MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF PURE AND APPLIED SCIENCE

DEPARTMENT OF APPLIED SCIENCE

UNIVERSITY ORDINARY EXAMINATION

2017/2018 ACADEMIC YEAR

SECOND YEAR **SECOND** SEMESTER EXAMINATION FOR DEGREE OF BACHELOR OF SCIENCE IN INFORMATION TECHNOLOGY

SMA 2425 – FLUID MECHANICS III

DURATION: 2 HOURS

DATE: 24TH APRIL, 2018

TIME: 9.00 – 11.00 A.M.

Instructions to Candidates:

1. Answer **Question 1** 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

a) Explain each of the following:

i. Porous medium (2 marks)

ii. Porosity (2 marks)

State the generalized Darcay's law hence show that for a steady fluid flow through a porous medium with constant permeability the equation for the potential function $\nabla^2 \emptyset = 0$ (4 marks)

b) Discuss fluid flow problem through a porous slab of thickness b confined between the plate t=0 and t=b (assume that the permeability K is a constant) (4 marks)

c) Explain each of the following:

i. Dynamical similarity (2 marks)

ii. Reynolds number (1 mark)

iii. Froude Number (1 mark)

Hence state the physical significance of the Reynold number and the Froude number (4 marks)

d) Discuss each of the following:

i. Boundary layer (1 mark)

ii. Displacement thickness (1 mark)

Hence show that the displacement thickness is given by $\delta = \int_0^\infty \left(1 - \frac{u}{u_o}\right) dy$ (4 marks)

e) Show that the energy equation for couette flow is given by $K\frac{d^2T}{dy^2} = -\mu\left(\frac{du}{dy}\right)^2$ (4 marks)

SECTION B – ANSWER ANY TWO QUESTIONS IN THIS SECTION

QUESTION TWO

a) Consider fluid flow through porous annulus with constant permeability. If the inner and outer radius is a and b respectively where b>a and atr=a the pressure is P_o and at r=b presume is P_1. Prove that the discharge q is given by: $q = \frac{2\pi K(P_1 - P_o)}{\mu \ln(b/q)}$ (10 marks)

b) The velocity distribution in the boundary over the face of high spill way was observed to be 20mls and the boundary thickness of 5cm was estimated from the velocity distribution measured at this section. If the discharge passing over the space way is $5m^3$/sec per metre length of the spill way, compute:

i. The displacement thickness (3 marks)

ii. The energy thickness (3 marks)

iii. The energy loss upon the section under consideration (4 marks)

QUESTION THREE

a) Using appropriate transformations non-dimensionalize the momentum equation

$$\frac{\partial u_i}{\partial t} + u_j \frac{\partial u_i}{\partial x_j} = -\frac{1}{y}\frac{\partial P}{\partial x_i} + F_i + \ldots \nabla^2 U_i$$ (6 marks)

b) Define and express mathematically any three non-dimensional numbers (6 marks)

c) A geometrically similar model of an airduct is built to a $^1/_{50}$ scale and tested with water which is 75 times more viscous and 1200 times denser than air. When tested under dynamically similar conditions the pressure drop is 400KN/m^2 in the model. Find the corresponding pressure drop in the full scale prototype (8 marks)

QUESTION FOUR

a) Discuss fluid flow problem in a thrust bearing (10 marks)

b) Using appropriate transformations non-dimensionalize

$$y\mathrm{C}_v \frac{D\theta}{Dt} = \frac{\partial}{\partial x_i}\left(K\frac{\partial \theta}{\partial x_i}\right)\partial\theta + \frac{1}{2}N\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_i}{\partial x_i}\right)^2$$ (6 marks)

c) Explain each of the following:

i. Prandtl number (2 marks)

ii. Peclet number (2 marks)

QUESTION FIVE

a) An aircraft is to fly at a height where temperature is 45°C and pressure is 4.2 x 10^{5}N/m^2 and velocity is 1300mls. A 1:30 scale model is tested in a pressurized wind tunnel in which the air is at 15°C. what velocity and pressure should be used in the wind tunnel for complete dynamical similarity when the coefficient of viscosity of air at T°K is proportional to $^{T^{1.5}}/_{(T+117)}$

(10 marks)

b) Explain each of the following

i. Momentum thickness (2 marks)

ii. Energy thickness (2 marks)

iii. Boundary thickness (2 marks)

Hence given that the velocity distribution in a lamina boundary layer is given by $\frac{u}{u_m} = 3\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^2$ where u is velocity at a distance y from the boundary and u_m is the velocity a a distance δ from the boundary, determine the value of displacement thickness

(4 marks)