Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/B.TECH(CHE-N)/SEM-3/CHE-301/2011-12

2011

FLUID MECHANICS

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.

Candidates are required to give their answers in their own words as far as practicable.

GROUP – A
(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

   i) A streamline is a line in flow field

      a) that is traced by all the fluid particles passing through a given point

      b) along which a fluid particle travels

      c) such that at every point on it, the velocity is tangential to it

      d) none of these.

   ii) Vena-contracta pressure tapping is at a distance of ..... from the position of an orifice meter fitted in a pipe of internal diameter 'd '.

      a) d b) $0{\cdot}5d$

      c) $2d$ d) $4d$.

iii) Bernoulli's equation deals with the law of conservation of

a) mass b) momentum

c) energy d) none of these.

iv) Pitot tube is used to measure

a) average velocity b) local velocity

c) maximum velocity d) none of these.

v) Stokes law is valid when the particle's Reynolds No. is

a) greater than 1

b) less than 1

c) lies between 1 and 100

d) greater than 100.

vi) A Newtonian fluid (density = ρ, viscosity = μ) is flowing with average velocity v in a tube of diameter D. Let Δp be the pressure drop across the length L. For a laminar flow, Δp is proportional to

a) $L \rho v^2 / D$ b) $D \rho v^2 / L$

c) $L \mu v / D^2$ d) $\mu v / L$.

vii) A ..... pump can develop maximum discharge pressure.

a) centrifugal b) piston

c) rotary d) plunger.

viii) For pumping slurry, one can use a ..... pump.

a) plunger b) centrifugal

c) diaphragm d) pneumatic.

ix) The pressure drop in a packed bed for turbulent flow is given by

a) Kozeny-Carman equation

b) Blake-Plummer equation

c) Hagen-Poiseuille Equation

d) none of these.

x) The equivalent diameter for fluid flow through a square cross-section channel of side x is given by

a) $4x$ b) $2x$

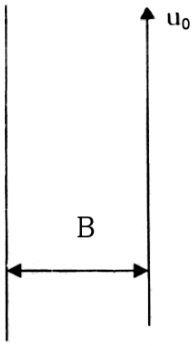
c) x d) $0{\cdot}5\ x$.

GROUP – B

(Long Answer Type Questions)

Answer any *five* of the following. $5 \times 12 = 60$

2. a) A Newtonian fluid is confined between two broad, parallel, vertical plates separated by a distance B. The plate on left is stationary, that on right is moving vertically upward with a constant velocity u_0. Assuming that the flow is laminar, find the steady-state velocity profile in the fluid.



b) Define steamline, streak line and path line.

c) What do you understand by 'velocity boundary layer' ?

6 + 3 + 3

3. a) For turbulent flow in a smooth circular tube with a radius R, the velocity profile varies according to :

$$V = V_{\max}\left(\frac{R-r}{R}\right)^{\frac{1}{7}}$$

at a Reynolds number of about 10^5, where r is the radial distance from the centre and $V_{\max}$, the maximum velocity at the centre. Find out the relationship between average velocity V_{avg} to $V_{\max}$ for an incompressible fluid.

b) A small capillary with an inside diameter of 2·3 mm and a length of 0·32 m is being used to continuously measure the flow rate of a fluid having a density of 880 kg/m^3 and viscosity of $1{\cdot}13\times10^{-3}$ Pa.s. The pressure drop reading across the capillary during flow is 0·066 m of water (density 996 kg/m^3). What is the flow rate in m^3/s if end-effect corrections are neglected ?

c) Write down the relation between friction factor and Reynolds number during laminar flow of a Newtonian fluid in a smooth circular tube. 6 + 5 + 1

4. a) A packed bed is composed of cylinders having a diameter D = 0·02 m and length $L = D$. The bulk density of the overall packed bed is 962 kg/m^3 and the density of the solid cylinder is 1600 kg/m^3. Find,

i) the void fraction

ii) effective diameter, D_P of the particle.

b) Define drag coefficient. How does drag coefficient vary with Particle Reynolds No.

c) Air at 41°C and 101·3 kPa absolute pressure flows at a velocity of 25 m/s past a sphere having a diameter 46 mm. What is the force on the sphere ?

[Data Given : $\mu_{air} = 1 \cdot 915 \times 10^{-5}$ = Pa.s; $C_D = 0 \cdot 47$]

(2 + 3) + (2 + 2) + 3

5. a) What is the working principle of a venturi meter ?

b) A venturi meter having a throat diameter of 38·9 mm is installed in a line having an inside diameter of 102·3 mm. It meters water having a density of 999 kg/m^3. The measured pressure drop across the venturi is 156·9 kPa. The venruti coefficient is 0·98. Calculate the flow rate in m^3/hr.

c) A rectangular channel 2·0 m wide has a discharge of 250 litres per second, which is measured by a right-angled *V*-notch weir. Find the position of the apex of the notch from the bed of the channel if maximum depth of water is not to exceed 1·3 m. Take C_d = 0·62.

3 + 4 + 5

6. a) Write down the differences between centrifugal pump and reciprocating pump.

b) It is desired to use 28 m^3/min of air (metered at a pressure of 1 atm and 26°C) in a process. This amount of air, which is at rest, enters the suction of a centrifugal fan at a pressure of 742 mm of Hg and a temperature of 90°C and is discharged at a pressure of 770 mm of Hg and a velocity of 46·2 m/s. A centrifugal fan having a fan efficiency of 65% is to be used. Calculate the break-kW power needed. [Molecular weight of air is 28·97] 4 + 8

7. a) Write about the advantages of triangular notch or weir over Rectangular Notch or weir.

   b) Crude oil of specific gravity 0·85 flows upwards at a volume rate of flow of 60 litre/s through a vertical venturi meter with an inlet diameter of 200 mm and a throat diameter of 100 mm. The coefficient of discharge of the venturi meter is 0·98. The vertical distance between the pressure tappings is 300 mm.

      i) If two pressure gauges are connected at the tappings such that they are positioned at the levels of their corresponding tapping points, determine the difference of readings in N/cm^2 of the two pressure gauges.

      ii) If a mercury differential manometer is connected in place of pressure gauges to the tappings such that the connecting tube up to mercury are filled with oil, determine the difference in the level of the mercury column. 2 + (6 + 4)

8. a) Derive an expression of virtual head developed by a centrifugal pump & show that it is independent of the density of the fluid.

   b) How cavitation does occur in a centrifugal pump ? Distinguish between blower & compressor. 6 + 3 + 3

9. a) What are the differences between particulate fluidization & bubbling fluidization ? Estimate the minimum fluidization velocity for a bed of particles fluidized by water.

Take : d_p = 110 μm, φ_s = 1, ρ_p = 2200 kg/m^3, e_{mf} = 0·5, ρ = 1000 kg/m^3, μ = 0·7 kg/m^3.

b) Calculate the bed voidage & the ratio of the height of the fluidized bed to that of the fixed bed for μ_0 / μ_{mf} = 10.

4 + 8

==========