(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS

2020/2021 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER

SPECIAL/ SUPPLEMENTARY EXAMINATION

FOR THE DEGREE OF BACHELOR OF SCIENCE

MATHEMATICS

COURSE CODE: MAA313/MAT 325

COURSE TITLE: FLUID MECHANICS I

DATE: 10/01/2022 **TIME:** 2:00 – 4:00 PM

INSTRUCTIONS TO CANDIDATES

Answer Question One and Any other TWO Questions

TIME: 2 Hours

QUESTION ONE (30 MARKS)

a. Define the following terms. (2 marks)

   (i) A fluid

   (ii) Fluid kinematics

b. State the law of conservation of mass (2 Marks)

c. Derive the equation of continuity for a compressible fluid (4 Marks)

d. State the Bernoulli's theorem (2 Marks)

e. The velocity components for a 2 dimensional fluid system can be given in the Eulerian system by $u = 2x + 2y + 3t,\ v = x + y + 0.5t$. Find the displacement of a fluid particle in the Lagrangian system. (4 Marks)

f. Describe the continuum hypothesis as used in fluid dynamics (4 Marks)

g. Differentiate between the following terms (4 Marks)

   (i) Uniform and non uniform flow

   (ii) Real and ideal fluids

h. The velocity components for a two dimensional fluid system is given in the Eulerian system is given by

$$u = 2x + 2y + 3t$$
$$v = x + y + 0.5t$$

Find the displacement of a fluid in the lagrangian system. (4 Marks)

i. A horizontal pipe gradually reduces in diameter from *24m* to *12m*. Determine the total longitudinal thrust exerted on the pipe if the pressure at the larger end is $50N/m^2$ and the velocity of water is *96m/sec*. (4 Marks)

QUESTION TWO (20 MARKS)

a) Define the following terms (4 marks)

   (i) Streamline

   (ii) Pathline

   (iii) Vorticity

   (iv) Circulation

b) A two dimensional flow field is given by $V = (3 + 2xy + 4t^2)i + (xy^2 + 3t)j$. Find the velocities and acceleration at A(1,2) after 2 sec. (5 Marks)

c) A fluid flow field is given by $V = xyi + 2yzj - (yz + z^2)k$

   (i) Is the flow rotational or irrotational? (3 Marks)

   (ii) If rotational, determine the angular velocity, vorticity, shear strain and delatency at P(1,2,3). (8 Marks)

QUESTION THREE (20 MARKS)

a. Differentiate between the following terms (4 marks)

(i) Rotational and irrotational flow

(ii) Steady and unsteady flow

b. Examine whether the velocity components given by

$$u = -4ax(x^2 - 3y^2)$$

$$v = 4ay(3x^2 - y^2)$$

Represent a physically possible two dimensional flow; if so whether the flow is rotational or irrotational? (6 Marks)

c. A two dimensional flow field is given by $\emptyset = 3xy$.

(i) Determine the stream function (4 Marks)

(ii) Determine the velocities at A(1,3) and B(3, 3) and the pressure difference between the points A and B (3 Marks)

(iii) What is the discharge between the streamlines passing through these points (3 Marks)

QUESTION FOUR (20 MARKS)

a. A source of strength $10m^2/s$ is located at (-1,0) and a sink of strength $20m^2/s$ is located at (1,0).

(i) Find the velocity and stream function at P(1,1). (4 Marks)

(ii) If the dynamic pressure at infinity is zero for density of $2kg/m^3$. Calculate its dynamic pressure at P. (4 Marks)

b. The flow of a given fluid is given by $\emptyset = Ux + m \log r$

(i) Is the flow physically possible for all values of U and m (4 Marks)

(ii) What does the flow pattern represent (3 Marks)

(iii) Give the characteristics of the body profile by assuming the $U=12m/s$ and $m=6m^2/s$ (5Marks)

QUESTION FIVE (20 MARKS)

a. A flow in a parallelopipe is described by $u=2x$ and $v=-2y$

(i) Is the flow physically possible (2 Marks)

(ii) Determine the expression for the stream function (3 Marks)

(iii) Does the velocity potential exist? If so obtain the expression for the velocity potential. (4 Marks)

(iv) Plot the flow net and describe the flow (4 Marks)

b. i) An orifice has to be placed in the side of a tank so that the jet will be at maximum horizontal distance at the level of its base. If the depth of the liquid in the tank is D, what is the position of the orifice? (4 Marks)

ii) Show that the jet from the orifice in the side of a tank will intersect at the level of the base if the head on the upper orifice is equal to the height of the lower orifice above the base. (3 Marks)