu\nu}}{\partial x^\nu} = \mu_0 J^\mu$ correspond to Ampere-Maxwell law.[5]

Q.8. Calculate the velocity and momentum of a relativistic electron with kinetic energy of 10 MeV.[5]

OR

Write down the lagrangian of an electron in an electromagnetic field and derive the Lorentz force equation using the principle of least action.[5]