



TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCE

DEPARTMENT OF MATHEMATICS AND PHYSICS

**UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN
MATHEMATICS AND COMPUTER SCIENCE.**

AMA 4326: FLUID MECHANICS II

END OF SEMESTER EXAMINATION: MAY 2016 - SERIES

TIME: 2 HOURS

Instructions to Candidates

You should have the following to do this examination:

-Answer Booklet, examination pass and student ID

Do not write on the question paper.

Answer question one and any other two

Question one: 30 marks (Compulsory)

a) Briefly describe the following standard conformal transformations:

i) Inversion 1 mark

ii) Enlargement 1 mark

b) Prove that $w = \phi + i\psi$ is an analytic function. 4 marks

c) Two parallel plates kept 100mm apart have laminar flow of oil between them with a maximum velocity of 1.5m/s and viscosity of oil 2.45Ns/m².

Calculate: i) The discharge per metre width. 2 marks

ii) The shear stress at the plates. 3 marks

- d) Find a relevant stream function for a set of velocity components $u = \frac{-cx}{y}$ and $v = c \ln xy$ to obtain a steady incompressible flow. 6 marks
- e) State the Blasius theorem. 3 marks
- f) What is the irrotational velocity field associated with the potential $\phi = 3x^2 - 3x + 3y^2 + 16t^2 + 12zt$. Does the flow field satisfy the incompressible continuity equation? 5 marks
- g) Prove that the transformation $w = \frac{1}{z}$ maps the circle $x^2 + y^2 + 2gx + 2fy + c = 0$ in the Z plane onto a circle in the w plane and maps circles in the Z plane through the origin onto a straight line in the w-plane. 5 marks

Question TWO (20 marks)

- a) Fluid is in laminar motion between two parallel plates under the action of motion on one of the plates and also under the presence of a pressure gradient in such a way that the net forward discharge across any section is zero:
- i) Find out the point where minimum velocity occurs and its magnitude. 7 marks
 - ii) Draw the velocity distribution profile (sketch graph) across a section of the parallel plates. 2 marks
- b) The velocity components in a fluid flow are given by $U = 2xy$ and $V = a^2 + x^2 - y^2$
- i) Show that the flow is possible. 2 marks
 - ii) Derive the relative stream function. 4 marks
- c) If streamlines are represented by $\psi = x^2 + y^2$ determine the velocity and its direction at (3, 4). 5 marks

Question THREE (20 marks)

- a) Discuss the flow pattern due to a line source at the origin of a complex potential function. 4 marks
- b) In a pipe of 300mm diameter the maximum velocity of flow is found to be 2m/s, if the flow in the circular pipe is laminar. Find :
- i) The average velocity and the radius at which it occurs. 5 marks

- ii) The velocity at 50mm from the wall of the pipe. 2 marks
- c) Consider a conformal mapping $w = \sqrt{z}$, show that the curve $|z - 1| = 1$ transforms to $\rho^2 = 2 \cos 2\phi$ where $w = \rho e^{i\phi}$ in the w - plane. 6 marks
- d) Determine a relevant stream function to a set of velocity components of steady incompressible flow if $u=2cx$ and $v = -2cy$. 3 marks

Question FOUR (20 marks)

- a) Define the following terms as used in fluid mechanics:
- i) Incompressible flow. 1 mark
- ii) Equipotential line. 1 mark
- b) Discuss the flow due to a uniform line doublet at point O of strength μ per unit length if its axis is along the x- axis. 7 marks
- c) A lubricating oil of viscosity 1 poise and specific gravity 0.9 is pumped through a 30mm diameter pipe, if the pressure drop per metre length of pipe is 20KN/m². Determine
- i) The mass flow rate in kg/min. 4 marks
- ii) Shear stress at the pipe wall. 2 marks
- iii) The Reynolds number for the flow. 2 marks
- d) Show whether the function $\psi = A(x^2 - y^2)$ represents a possible irrotational flow. 3 marks

Question FIVE (20 marks)

- a) The velocity distribution in a pipe is given by $\frac{U}{U_{\max}} = 1 - \left(\frac{r}{R}\right)^n$ where U_{\max} is the maximum velocity at the centre of a pipe, U is the velocity at a distance r from the centre and R is the pipe radius. Obtain an expression for mean velocity in terms of U_{\max} and n . 5 marks
- b) The flow field of a fluid is given by $V = xyi + 2yzj - (yz + z^2)k$:
- i) Show that it represents a possible 3 dimensional steady incompressible continuous flow. 2 marks
- ii) Is this flow rotational or irrotational. 2 marks

iii) If irrotational determine at point A (2, 4, 6) the value of angular velocity and vorticity. 4 marks

b) If there is a line source of strength m at a point Z and a line source of equal strength at the mirror image of z_1 at the line $x=0$. Prove that there is no fluid motion across the mirror $x=0$. 7 marks

THE END