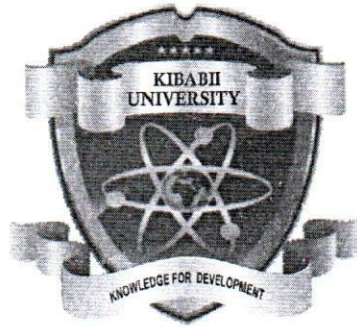


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(Knowledge for Development)

KIBABII UNIVERSITY
UNIVERSITY EXAMINATIONS
2017/2018 ACADEMIC YEAR
FOURTH YEAR FIRST SEMESTER
MAIN EXAMINATION
FOR THE DEGREE OF BACHELOR OF SCIENCE
(MATHEMATICS)

COURSE CODE: MAT 425

COURSE TITLE: FLUID MECHANICS II

DATE: 20/12/17

TIME: 8 AM -10 AM

INSTRUCTIONS TO CANDIDATES

Answer Question One and Any other TWO Questions

TIME: 2 Hours

This Paper Consists of 3 Printed Pages. Please Turn Over.

QUESTION ONE (30 MARKS)

a) Define the following terms

(4 Marks)

- (i) Potential flow
- (ii) Source
- (iii) Sink
- (iv) Doublet

b) State the theorem of Blasius

(2 Marks)

c) A stream function is given by

$$\psi = 3x^2 - y^3$$

Determine the magnitude of the velocity at the point (3,1)

(4 Marks)

d) Discuss the flow determined by $W = z^2$

(7 Marks)

e) A source and a sink of equal strength are placed at the points $(\pm \frac{1}{2}a, 0)$ within a fixed circular boundary $y^2 + x^2 = a^2$. Show that the streamlines are given by

$$(r^2 - \frac{1}{4}a^2)(r^2 - 4a^2) - 4a^2y^2 = ky(r^2 - a^2). \quad (6 \text{ marks})$$

f) The pressure difference ΔP in a pipe of diameter D and length l due to turbulent flow depends on the velocity V , viscosity μ , density ρ , roughness K . Using Buckingham's π -theorem, obtain an expression for ΔP .

(7 marks)

QUESTION TWO (20 MARKS)

a) Differentiate between the following terms as used in dimensional analysis (6 marks)

- (i) Geometrical symmetry
- (ii) Kinematic similarity
- (iii) Dynamic similarity

b) Show that for a two dimensionally axially symmetric boundary layer flow.

$$\int_0^\infty (1 - \frac{u}{U})^2 \frac{r}{a} dn = \delta_1 - \delta_2, \int_0^\infty (1 - \frac{u}{U})^3 \frac{r}{a} dn = \delta_1 - 3\delta_2 + \delta_3$$

Where n the normal distance from the surface of the body is, r is the axial distance and a is the reference radius which may be a function of the axial distance. (4 marks)

- c) A velocity is given by $\mathbf{q} = -x\mathbf{i} + (y + t)\mathbf{j}$. Find the stream function and streamlines for this field at $t=2$ (4 Marks)
- d) A two dimensional flow field is given by $\psi = xy$
- Show that the flow is irrotational (2 Marks)
 - Find the velocity potential (3 Marks)
 - Find the streamlines and potential lines (1 Marks)

QUESTION THREE (20 MARKS)

- a) What arrangement of sources and sinks will give rise to the function $W = \log\left(z - \frac{a^2}{z}\right)$ and prove that two streamlines subdivide into the circle $r=a$ and axis of y (5 Marks)
- b) Find the equations of the streamlines due to uniform line source of strength m through the points $A(-c,0)$ $B(c,0)$ and uniform line sink of strength $2m$ through the origin (5 Marks)
- c) Discuss the flow due to a uniform line doublet at 0 of strength μ per unit length and its axis being along OX . (5 marks)
- d) A flow field is described by the equation $\psi = y - x^2$
- Sketch the streamline $\psi = 0$, $\psi = 1$, and $\psi = 2$ (2 Marks)
 - Derive an expression for the velocity V at any point in the flow field (3 Marks)

QUESTION FOUR (20 MARKS)

- a) By use of a well labeled diagram, define what is meant by boundary layer as used in fluid dynamics (3 Marks)
- b) Find the displacement thickness, the momentum thickness, and energy thickness for the velocity distribution in the boundary layer given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$ (6 Marks)
- c) Verify that $W = ik \log\left\{\frac{z-ia}{z+ia}\right\}$ is the complex potential of a steady flow of liquid about a cylinder with the plane $y = 0$ being the rigid boundary. Find the forces exerted by the liquid on unit length of the cylinder. (6 Marks)
- d) Find the image of a line source in a circular cylinder (5 Marks)

QUESTION FIVE (20 MARKS)

- a) State the Buckingham's π -theorem. (2 marks)
- b) Show that the velocity vector \mathbf{q} is everywhere tangent to the line in the xy plane along which $\psi(x, y) = \text{constant}$. (5 marks)
- c) Using Rayleigh's technique, show that the resistance (R) to the motion of a sphere of diameter (D) moving with a uniform velocity (V) through a real fluid having density ρ and viscosity μ is given by $R = \rho D^2 V^2 f\left(\frac{\mu}{\rho V D}\right)$. (6 marks)
- d) Show that for an incompressible steady flow with constant velocity components

$$u(y) = y \frac{U}{h} + \frac{h^2}{2\mu} \left(-\frac{dp}{dx}\right) \frac{y}{h} \left(1 - \frac{y}{h}\right)$$

$$v = w = 0$$

Satisfy the equation of motion, when the body force is neglected $h, U, \frac{dp}{dx}$ are constants

and $P = P(x)$.

(7 marks)