CHUKA  UNIVERSITY

UNIVERSITY EXAMINATIONS

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

MATH 325: FLUID MECHANICS I

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

DAY/DATE: MONDAY 17/12/2018 **8.30 A.M. – 10.30 A.M.**

INSTRUCTIONS:

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

QUESTION ONE (30 MARKS)

(a) Calculate the specific weight and specific mass of a liquid having a volume of $10m^3$ and a weight of 50 KN. [4 marks]

(b) A plate having an area of $0.4m^2$ is sliding down the inclined plane a velocity of 0.5m/s. there is a cushion of fluid 1.2mm thick between the plane and the plate. Find the viscosity of the fluid if the weight of the is 300N [4 marks]

(c) The velocity distribution for flow over a plate is given by $u=\sqrt{2y^2+y3}$, where u is the velocity in m/s at a distance y metres above the plate. Determine the velocity gradient and shear stress at the boundary and at 2m from the plate. Take $\mu=0.6\,Nn/m^2$ [5 marks]

(d) A soap bubble 20 mm diameter has an internal pressure in excess of the outside pressure of 10 N/m^2. Find the tension in the soap film. [3 marks]

(e) A u tube is made up of two capillaries of bores 1.2 mm and 2.4 mm 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 [5 marks]

(f) In a fluid the velocity field is given by

$$v=(2x+3y)i+(3z+2x^2)i+(2t-3z)k$$

Determine the speed at time t ¿ $2s$ at the point $(0,0,3)$ [3 marks]

(g) Obtain the equation to the streamlines for the velocity field given as $v=2x^3i-6x^2yj$

[3 marks]

(h) Given $u=¿(y^2+z^2)$ and $w=¿(x^2+y^2)$. Find the most general form of V so that the flow is possible for a steady three dimensional incompressible flow [3 marks]

QUESTION TWO

(a) Given that $u=4x(x^2-3y^2, v=4y(3x^2-y^2),$ examine whether these velocity components represent a physically possible two dimensional flow and whether the flow is rotational or irrotational [5 marks]

(b) Given that $u=xy, v=2yz,$ examine whether these velocity components represent two or three dimensional incompressible flow. If three dimensional determine the third component. [4 marks]

(c) The velocity components for a fluid flow are $u=1+2y-3z, v=4-2x-5z$,

$w=6+3x-5y$

(i) Show that it is possible case of fluid flow [2 marks]

(ii) Determine whether the fluid flow is irrotational and find the vorticity and rotation [6 marks]

(d) A two dimensional incompressible flow is given by $V_r = 2r\sin\theta\cos\theta$,

$V_\theta = -2r\sin^2\theta$

Determine whether these velocity components represents a physically possible flow field [3 marks]

QUESTION THREE

(a) A stream function $\Psi = 4xy$ locate the point at which the velocity vector has a magnitude of 7 units and makes an angle of 150° with $x-axis$ [5 marks]

(b) The velocity potential function for a two dimensional flow is $\phi = x(2y-1)$. At point $p(4,5)$ determine

(i) The velocity [2 marks]

(ii) The value of the stream function [4 marks]

(c) The velocity function for a two dimensional flow is given by $\phi = x^2 - y^2$

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

(ii) Show that the velocity components satisfy the conditions for flow of continuity and irrotationality [5 marks]

(iii) Determine the stream function [2 marks]

QUESTION FOUR

(a) Water is flowing in a pipe of 100 mm diameter with a mean velocity of 4m/s and at a gauge pressure of 300kN/$m^{2.}$ Determine the total head if the pipe is 10 metres above the datum line. Neglect friction [4 marks]

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

(c) A pipe 200 m long slopes down at one in hundred and tapers from 600 mm diameter at the higher end to 300 mm diameter at the lower end and carries 100 litres/sec of oil (sp. Gravity 0.8). If the pressure gauge at the higher end reads 60 KN/m^2. Determine

(i) Velocity at the two ends [3 marks]

(ii) Pressure at the lower end [4 marks]

QUESTION FIVE

(a) Find the velocity and acceleration at a point $(0,1,3)$ after 2 seconds for a 3 dimensional flow given by $u = yz + t, v = xz - t, w = xy$ [7 marks]

(b) A circular plate of diameter 1.2 m is placed vertically in water in such a way that the centre of the plate is 2.5m below the free surface of water. Determine

(i) Total pressure in the plate [3 marks]

(ii) Position of the centre of pressure [4 marks]

(c) When the pressure of a liquid is increased from 3.5N/m^2 to 6.5Mn/m^2, its volume decreases by 0.08%. Find the bulk modules of the elasticity of the liquid [3 marks]

(d) A clean tube of diameter 4 mm is immersed in a liquid with a coefficient of surface tension of 0.05 N/m. The angle of contact of the liquid with the glass is 140°. The density of the liquid is 13600 kg/m^3. Find the level of the liquid in the tube relative to the free surface of the liquid surface the tube. [3 marks]
