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PG (NEW) CBCS
M.Sc. Semester-II Examination, 2019
APPLIED MATHEMATICS WITH OCEANOLOGY AND COMPUTER PROGRAMMING
PAPER: MTM- 201
(FLUID MECHANICS)

Full Marks: 40 **Time: 2 Hours**

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1. **Answer any four questions of the following:** **2×4**

   a) Define Newtonian and non-Newtonian fluid.

   b) Define Reynolds number.

   c) State kelvin's theorem for barotropic fluid.

   d) Find the potential function from the velocity field $u=a(x^2-y^2)$, $v=-2axy$, $w=0$.

   e) Draw an infinitesmally small moving element and show all energy fluxes along x- direction associated with the above element.

   f) Write the physical principles used for the equations of continuity, Navier-Stokes and energy, and then write the equation of continuity and Naiver-Stokes for incompressible viscous two-dimensal flow.

   g) What the differences between laminar and turbulent flows? Also show the rout to turbulent flow from laminar flow.

   h) Arrange the velocities (x- and y-components) and pressure in the Staggered Gird and then write the advantage-disadavantage of this arrangement.

(Turn over)

2. Answer any four questions of the following: 4×4

a) Obtain the momentum equations in non-conservative form.

b) Derive mean velocity of the steady flow between two parallel plates of Newtonian fluid.

c) Show that, for steady fully developed laminar flow down the slope, the Navier-Strokes equation is of the form:

$$\frac{d^2x}{dy^2} = -\frac{\rho g}{\mu} \sin\theta$$

where μ is the viscosity of the fluid in x direction.

d) Briefly describe the contributions of fluid elements in the energy.

e) Derive the continuity equation for the model of an infinitesimally small element fixed in space.

f) Write all the possible boundary conditions for tangential and normal component of velocity, and temperature.

g) Derive the expression for substantial derivatives of x-component of the velocity and hence discuss its physical significance.

h) Discretize the $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial t^2}$ using Crank-Nicolson scheme and hence write the algebraic expression in a matrix from for the case of Neumann boundary conditions.

(Turn over)

3. Answer any two questions of the following: 2×8

a) Define coquette flow. Find the expression of maximum velocity in the symmetric plane of a couette flow.

b) Find the velocity field of the standard poiseuille flow.

c) i) Write the x-component of Navier-Stokes equation and energy equation for Newtonian incompressible, viscous fluid flow with negligible gravity and radiation effects.

ii) Make the above equations in non-dimensional form (Navier-Stokes equation in terms of Reynolds number $Re = \frac{UL}{\gamma}$, and energy equation in terms of Re and Prandtl number $Pr = \frac{\gamma}{\alpha}$) with the help of characteristics length, velocity, pressure, and temperatures as L, U, ρU^2 and T_w-T_c, respectively, where symbols have their usual meaning. 2+6

d) Discretize the heat conduction equation $\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial t^2}$ using FTCS (forward time central space), DuFort-Frankel and three-time fully implicit schemes followed by their leading term of truncation error and stability restriction.

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