TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF APPLIED AND HEALTH SCIENCE

DEPARTMENT OF MATHEMATICS AND PHYSICS

UNIVERSITY EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE.

AMA 4326: FLUID MECHANICS II

END OF SEMESTER EXAMINATION**: MAY 2016 - SERIES**

TIME: 2 HOURS

Instructions to Candidates

You should have the following to do this examination:

-Answer Booklet, examination pass and student ID

Do not write on the question paper.

Answer question One and any other two

Question one: 30 marks (Compulsory)

a) Define the following terms. i) Circulation. 2 mark

ii) Stream function. 2 mark

b) Find a relevant stream function to a set of velocity components for a steady incompressible flow if U=x+y and V=x-y. 4 marks

c) Show that the discharge per unit width between two parallel plates distance b apart when one plate is moving at velocity U while the other one is held stationary for the condition of zero shear stress at the fixed plate is $q = \frac{Ub}{3}$. 6 marks

d) Given that $U = -4ax(x^2 - 3y^2)$ and $V = 4ay(3x^2 - y^2)$ examine whether these velocity components represent a physically possible 2 dimensional flow, if so is the flow rotational or irrotational. 5 marks

e) Obtain the velocity profile of a plane parallel (coutte) flow between two plates moving at a constant velocity U_0 but in opposite direction, the distance y is measured from a fixed point 0 and the distance between the plates is 8mm if $\frac{\partial p}{\partial x} \neq 0$; determine the skin friction on each of the plates. 7 marks

f) Discuss the flow whose complex potential function is given by $w = z^2$. 4 marks

Question TWO (20 marks)

a) The velocity potential for a two dimensional flow is $\phi = x(2y-1)$ at the point P(4,5) determine : i) the velocity. 4 marks

ii) The value of the stream function. 4 marks

b) Discuss the complex velocity potential of an incline flow to the x axis at an angle α^0 if $\nabla\phi = -\vec{q}$. 7 marks

c) A fluid is flowing steadily between two fixed parallel plates under constant pressure gradient $P_0 = \frac{-\partial P}{\partial x}$. Show that the velocity distribution of this flow is $U = \frac{P_0}{2\mu}\left(d^2 - y^2\right)$ where 2d is the distance between the 2 plates and y is measured from the midpoint. 5 marks

Question THREE (20 marks)

a) Write the complete Navier Stokes equation for conservation of momentum then name all the terms in the equation. 3 marks

b) The velocity components for a fluid flow are U=a+by-cz, V=d-bx-ez and W=f+cx-ey, where a, b, c, d, e and f are arbitrary constants.

i) Show that it is a possible case of fluid flow. 2 marks

ii) Is the fluid flow irrotational. 3 marks

iii) If not determine the vorticity of the flow. 2 marks

c) Suppose that a liquid is in the region of the positive side of x- axis with rigid boundary y=0 and there is a source of strength –m at (0, a) and an equal sink at (0, b). If the pressure on the negative side of the boundary is the same as the pressure at infinity, show

that if the fluid satisfies the no – slip condition on the boundary then the resultant pressure on the boundary is given by $P = \frac{1}{2}\rho \int_{-\infty}^{+\infty} \frac{4m^2x^2\left(b^2-a^2\right)}{\left(x^2+a^2\right)^2\left(x^2+b^2\right)^2}dx$.

10 marks

Question FOUR (20 marks)

a) Find the equation of the streamlines due to 2 line sinks each of strength m through the point (-C, 0) and (C, 0) with a uniform line source of strength 2m through the origin.

9 marks

b) In a 2 dimensional flow the velocity function is given by the expression $\phi = x^2 - y^2$:

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

ii) Show that the velocity components satisfy the conditions of continuity flow and irrotationality. 4 marks

iii) Determine stream function and the flow rate between the streamlines (2,0) and (2,2)

3 marks

iv) Show that streamlines and potential lines intersect orthogonally at point (2, 2). 2 marks

Question FIVE (20 marks)

a) In a 2 dimensional flow the velocity components are U=Cy where C is a constant and V=0, find the circulation about the circle $x^2 + y^2 - 2\boldsymbol{a}$ y=0 situated in the flow if $\boldsymbol{a}$ is the radius of the circle. 5 marks

b) The radial velocity profile in a pipe is given by $U = U_{\max}\left(\frac{1-r}{R}\right)^n$ where U is the velocity at a radial distance r, U_{max} is the maximum velocity and R is the radius of the pipe. Derive an equation for the average velocity in the pipe. 8 marks

c) Discuss the flow equation of a line vortex whose complex velocity potential is $w = \frac{ik\log z}{2\pi}$

7 marks

THE END