This question paper contains 4 printed pages.

3075 *Your Roll No.* .....

MEM **J**

Paper— ME.505

FLUID MECHANICS

Time : 3 hours *Maximum Marks* : 100

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt any five questions.
All questions carry equal marks.

Use of Gas table is permitted.

1. Explain the terms:

   (*i*) Convective and Diffusive transport

   (*ii*) Rate of rotational tensor, Rate of expansion tensor and Rate of shear deformation tensor

   (*iii*) Vorticity and Circulation

   (*iv*) Stress tensor and Stress vector. 20

2. (*a*) Prove that the stress vector acting on a surface of arbitrary orientation $\hat{n}$ located at a point in a fluid is related by a dot product to the stress tensor at this point. What is the physical significance of this result?

P. T. O.

(*b*) From the first principles prove that:

$$\rho\vec{a}=\rho\vec{f}+\nabla \cdot \sigma. \qquad 10+10$$

3. (*a*) With the help of a polar coordinate system determine the stress tensor of a suitable steady viscous flow system.

(*b*) Starting from the N-S equations obtain the boundary layer equations for steady two dimensional incompressible flow. Why is the pressure within the boundary layer equal to that at the outer edge of the boundary layer where its value is determined by frictionless flow? 10+10

4. Classify various methods for solution of boundary layer equations. Explain any *one* method in detail. 20

5. With the help of general N-S equation, derive the following coordinate free form of the time average N-S equation for turbulent flow:

$$\rho\left[\frac{\partial\vec{u}}{\partial t}+\vec{u} \cdot \nabla\vec{u}\right]=-\nabla p+\mu\nabla^2 u+\nabla \cdot \sigma_T.$$

Discuss the physical significance of Reynolds stresses. 20

6. A plate 1 m×1 m in size and of negligible thickness is moved in air in its own plane at a speed of 2 m/s. Find the force required to maintain this motion. If the

plate is moved in water, find the force required. If the plate is moved normal to its own plane in air, find the force required. In each of these calculations state the assumptions made. 20

7. (*a*) Discuss choking of the nozzle.

(*b*) A sampling tube, 0·25 mm ID and 15 mm long, is inserted into a section of a fluid stream where the static pressure and static temperature are 2 bar and 700°C and the fluid stream velocity is 300 m/s. The sampling tube exit is connected to a very large space connected to a vacuum pump. Determine the maximum rate of sampling of the stream mass, and the pressure the vacuum pump must maintain to achieve the rate.

(Assume that the properties of air apply to stream.) 20

8. (*a*) Discuss and explain the operation of convergent-divergent nozzle under on and off design back pressure.

(*b*) The mass flow rate of air through a short heat exchanger is 150 kg/m^{2}s. The inlet static pressure and temperature are $1{\cdot}5\times10^5$ N/m^2 and 30°C. If the temperature at the exchanger exit is 200°C,

estimate the inlet and exit Mach numbers and the pressure drop in flow through the exchanger, although friction is negligible. 20

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