MURANG'A UNIVERSITY OF TECHNOLOGY

SCHOOL OF PURE AND APPLIED SCIENCE

DEPARTMENT OF APPLIED SCIENCE

UNIVERSITY ORDINARY EXAMINATION

2017/2018 ACADEMIC YEAR

FOURTH YEAR **FIRST** SEMESTER EXAMINATION FOR BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE

SMA 2424 – FLUID MECHANICS II

DURATION: 2 HOURS

DATE: 14TH DECEMBER 2017

TIME: 9.00AM – 11.00AM

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 (Compulsory)

QUESTION ONE (30 Marks)

a) Differentiate the following terms as used in fluid mechanics;

   i. Irrotational flow and rotational flow

   ii. Line source and sink lines (4 Marks)

b) Show that the general velocity profile of a Newtonian fluid flowing between two fixed parallel plane of infinite length is given by $u = \frac{p_0 y^2}{2\mu} + Cy + A$. (5 Marks)

c) The streamlines of a flow are represented by$\psi = x^2 - y^2$ and $\psi = x^2 + y^2$. Determine the velocity and its direction at (2,2) and sketch the streamlines and show the direction of flow in each of the cases. (5 Marks)

d) State the momentum equation and indicate what each term represents. (5 Marks)

e) Find the complex velocity potential due to a line source and a line sink. (5 Marks)

f) A two dimensional flow field is given by $\psi = xy$

   i. Show that the flow is irrotational

   ii. Find the velocity potential

   iii. Verify that ψ and $\emptyset$ satisfy the laplace equation. (6 Marks)

SECTION B (Answer any two questions)

QUESTION TWO (20 Marks)

a) For a two dimensional fluid flow, the velocity potential function is given by $\emptyset(x, y) = x^2 - y^2$. Determine stream function and the flow rate between the streamlines through (2, 0) and (2, 2). (5 Marks)

b) In a two dimensional incompressible flow, the fluid velocity components are given by $u = x - 4y$ and $v = -y - 4x$. Show that velocity potential exists and determine its form as well as stream function. (5 Marks)

c) The velocity components for a fluid are $U = a + by - cz, V = d - bx - ez$ and $W = f + cx - ey$. Where a, b, c, d, e and f are arbitrary constants;

   i. Show that it is a possible case of fluid flow

   ii. Is the fluid flow irrotational? If not, determine the vorticity and rotation.(10 Marks)

QUESTION THREE (20 Marks)

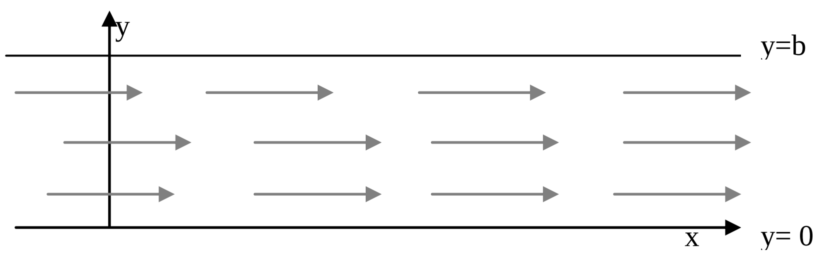
a) Proof that $w = \frac{1}{z}$ maps the circle $x^2 + y^2 + 2gx + 2fy + c = 0$ in the z-plane into the w-plane and maps the origin onto a straight line onto w-plane. (10 Marks)

b) State Blasius theorem (2 Marks)

c) Show that the velocity profile of a general plane poiseville flow is described by $u = \frac{Py(d-y)}{2\mu}$ where d is the distance between the plates and the skin friction is given by $\tau = \frac{p}{2}(d - 2y)$. (5 Marks)

QUESTION FOUR (20 Marks)

a) Consider flow of Newtonian fluid between two parallel plates of infinite length shown below



Obtain velocity distribution for the configuration and determine skin friction. (12 Marks)

b) In a 3D incompressible fluid flow, the velocity components in x and y directions are given by $u = x^2 + y^2 + z^2, v = -(xy + yz + zx)$. Use continuity equation to get an expression in the Z direction. (5 Marks)

c) Explain each of the following;

i. Incompressible fluid flow

ii. No slip condition

iii. Line doublet (3 Marks)

QUESTION FIVE (20 Marks)

a) Find the velocity and acceleration at the point (1,2,3) after 1 sec for a three dimensional flow given by $u = yz + t, v = xz - t, w = xy$. Classify the flow as uniform or non-uniform. (5 Marks)

b) State the physical significance of each of the following;

i. $\nabla\vec{u} = 0$

ii. $\nabla \times \vec{u} = 0$ (2 Marks)

Where u is the velocity of the fluid, hence determine whether the component $u = \frac{x}{x^2+y^2}$ and $v = {}^{y}\!/_{x^2} + y^2$ represents a possible velocity for a two dimensional incompressible irrotational fluid flow. (4 Marks)

c) Explain each of the following;

i. Stream and velocity potential functions

ii. Equipotential and streamlines (4 Marks)

Hence prove that the complex potential function $w(z)$ of a fluid flow field is analytics function. (5 Marks)