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University Examinations 2023/2024

THIRD YEAR SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN EDUCATION

SMA 3355: FLUID MECHANICS I

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: *Answer question **one** and any other **two** questions*

QUESTION ONE (30 MARKS)

a) Explain briefly the following fluid properties

i) Mass density (2marks)

ii) Specific volume (2marks)

iii) Weight density (2marks)

iv) Viscosity (2marks)

v) Specific gravity (2marks)

b) Determine the mass density, specific volume and specific weight of a liquid whose specific gravity is 0.85 (6marks)

c) State and explain the Newton's law of viscosity (5marks)

d) A plate 0.05mm distant from a fixed plate moves at 1.2m/s and requires a force of 2.2N/m^2 to maintain this speed. Find the viscosity of the fluid between the plates. (3 marks)

e) Describe the motion of fluid particles by Eulerian method and explain why its preferred (3 marks)

f) In a three-dimensional incompressible flow, the velocity components in x and y directions are; $u = x^2 + y^2z^3, v = -(xy + yz + zx)$. Find an expression for the velocity component in z-direction (3 marks)

QUESTION TWO (20 MARKS)

a) Explain the terms; 'no slip and no temperature jump conditions' as applied in fluid flow bounded by a solid surface. (4 marks)

b) Giving one example in each case differentiate between the following fluids

i) Real and ideal fluid (4 marks)

ii) Newtonian and non-Newtonian fluid (4 marks)

c) The velocity potential is given by

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

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

ii. Show that ϕ represents a possible case of flow (4 marks)

d) Explain the effect of temperature and pressure on viscosity of fluid (2 marks)

QUESTION THREE (20 MARK)

a) Determine the components of rotation for the velocity field pertaining to the flow of an incompressible fluid $u = xy^3z, v = -y^2z^2, w = yz^2 - \frac{y^3z^2}{2}$ state whether the flow is rotational or irrotational (8 marks)

b) Describe the Rayleigh's and Buckingham's method to formulate a dimensionally homogenous equation between the various physical quantities effecting a certain phenomenon (4 marks)

c) The velocity components of a three-dimensional incompressible fluid flow are; $u = x^2 y, v = 2yz - xy^2$ and $w = x^2 - z^2$ show that this flow is kinematically possible

(5 marks)

d) Distinguish between the flow lines; path lines, streamlines and streak lines (3marks)

QUESTION FOUR (20 MARKS)

a) In an incompressible flow, the velocity vector

$$\vec{q} = (6xt + yz^2)\hat{i} + (3t + xy^2)\hat{j} + (xy - 2xyz - 6tz)\hat{k}$$

i) Verify whether the continuity equation is satisfied (5 marks)

ii) Determine the acceleration vector at point L (2,2,2) at t=2 seconds (9 marks)

b) Describe the following flows;

i) Steady flow (2 marks)

ii) Incompressible flow (2 marks)

iii) Irrotational flow (2 marks)

QUESTION FIVE (20 MARKS)

a) Define and explain briefly the following terms

i) Velocity potential (2 marks)

ii) Circulation (2 marks)

iii) Vorticity (2 marks)

iv) Stream function (2 marks)

b) If for two-dimensional flow, the stream function is given by $\psi = 2xy$ calculate the velocity at the point (3,6). Show that velocity potential ψ exists for this case and deduce it. (12 marks)