B.TECH/CHE/3RD SEM/CHEN 2102/2016

FLUID MECHANICS
(CHEN 2102)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Darcy friction factor is related to Reynold's number (Re) as
(a) $f = \frac{64}{Re}$ (b) $f = \frac{16}{Re}$
(c) $f = \frac{32}{Re}$ (d) None of these.

(ii) Chezy's formula for an open channel flow is given as
(a) $V = C\sqrt{R\,S}$,
(b) $V = R\sqrt{C\,S}$,
(c) $V = CS\sqrt{R}$,
(d) $C = V\sqrt{RS}$, [V= velocity; R= hydraulic radius & S = Bottom].

(iii) Streamlines, streaklines and pathlines coincide for
(a) steady flow (b) unsteady flow
(c) inviscid flow (d) creeping flow.

(iv) The dimension of momentum diffusivity is
(a) LT^{-1} (b) LT^{-2} (c) L^2T^{-1} (d) None of these.

(v) Bernoulli's equation is a _______ balance equation.
(a) mass (b) momentum
(c) energy (d) both (a) and (c).

(vi) For flow over a flat plate entrance length varies with Reynold's number (Re) as
(a) $Re^{0.1}$ (b) Re^{-1} (c) $Re^{0.06}$ (d) Re.

(vii) Hydraulic Radius (R_H) is given as
(a) $R_H = \frac{P}{A}$, (b) $R_H = \sqrt{\frac{P}{A}}$, (c) $R_H = \frac{P^2}{A}$, (d) $R_H = \frac{A}{P}$,
Where, p = wetted perimeter, A = Area of flow

(viii) The continuum hypothesis for fluid flow is valid for Knudsen number(Kn)
(a) Kn>10 (b) 0.01<Kn<10
(c) Kn<0.01 (d) Kn = 0

(ix) Which is a variable area flow meter?
(a) Venturi meter (b) Orifice meter
(c) Rotameter (d) Anemometer.

(x) Gas flow rate measurement in the incompressible range can be accomplished by
(a) venturimeter only, (b) orifice meter only
(c) rotameter only, (d) all of the above.

Group – B

2. (a) Differentiate between streamlines, streaklines and pathlines.

(b) A velocity field is given by $\vec{V} = 3x\hat{i} + 4y\hat{j}$, where velocity is expressed in m/s and x and y in m.
(i) Obtain the equation for the streamlines in the xy plane.
(ii) Determine the velocity of the particle at (5, 10).
(iii) Determine the equations for the pathline for a particle moving in this velocity field.

6 + (2 + 2 + 2) = 12

3. (a) Why shear stress is also called Momentum flux? Explain mathematically.

(b) Differentiate between thixotropic and rheopectic fluids. Give examples. Write the general expression for variation of momentum flux with shear rate for Non-Newtonian fluids. Draw the shear stress vs. shear rate curve for dilatant and pseudoplastic fluids.

3 + (3 + 2 + 2 + 2) = 12

Group – C

4. (a) What is the significance of momentum correction factor? Explain the significances of the various terms in Navier-Stokes equation.

(b) A pump draws a solution of specific gravity 1.84 from a storage tank through a 75 mm schedule 40 steel pipe. The efficiency of the pump is 60%. The velocity in the suction line is 0.914 m/s. The discharge is through a 50 mm schedule 40 pipe to an overhead tank. The end of the discharge pipe is 15.2 m above the solution level in the tank. Friction losses in the entire piping system are 29.9 J/kg. What pressure must the pump develop? What is the power delivered to the fluid by the pump? Cross sectional areas of 75 mm and 50 mm schedule 40 pipe are 0.0048 and 0.0022 m^2 respectively.

(2 + 2) + 8 = 12

5. (a) A liquid of constant density and viscosity is in a cylindrical container of radius R. The container is rotating about its own axis at an angular velocity Ω. The cylinder axis is vertical so that $g_r = g_\theta = 0$, $g_z = -g$. Find the shape of the free surface of the liquid when steady state has been established.

(b) What are the assumptions of Bernoulli's equation? What is the significance of kinetic energy correction factor?

7 + (3 + 2) = 12

Group – D

6. (a) Derive an expression for the determination of volumetric flow rate of an incompressible fluid through an orifice meter.

(b) A drainage pump has a tapered section pipe. The pipe is running full of water. The pipe diameter at the inlet and outlet are 1 m and ½ m respectively. The free water surface is 2 m above the surface of the surface of the inlet and the centre of upper end (outlet) is 3m above the top of free water surface.
The pressure at the top end of the pipe is 25 cm of Hg (vacuum) and it is known that loss of head by friction between the top & the bottom section is 1/10th of the velocity head at the top section. Compute the discharge. Neglect losses of head at the entrance of the tapered pipe.

6 + 6 = 12

7. (a) Explain the working principle of a Hot wire anemometer.

(b) Water flows through a Venturi meter which has a diameter at the inlet of 1.2 m and a diameter of 0.6 m at the throat. The difference in pressure between the main and the throat is measured by a differential mercury gauge, which shows a deflection of 5.1 cm. Find the discharge through the meter and also calculate the velocity of water at the throat. Take the coefficient of discharge of the meter as 0.98. (1.016 m^3/sec; 3.594 m/sec).

(c) A 75° triangular notch is discharging under submerged conditions. The vertex of the notch is at a height of 30 cm from the channel bed. The elevation of water surfaces upstream and downstream of the notch, measured from the channel bed are 75 cm and 50 cm respectively. Assuming C_d = 0.6, estimate the discharge over the notch.

2 + 5 + 5 = 12

Group – E

8. (a) (i) How would you classify pumps in regard to the energy transfer to the fluid for its motion?
(ii) Define cavitation as a capacity reduction process in the transportation of a fluid by pump and its remedy with the concept of net positive suction head (NPSH).
(iii) Explain the various pump characteristics and indicate the shut-off head and design point.

(b) A centrifugal pump impeller rotating at 1000 r.p.m has the inlet & outlet diameter 25 cm & 60 cm respectively; width of the impeller at the inlet(b_1) & outlet (b_2) = 6 mm; Vane angle at the inlet (ϕ_1) & outlet (ϕ_2) are 0.5 radians & 0.3 radians respectively; assuming shockless entry, determine the discharge, head developed and power required by the pump.

(2 + 3 + 3) + 4 = 12

9. (a) Derive an expression for minimum fluidization velocity. Also give its physical significance.

(b) Calculate the minimum fluidisation velocity u_{mf} for a bed of sharp sand particles.
Following data may be used:
$Bed : \epsilon_{mf} = 0.55$;
Ambient Air: $\rho_g = 0.0012\ g/cc$, μ =0.00018g/(cm –s);
Solids: Sharp irregular sand, with $\overline{d_p} = 160\mu m$;, $\varphi_s = 0.67$ & $\rho_s = 2.6\ g/cc$.

(c) A water softener consists of a vertical tube of 50 mm diameter and packed upto a height of 0.5 m with ion-exchange resin particle. The particles may be considered as sphere with a dia of 1.25 mm. Water flows over the bed, because of gravity as well as pressure difference, at a rate of 300 cm/s. The bed has a porosity of 0.3. Calculate the pressure drop.

3 + 4 + 5 = 12