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University Examinations 2012/2013

SECOND YEAR, FIRST SEMESTER EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN APPLIED MATHEMATICS

SMA 3140: FLUID MECHANICS III

DATE: AUGUST 2013 **TIME:3 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

QUESTION ONE – (30 MARKS)

(a) Define magnetohydrodynamics. (2 Marks)

(b) State each of the Maxwell's equations (4 Marks)

(c) Discuss the following non dimensional numbers

(i) Magnetic Reynold's number (2 Marks)

(ii) Hartmann number (2 Marks)

(d) Give an analogy of magnetic field of MHD and vorticity of ordinary hydrodynamics. (6 Marks)

(e) State the basic equations governing MHD fluid flows explaining each of the terms. (6 Marks)

(f) (i) What is the significant of using non-dimensional quantities as opposed to dimensional quantities in analyzing fluid flows? (2 Marks)

(iii) Use proper scaling variables to nondimensionalize the following equation

$$\rho \frac{\Delta\vec{q}}{\Delta t} = -\vec{\nabla}p + \mu\nabla^2\vec{q} + \mu_e\vec{H}(\vec{\nabla}.\vec{H}) - \nabla\left(\frac{1}{2}\mu_e H^2\right) where\ (\vec{q} = \vec{q}(u,v))$$

(6 Marks)

QUESTION TWO – (20 MARKS)

(a) Define each of the following terms

(i) Stagnation point (2 Marks)

(ii) Lorentz force (2 Marks)

(iii) Hartmann flow (2 Marks)

(b) Discuss the MHD fluid flow past an infinite insulated plate set impulsively into uniform motion with velocity U along the x-axis given that there is a transverse uniform magnetic field of strength H_0 along the y axis. (14 Marks)

QUESTION THREE – (20 MARKS)

(a) State the Faraday's law. (2 Marks)

(b) A fluid flows past a flat plate, having small electrical conductivity. A constant transverse magnetic field of strength H_0 is applied. Formulate the two dimensional boundary layer equations for the flow. (18 Marks)

QUESTION FOUR – (20 MARKS)

(a) A fluid flows uniformly along the x axis and has a normal shock along the y axis. The pressures in front and behind the shock are p_1 and p_2 respectively. Show that $\frac{p_2}{p_1} = y - N^2\left(1 - \frac{1}{x_0}\right) - Q^2(x_0^2 - 1)$ where $x_0 = \frac{\gamma+1}{\gamma-1}$, $N^2 = \gamma m_1^2$, $Q = \frac{1}{2}\mu_e \frac{H_1^2}{p_1}$

(18 Marks)

(b) State the Alfuen's theorem. (2 Marks)