00237

BACHELOR OF TECHNOLOGY IN MECHANICAL ENGINEERING (COMPUTER INTEGRATED MANUFACTURING)

Term-End Examination

June, 2010

BME-028 : FLUID MECHANICS

Time : 3 hours *Maximum Marks : 70*

Note : *Attempt **any seven** questions. **All** questions carry **equal** marks. Use of Calculator is permitted.*

1. (a) If the velocity distribution over a plate is given by : **5+5=10**

$$u = \frac{3}{4} y - y^2$$

Where u is the velocity in m/s at distance y metres above the plate, determine the shear stress at a distance of 0.15 m from the plate. Take the dynamic viscosity of the fluid as 0.834 Ns/m^2.

(b) A hydraulic jack consists of a connected mass of oil with two pistons. The smaller piston 15 cm^2 in area is to take the force applied where as the large piston 150 cm^2 in area carries the load. Assuming that a person can apply a force of 300 N, determine the maximum load that the jack can lift if the pistons are at the same level.

2. (a) Determine the stream function (Ψ) and the velocity potential function (ϕ) for a fluid flow if $u = 2x$, and $v = -2y$. **5+5=10**

(b) State if the flow represented by

$$v = 3x + 4y, \text{ and}$$

$$u = 2x - 3y$$

is rotational or irrotational. Find the potential function if the flow is irrotational and vorticity if it is rotational.

3. (a) Glycerine of density 1250 kg/m^3 and viscosity 0.72 kg/ms flows through a pipe of 80 mm diameter. If the shear stress at the wall is 300 N/m^2, calculate : **5+5=10**

(i) the pressure gradient along the flow,

(ii) the average velocity in the pipe,

(iii) the rate of discharge, and

(iv) the Reynolds number of the flow.

(b) What do you understand by the terms ? Give suitable examples :

(i) Laminar flow, and

(ii) Turbulent flow

4. (a) With neat sketches explain the development of a boundary layer along a thin flat smooth plate held parallel to a uniform flow and indicate the salient features. **5+5=10**

(b) A uniform free stream of air at 10 m/s flows over a flat plate. Calculate the drag force for the plate, 0.5 m long, and 2m wide.

Take : Drag coefficient $C_D = 0.00232$,

$\rho_{air} = 1.2$ kg/m^3, $\mu_{air} = 18 \times 10^{-6}$ NS/m^2.

5. (a) The resisting force F of a supersonic plane during flight can be considered as dependent upon the length of aircraft L, velocity V, air viscosity μ, air density ρ, and bulk modulus of air K. Express the functional relationship between the variables and the resisting force in the form

$$\frac{F}{\rho L^2 V^2} = f\left(\frac{\mu}{\rho LV}, \frac{K}{\rho V^2}\right). \qquad \textbf{5+5=10}$$

(b) What is the significance and the role of the following parameters :

(i) Reynolds number

(ii) Froude number

(iii) Mach number

(iv) Weber number

(v) Euler number

6. (a) If the velocity profile in a laminar boundary layer is approximated by parabolic profile : **5+5=10**

$$\frac{u}{v} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

where u is the velocity at y and $u \to v$ as $y \to \delta$. Calculate the displacement thickness and the momentum thickness.

(b) A lubricating oil flows in a 10 cm diameter pipe with velocity of 1 m/s. Determine whether the flow is laminar or turbulent for the lubricating oil, $\mu = 0.1$ Ns/m^2 and $\rho = 930$ kg/m^3. Also calculate the transition velocity.

7. (a) Explain, by drawing streamlines, the formation of vena contracta when a fluid flows out of an orifice. **5+5=10**

(b) Air flows steadily through a horizontal nozzle as shown in figure - 1. At the nozzle inlet, the velocity is 6 m/s, and the pressure is 100 KN/m^2. If the inlet area is 0.1 m^2 and the contraction ratio is 5, determine :

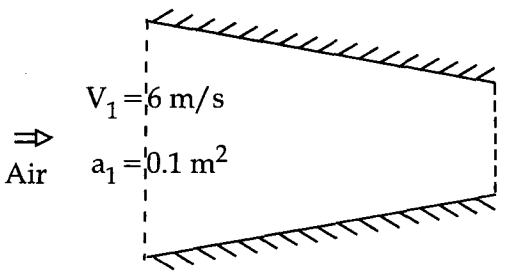

Figure - 1

(i) the velocity and the pressure at the exit, and

(ii) the discharge and mass flow rate through the nozzle

8. (a) Derive the equation of a streamline **5+5=10**

$$u\,dy - v\,dx = 0$$

for plane flow in the $x-y$ plane.

(b) An ice - cube is floating in a glass of water. As the cube melts, state and explain whether water level rises, falls or remains constant.

9. (a) Define the stream function ψ and velocity potential function ϕ and hence show that the lines of constant ϕ and ψ must intersect orthogonally. **5+5=10**

(b) Does the flow field associated with the potential

$$\phi = 3x^2 - 3x + 3y^2 + 16t^2 + 12zt$$

satisfy the incompressible continuity equation ?

10. (a) Differentiate between the following pair of terms : **5+5=10**

(i) Ideal fluid and perfect fluid

(ii) Irrotational flow and inviscid flow

(b) (i) State the Newton's law of viscosity and give examples of its applications

(ii) What happens when the pressure of a liquid flowing in a passage drops and falls below the vapour pressure at that temperature ?