TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCES

DEPARTMENT OF MATHEMATICS & PHYSICS

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE

AMA 4324 FLUID MECHANICS I

SPECIAL/ SUPPLIMENTARY EXAMINATIONS

SERIES: SEPTEMBER 2018

TIME: 2 HOURS

DATE: SEPTEMBER 2018

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt QUESTION ONE and any other TWO questions.

Do not write on the question paper.

QUESTION ONE Compulsory (30 marks)

a) Name the three branches of fluid mechanics. (3 marks)

b) i) Differentiate between specific mass and specific weight. (2 marks)

ii) Calculate the specific weight, specific mass and specific volume of a liquid having a volume of $6m^3$ and weight of 44 kN (4 marks)

c) The velocity distribution of flow over a plate is given by $u = 2y - y^2$ where u is the velocity in m/s at a distance y metres above the plate. Determine:-

i) the velocity gradient (3 marks)

ii) shear stress τ, 0.15 m from it.

(Take $\mu = 0.9Ns/m^2$) (2marks)

d) Show that the velocity field given by $U = 5x^3\hat{i} - 15x^2y\hat{j} + t\hat{k}$ represent a possible fluid motion of an incompressible fluid. (5 marks)

e) Determine the stream function for a flow field described by $u = 2y$ and $v = -2x$

(6 marks)

f) A liquid compressed in a cylinder has a volume of 0.4 cm^3 at a pressure of 6.8×10^7 N/cm^3 and a volume of 0.396 cm^3 at a pressure of 1.36×10^8 N/cm^2. Calculate the bulk modulus of the liquid.

(5 marks)

QUESTION TWO (20 marks)

a) A gas obeying Boyle's law $(P = k\rho)$ is in motion in a horizontal uniform tube of small cross section. Prove that $\frac{\partial^2 p}{\partial t^2} = \frac{\partial^2}{\partial x^2}\left[\left(k + u^2\right)\rho\right]$ where ρ is the fluid density and u is the velocity at a distance x from a fixed point at time t. (9 marks)

b) i) If for a two dimensional flow the stream function is given by $\psi = 2xy$, calculate the velocity at the point (3,6) (7 marks)

ii) Show that the potential ϕ exists for this case and deduce it. (4marks)

QUESTION THREE (20 marks)

a) A fluid flow is described by the velocity vector $u = 5x^2\hat{i} - 15x^2y\hat{j}$. Test the flow for rationality and shear strain rate. (5 marks)

b) A fluid field is given by $u = xy\,\hat{i} + 2yz\,\hat{j} - \left(yz + z^2\right)\hat{k}$

i) Determine whether this is a possible steady incompressible fluid flow.

(5 marks)

ii) Calculate the acceleration, angular velocity and velocity at the point (1,2,3)

(10 marks)

QUESTION FOUR (20 marks)

a) For the velocity field given by $V = 10xy\,\hat{i} - 5y^2\,\hat{j}$ find at point $P(2,3)$

i) Absolute velocity (5 marks)

ii) Absolute acceleration (7 marks)

iii) Angular velocity (2 marks)

iv) The value of the stream function if the streamlines passing through the origin is assigned $\psi = 0$
(3 marks)

b) Obtain the equation of the streamline passing through $(2,2)$ for the flow $V = -y^2\hat{i} - 6x\,\hat{j}$
(3 marks)

QUESTION FIVE (20 marks)

a) Given that $u = -4ax\left(x^2 - 3y^2\right), v = 4ay\ \left(3x^2 - y^2\right)$. Examine whether these velocity components represent a physically possible two- dimensional flow, if so whether the flow is rotational or irrotational.
(9 marks)

b) A rectangular duct of width 25cm has an elbow made up of circular archs of radii 40 cm and 65 cm for the inner and outer walls respectively. Calculate the discharge per unit width of the duct when the pressure difference between the inner and outer walls is $30KPa$. Assume the flow to be irrotational.
(8 marks)

a) Define the following terms:
   i) Steady flow (1 mark)
   ii) Compressible flow (1 mark)
   iii) Pathline (1 mark)