CHUKA UNIVERSITY

UNIVERSITY EXAMINATIONS

THIRD YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE (MATHEMATICS) AND BACHELOR OF EDUCATION (SCIENCE AND ARTS)

MATH 325: FLUID MECHANICS 1

STREAMS: BED (SCI&ARTS) & BSC (MATH) **TIME: 2 HOURS**

DAY/DATE: MONDAY 22/03/2021 **8.30 A.M. – 10.30 A.M.**

INSTRUCTIONS:

- **Answer question ONE and any other TWO questions.**
- **Take $g = 10Nkg^{-1}$**

QUESTION ONE (30 MARKS) (COMPULSORY)

(a) Explain the term "fluid mechanics." (2 marks)

(b) A plate 0.05 mm distant from a fixed plate moves at 1.2 m/s and requires a force of $2.2N/M^2$ to maintain this speed. Find the viscosity of the fluid between the plates. (4 marks)

(c) The velocity for a two-dimensional flow field is given by $V = (3 + 2xy + 4t^2)i + (xy^2 + 3t)j$. Find the acceleration at a point (1,2) after 2 s. (5 marks)

(d) For a three dimensional flow the velocity distribution is given by $u = -x, v = 3 - y \; and \; w = 3 - Z$. Determine the equation of the streamline passing through (1, 2, 2). (5 marks)

(e) A horizontal venturimeter with inlet diameter 200 mm and throat diameter 100 mm is used to measure the flow of water. The reading of the differential manometer connected to the inlet is 180 mm of mercury. If the coefficient of discharge is 0.98, determine the rate of flow. (5 marks)

(f) If $\phi = 3xy$, determine:

(i) The $x\ and\ y$ components of velocity at the points $(1,3) and\ (3,3)$. (2 marks)

(ii) The discharge passing between streamlines that pass through the points in f(i) above. (3 marks)

(g) Distinguish between the following terms:

(i) Rotational and irrotational flow (2 marks)

(ii) Path line and streamline (2 marks)

QUESTION TWO (20 MARKS)

(a) A two-dimensional flow is given by $\phi = 3xy$. Determine

(i) The stream function. (4 marks)

(ii) The velocity at L(2,6) and M(6,6) and pressure difference between the points L and M. (5 marks)

(iii) The discharge between the streamline passing through the points L and M. (2 marks)

(b) Two large fixed parallel planes are 12 mm apart. The space between the surfaces is filled with oil of viscosity 0.972 NS/MS. A flat thin plate of $0.25m^2$ area moves through the oil at a velocity of 0.3m/s. Calculate the drag force:

(i) When the plate is equidistant from both the planes. (5 marks)

(ii) When the thin plate is at a distance of 4 mm form one of the plane surfaces. (4 marks)

QUESTION THREE (20 MARKS)

(a) State and prove Bernoulli's equation. (11 marks)

(b) A 200 mm x 100 mm venturimeter is provided in a vertical pipe carrying water, flowing in the upward direction. A differential mercury manometer connected to the inlet and throat gives a reading of 220 mm. Find the rate of flow assuming $C_d = 0.98$. (5 marks)

(c) Distinguish between Newtonian and non-Newtonian fluids giving an example for each. (4 marks)

QUESTION FOUR (20 MARKS)

(a) In the two-dimensional incompressible flow field the velocity components are expressed as:

$$u = 2x - x^2y + \frac{y^3}{3}$$

$$v = xy^2 - 2y - \frac{x^3}{3}$$

(i) Determine the velocity and acceleration at the point $L(x = 1m, y = 3m)$ (7 marks)

(ii) Is the flow possible? If so, obtain an expression for the stream function. (3 marks)

(iii) What is the discharge between streamlines passing through (1, 3) and (2, 3)? (3 marks)

(iv) Is the flow irrotational? If so, determine the corresponding velocity potential. (4 marks)

(v) Show that each of the stream function satisfy Laplace equation. (3 marks)

QUESTION FIVE (20 MARKS)

(a) State five assumptions that are made in the derivation of Bernoulli's equation. (5 marks)

(b) (i) State Euler's equation for motion in the form of differential equation. (2 marks)

(ii) Use the Euler's equation in (b) (i) to prove Bernoulli's equation. (3 marks)

(c) Derive the equation of continuity in Cartesian co-ordination for a three dimensional steady flow. (10 marks)
