M.A./M.Sc. Examination 2017

Semester - III

Mathematics

Course: MMO-31 (A6)

(Plasma Dynamics-I)

Time: Three Hours Full Marks: 40

Questions are of value as indicated in the margin.
Notations and symbols have their usual meanings.
Attempt ***any four*** questions.

1. a) Starting from Maxwell's Equations, obtain the wave equation in free space. Show that electromagnetic waves are transverse in nature. 3+2=5
   b) Express electromagnetic fields in term of electromagnetic potential A and Φ. Hence show that Maxwell's equations are reduced from four to two by electro-magnetic potential. 2+3=5

2. a) Describe the concept of Debye Shielding in a plasma. Deduce an expression for the Debye potential for a test charge $+q$ immersed in a plasma consisting of electrons and ions. 3+5=8
   b) For a typical fusion reactor, plasma electron density is $10^{21} m^{-3}$ and temperature is 10 kev. Check if it can be considered as plasma. 2

3. a) Consider the motion of a charged particle in a crossed static uniform electric field $E = E\hat{j}$ and magnetic field $B = B\hat{k}$. Assuming that initially $(t = 0)$ the particle is at rest at the origin of a Cartesian coordinate system. Show that the particle trajectory will be a cycloid. 7
   b) Explain diamagnetic behaviour in plasma. 3

4. a) Show that the magnetic field lines are frozen into the magnetized plasma. 2
   b) Starting from fluid equations for electrons and the Poisson's equation derive the Bohm-Gross dispersion relation $\omega^2 = {\omega_{pe}}^2 + \frac{3}{2}k^2 {v_{th}}^2$. Also, obtain Phase velocity and Grasp velocity. Discuss the case $\omega < \omega_{pe}$. 5+2+1=8

5. a) When does a wave in plasma is called and a) parallel b) Perpendicular c) Longitudinal and d) Transverse? With example explain the difference between electrostatic and electromagnetic waves in plasma. 4
   b) Find the dispersion relation for electrostatic cyclotron waves. Show that if ion acoustic speed $v_s = 0$ then the electrostatic cyclotron wave becomes cyclotron frequency. 6

6. Write down the differences between ordinary and extraordinary waves. Starting from Maxwell's equations, obtain the dispersion relation of ordinary waves. 2+8=10

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