M.Sc. MATHEMATICS
FOURTH SEMESTER
FLUID DYNAMICS
MSM-403 A

(Use separate answer scripts for Objective & Descriptive)

Duration : 3 hrs. **Full Marks : 70**

(PART-A : Objective)

Time : 20 min. **Marks : 20**

Choose the correct answer from the following: ***1x20=20***

1. When a fluid is incompressible, then we have:
   a. $\nabla . q = 0$ b. $\nabla \times q = 0$
   c. Both of them d. None of them

2. When a force F is conservative and V is the potential, then:
   a. F=0 b. $F = -\nabla V$
   c. $F = V$ d. None of these

3. The equation $\vartheta = \frac{\mu}{\rho}$ is known as:
   a. Perfect fluid b. Kinematic viscosity
   c. Both of these d. None of these

4. The boundary layer concept was given by:
   a. Galileo b. Newton
   c. Prandtl d. None of these

5. In equation of motion the non linear term is:
   a. $(\nabla . q)$ b. $(\nabla . q)q$
   c. zero d. None of these

6. The shear stress distribution in any flow is given by:
   a. $\tau = \mu \frac{du}{dy}$ b. $\tau = -\mu \frac{du}{dy}$
   c. absent d. None of these

7. From no slip condition of a viscous fluid it follows that:
   a. q=1 b. q=0
   c. q= -1 d. zero

8. The no slip condition of a viscous fluid in case of a closed region is satisfied:
   a. On the surface b. At the centre
   c. Both of these d. None of these

9. When Reynold's number is very very less than 1, then the inertia term compared to viscosity is:
   a. Less b. More
   c. Equal d. None of these

10. The friction in the region outside the boundary layer is:
    a. High b. Low
    c. Both of these d. None of these

11. An ideal fluid is that substance which is ________of sustaining shearing stresses.
   a. Capable b. Incapable
   c. Both of these d. None of these

12. Mercury is an example of:
   a. Non-Newtonian fluid b. Newtonian fluid
   c. Both of these d. None of these

13. In Non-Newtonian Fluid, shear stress is______ to velocity gradient.
   a. Proportional b. Not proportional
   c. Both of these d. None of these

14. If the fluid is non-viscous, then the equation of motion takes the form of:
   a. Lagrange's equation b. Navier Stoke's equation
   c. Euler's equation d. None of these

15. Euler's equation of motion is suitable for a:
   a. Viscous fluid b. Perfect fluid
   c. Real fluid d. None of these

16. Fluid motion is said to be irrotational if:
   a. Divergence of fluid velocity is zero b. Curl of fluid velocity is zero
   c. Gradient of fluid velocity is zero d. None of these

17. The rate of deformation tensor in a fluid is zero if the fluid is:
   a. Homogeneous b. Irrotational
   c. Incompressible d. Nonviscous

18. Viscous stress tensor is a function of:
   a. Vorticity tensor b. Deformation tensor
   c. None of these d. All of these

19. The vorticity equation for an incompressible viscous fluid is:
   a. $\frac{d\Omega}{dt} = (\Omega.q)q + \nu q^2$ b. $\frac{d\Omega}{dt} = (\Omega.\nabla)q + \nu\nabla^2 q$
   c. $\frac{d\Omega}{dt} = (\Omega.\nabla)q + \nu\nabla^2\Omega$ d. None of these

20. If the fluid is viscous, then the equation of motion takes the form of:
   a. Navier Stoke's equation b. Euler's equation
   c. Oseen's equation d. None of these

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(PART-B : Descriptive)

Time : 2 hrs. 40 min. **Marks : 50**

[Answer question no.1 & any four (4) from the rest]

1. Show that (i) $\int_0^\delta \frac{u}{U} dy = \delta - \delta_1$ 2+4+4=10
   (ii) $\int_0^\delta (\frac{u}{U})^2 dy = \delta - \delta_1 - \delta_2$
   (iii) $\int_0^\delta (\frac{u}{U})^3 dy = \delta - \delta_1 - \delta_3$
   where the symbols have their usual meaning.

2. Discuss Karman's momentum integral equation. 10

3. The velocity distribution in the boundary layer over a flat plate is $u = U(1 - e^{-\eta})$, $\eta = \frac{y}{\delta}$. Find the skin friction, displacement thickness and momentum thickness. 4+3+3=10

4. A liquid occupying the space between two coaxial circular cylinders is acted upon by a force $\frac{c}{r}$ per unit mass, the lines of force being circles around the axis. Prove that in the steady motion, the velocity at any point is given by the formula $\frac{c}{2\vartheta}\{\frac{b^2}{r}\frac{r^2-a^2}{b^2-a^2} log\frac{b}{a} - r log\frac{r}{a}\}$ 10

5. Write a short note on Reynold's number. Show that for a steady flow at small Reynold's number, the Stoke's stream function ψ satisfies the equation $E^4\psi = 0$, where $E^2 \equiv \frac{\partial^2}{\partial r^2} + \frac{\sin\theta}{r^2}\frac{\partial}{\partial\theta}(\frac{1}{\sin\theta}\frac{\partial}{\partial\theta})$ 10

6. In the steady motion of a viscous incompressible fluid through a circular pipe, show that the velocity $q_z = \frac{P}{4\mu}(a^2 - r^2)$, where $-P$ is the pressure gradient along the axis, a the radius of the pipe and r the radial distance from the axis. 10

7. Deduce Navier Stoke's equation. 10

8. Write in details about group velocity of a wave. 10

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