CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

THIRD YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF EDUCATION (SCIENCE & ARTS) & BACHELOR OF SCIENCE GENERAL

MATH 324: FLUID MECHANICS I

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

DAY/DATE: TUESDAY 05/12/2017 **2.30 P.M. – 4.30 P.M.**

INSTRUCTIONS:

- **Answer question ONE (Compulsory) and any other TWO questions**
- **Adhere to the instructions on the answer booklet**

QUESTION ONE

(a) The velocity distribution for flow over a plate is given by $u = \sqrt{2 + y^2}$, where u is the v velocity in m/s at a distance y metres above the plate. Determine the velocity gradient and shear stress at the boundary and 10 metres from it. Take dynamic viscosity of fluid as 0.9 ns/m^2. [4 marks]

(b) The space between two square flat parallel plates is filled with oil. Each of the plates is 720 mm. the thickness of the oil film is 15 mm. the upper place which moves at a speed of 3 m/s requires a force of 120N to maintain the speed. Determine the dynamic of the oil. [4 marks]

(c) A soap bubble 62.5mm diameter has an internal pressure in excess of the outside pressure of 20N/m^2. What is the tension in the soap film. [4 marks]

(d) A u-tube is made up of two capillaries of tones 1.2mm and 2.4mm respectively. The tube is held vertical and partially filled with liquid of surface tension 0.06 N/M and zero contact angle. If the estimated difference in the level of the two menisci is 15mm. determine the mass density of the liquid. [4 marks]

(e) Find the velocity and acceleration at a point (1, 2, 3) after 1 second, for a 3 dimensional flow given by $u = yz + t, v = xz - t, w = xy\ m/s$ [5 marks]

(f) In three dimensional incompressible fluid flow the velocity components in x and y directions

$u = x^2 + y^2z^3, v = (xy + yz + zx)$. Use the continuity equation to evaluate an expression for the velocity component (w) in the z-direction. [4 marks]

(g) For a two dimensional flow, the velocity function is given by the expression $\phi = x^2 - y^2$.

(i) Determine the velocity components in the x and y directions. [2 marks]

(ii) Show that the velocity components satisfy the conditions of flow continuity and irrotationality. [3 marks]

QUESTION TWO (20 MARKS)

(a) In a two dimensional incompressible flow filed, the velocity components are expressed as $u = 2X - x^2y + \frac{y^3}{3}$ and $v = xy^3 - 2y - \frac{-3^3}{3}$

(i) Determine the velocity and acceleration of a point $x = 1m, y = 3m$. [8 marks]

(ii) Show that the flow is possible and obtain an expression for the stream function. [5 marks]

(iii) Show that the flow is irrotational and determine the corresponding velocity potential. [4 marks]

(b) Determine whether the velocity functions $u = A\sin xy,\ \ r = A\sin xy$ satisfy the equation of continuity. [3 marks]

QUESTION THREE

(a) In order to form a stream of bubbles, air is introduced through a nozzle into a tank of water of 20˚C. If the process requires a 3.0 mm diameter bubbles to be formed, by low much the air pressure at the nozzle must exceed that of the surroundingwater. Take σ of water at 20˚C to be 0.0735 N/m. [3marks]

(b) When pressure of 20.7 mN/m^2 is applied to 100 litres of a liquid, its volume decreases by 1 litre. Find the bulk modulus of the liquid. [3 marks]

(c) A rectangular plate 3 metres long and 1 metre wide is immersed vertically in water in such a way that its 3 m side is parallel to the water surface and is 1 m below it. Find the total pressure on the plate and the position of centre of pressure. [5 marks]

(d) The velocity potential function for a two dimensional flow is given by $\phi = x(2y - 1)$. At a point $p(4, 5)$, determine the velocity and value of the stream function.[6 marks]

(e) In a three-dimensional incompressible fluid flow, the velocity components in x and y directions are $u = x^2 + y^2z^3, v = -(xy + yz + zx)$. Use the continuity equation to evaluate an expression, for the velocity components in the z −direction. [3 marks]

QUESTION FOUR

(a) Given that $u = xy, v = 2yz$. Examine whether these velocity components represent two or three dimensional incompressible flow. Assuming the flow is dimensional, determine the third component. [5 marks]

(b) A pipe A, 450mm in diameter branches into two pipes B & C of diameters 300 mm and 200mm respectively as shown in the figure below. If the average velocity in the 450 mm diameter pipe is 3 m/s. determine the discharge through pipe A and the velocity in pipe C, if the average velocity in pipe B is 2.5 m/s. [6 marks]

(c) A pipeline is 15cm in diameter and it is at elevation of 100m at section A. at section B it is at elevation of 107m and has a diameter of 30 cm. when a discharge of 50 litres see of water is passed through this pipeline, pressure at A is 35 Kpa. The energy loss in pipe is 2m. of water. Calculate the pressure at B if flow is from A to B. [9 marks]

QUESTION FIVE

(a) In a pipe of 90mm diameter, water is flowing with a mean velocity of 2 m/s and at a gauge pressure of 350 kN/m^2. Determine the total lead if the pipe is 8 metres above the datum line. [3 marks]

(b) Obtain the equation to the streamlines for the velocity field given as $v = 2x^3i - 6x^2yj$ [5 marks]

(c) The velocity vector in a flow is given by $v = 3xi + 4yj - 72k$. determine the equation passing through a point $L(1, 2, 3)$. [3 marks]

(d) Calculate the specific weight, specific mass & specific volume of a liquid having a volume of 60 m^3 and a weight of 440 KN. [6 marks]
