MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: 020-2069349, 061-2309217. 064-30320 Cell phone: +254 712524293, +254 789151411
Fax: 064-30321
Website: www.must.ac.ke Email: info@mucst.ac.ke

University Examinations 2013/2014

FIRST YEAR, THIRD TRIMESTER EXAMINATION FOR MASTER OF SCIENCE IN APPLIED MATHEMATICS

SMA 3140: FLUID MECHANICS III

DATE: DECEMBER 2013 **TIME: 3HOURS**

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

- **The variables used have their usual meaning**

QUESTION ONE - (30 MARKS)

a) Distinguish between Magneto hydrodynamics and magnetogasdynamics. (2 Marks)
b) Define the following terms as used in MHD
   i. Normal shock. (2 Marks)
   ii. Alfven's waves (2 Marks)
c) Discuss each of the following non-dimensional numbers
   i. Magnetic mach number. (2 Marks)
   ii. Magnetic pressure number. (2 Marks)
   iii. Hartmann number. (2 Marks)
d) Discuss each of the Maxwell's equations in a conducting media. (6 Marks)
e) State the general momentum equation of a MHD flow and show that this equation can reduce to the induction equation
   $\frac{\partial \vec{H}}{\partial t} = curl(\vec{q} \times \vec{H}) + \nu_H \nabla^2 \vec{H}$ (7 Marks)
f) An infinite insulated plate on the xz-plane is set impulsively into motion with velocity V in its own plane. A transverse uniform magnetic field of strength H_o is applied. Give a mathematical model for this flow. (5 Marks)

QUESTION TWO (20 MARKS)

a) Express the following equation in non dimensional form by applying the relevant scaling variables and non - dimensional numbers. (6 Marks)

$\frac{\partial u}{\partial t} = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + v\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) - \frac{\sigma}{\rho}{\mu_e}^2 H^2 u$.

b) Consider the boundary layer flow over a flat plate of a fluid of very small electrical conductivity in the presence of a constant transverse magnetic field of strength H_o. The plate is situated along the x-axis. Show that the ponder motive force in the x and y directions is respectively $Fe_x \cong \sigma u{\mu_e}^2 H_{y0}^2$ and $Fe_y \cong 0$. (14 Marks)

QUESTION THREE (20 MARKS)

a) By considering an inviscid, perfectly conducting fluid with a constant density, prove the existence of transverse waves in a fluid. (18 Marks)

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

QUESTION FOUR (20 MARKS)

A uniform flow of a compressible fluid along the x-axis experiences a normal shock along the y-axis. A magnetic field is applied in the y-axis direction. Given that $\rho_1, u_1, p_1, T_1, H_1$ and $\rho_2, u_2, p_2, T_2, H_2$ are respectively the density, velocity, pressure, temperature an magnetic field on the two sides of the shock, show that

a) $\frac{\rho_2}{\rho_1} = \frac{u_1}{u_2} = \frac{H_2}{H_1}$ (6 Marks)

b) $\frac{p_2}{p_1} = y - N^2\left(1 - \frac{1}{x_0}\right) - Q^2(x_0^2 - 1)$

where $x_0 = \frac{\gamma+1}{\gamma-1}, N^2 = \gamma M_1^2 \; and \; Q = \frac{1}{2}\mu_e \frac{H_1^2}{p_1}$.

(14 Marks)