PG – 264

Fourth Semester M.Sc. Degree Examination, June/July 2014
(RNS) (2012-13 & Onwards)
MATHEMATICS
M – 404 (A) : Magnetohydrodynamics

Time : 3 Hours Max. Marks : 80

Instructions : *1) Answer* ***any five*** *questions.*
2) ***All*** *questions carry* ***equal*** *marks.*

1. a) Discuss the evolution of electrostatics and electromagnetic systems of units. 4

   b) Derive Faraday's law and Ampere's law. 8

   c) Prove or disprove the statement that the tangential component of magnetic field is continuous across the interface of two media. 4

2. a) Establish the following :
      i) Electric field is not solenoidal in the presence of free charges.
      ii) Charges in a conductor decay exponentially and this is independent of electric field. 10

   b) Define polarization and prove that $\nabla \cdot \bar{P} = -\rho_{ac}$, where the quantities have their usual meaning. 6

3. a) Establish the energy equation for an incompressible electrically conducting fluid in its standard form. 13

   b) Discuss the boundary conditions on velocity. 3

4. a) State the prove Alfren's theorem. Hence explain the forozen-in-phenomenon. 10

   b) A perfectly electrically conducting fluid moves parallel to the vertical z-axis of a rectangular coordinate system (x, y, z) with velocity W and magnetic field H acts in the y-direction. If all the variables are independent of x and y, then show that H and ρ satisfy the following equations

   $$\frac{DH}{Dt} = -H\frac{\partial W}{\partial Z}, \quad \frac{D\rho}{Dt} = -\rho\frac{\partial W}{\partial Z}$$

   Hence deduce that $H = k\rho$, where k is a constant. 6

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5. a) In the magnetostatic configuration, show that $\vec{B}$ and $\vec{J}$ field lines lie on a surface of $p + \rho\Omega =$ constant, where the quantities have their usual meaning. 4

   b) Discuss the nature of force-free magnetic field $\vec{B}$ which is a function of r only in cylindrical coordinate system (r, θ, z). Also, find the nature of abnormality parameter. 8

   c) Explain the kink instability of Bennett pinch. 4

6. a) Explain the causes for the propagation of Alfven waves and discuss any two important applications of these waves. 8

   b) Explain briefly the experimental demonstration of Alfven waves by Lundquist and Lehnert. 3

   c) Show that Alfven waves transport equal amount of kinetic and magnetic energies. 5

7. a) Derive Alfven longitudinal and transverse wave equations for a compressible perfectly conducting non-viscous fluid in the presence of a uniform magnetic field H_0 making an angle θ with x-axis. Obtain the dispersion relation for longitudinal waves and discuss the existence of fast and slow waves. 16

8. a) Discuss about the following :
   i) Hartmann flow
   ii) Hartmann number
   iii) Prandtl number. 6

   b) Obtain the velocity distribution for hydromagnetic generalized plane couette flow. 10