MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS AND ACTUARIAL SCIENCE

UNIVERSITY ORDINARY EXAMINATION

2018/2019 ACADEMIC YEAR

THIRD YEAR **SECOND** SEMESTER EXAMINATION FOR, BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE

AMM 311 – FLUID MECHANICS 1

DURATION: 2 HOURS

DATE: 25/04/2019

TIME: 2:00-4:00PM

Instructions to candidates:

1. Answer question One and Any Other Two questions
2. Mobile phones are not allowed in the examination room.
3. You are not allowed to write on this examination question paper.

SECTION A: ANSWER ALL QUESTIONS IN THIS SECTION

QUESTION ONE (30 MARKS)

a) Define each of the following terms

i. Fluid 2marks

ii. Newtonian fluid 2marks

iii. Adiabatic process 2marks

iv. Differentiate between steady and unsteady flow 2marks

b) Distinguish between a pathline and a streamline. Hence determine the equation of pathline of fluid flow whose velocity is $u = x + t + 2$ 6marks

c) For the equation $\frac{\partial q}{\partial t} + (\vec{q}.\nabla\vec{q}) = \frac{-\nabla P}{\rho} + F$

Derive the Bernoulli's equation given by $\frac{1}{2}q^2 + \frac{1}{\rho}\int dP + \Omega = a\ constant$ stating the necessary conditions 6marks

d) From the definition of pressure P, determine its units dimensions 3marks

e) State the condition that the function $F(x, y, z, t) = 0$ must satisfy to be a possible boundary surface of a fluid 2marks

f) A liquid compressed in a cylinder has a volume of 0.4cm^3 at a pressure of $6.8 \times 10^9 N/cm^2$ and a volume of 0.396cm^3 at a pressure of $1.36 \times 10^8 N/cm^2$. Calculate the bulk modulus of the liquid

3marks

g) Show that if f(z) = u + iv, then u satisfies the equation $\nabla^2 u = 0$ 3marks

SECTION B – ANSWER ANY TWO QUESTIONS IN THIS SECTION

QUESTION TWO (20 MARKS)

a) Determine whether or not, if the fluid flow whose velocity components are $u = \frac{-2xyz}{x^2+y^2}$, $v = \frac{x^2-y^2}{x^2+y^2}$ and $w = \frac{y}{x^2+y^2}$ is irrotational. 12marks

b) A gas obeying Boyle's law is moving in a horizontal uniform tube of small cross-section, prove that $\frac{\partial^2 \rho}{\partial t^2} = \frac{\partial^2}{\partial x^2}[(k + u^2)\rho]$ where ρ is the fluid density and u is the velocity at a distance x from a fixed point at time t. 8marks

QUESTION THREE (20 MARKS)

a) State and briefly explain the four most important thermodynamic variables of a fluid 4marks

b) A plate at a distance of 0.2 cm from a fixed plate moves at 1cm/sec and requires a force of 40N to maintain that speed. Determine the coefficient of viscosity of fluid in between the two plates 4marks

c) By expressing entropy S and thermal energy Q in terms of pressure P and volume, show that

i) $\left(\frac{\partial s}{\partial v}\right)_p = \frac{c_p}{\alpha VT}$ 8marks

ii) $\left(\frac{\partial s}{\partial P}\right)_v = \frac{c_v}{\alpha kT}$ 4marks

QUESTION FOUR (20 MARKS)

a) In a fluid flow be velocity fixed is given by $v = (3x + 2y)\hat{\imath} + (2z + 3x^2)\hat{\jmath} + (2t - 3z)\hat{k}$

i) Determine the velocity component at any point (x, y, z) 2marks

ii) Determine the speed after t = 2 sec at the point (0, 0, 2) 3maks

iii) Determine the acceleration (1, 1, 1) after two seconds 6marks

b) Define and express mathematically any two non-dimensional numbers 4marks

c) Explain each and every term in the given equation

$\rho\left(\frac{\partial \hat{q}}{\partial t} + \hat{q}\nabla\hat{q}\right) = -\nabla P + \mu\nabla^2\hat{q} + \uparrow \rho\hat{F}$ 5marks