7. (a) Derive an expression for the head developed in an ideal pump and the power required to drive the pump for the developed head.

(b) An impeller with an eye radius of 51 mm and an outside diameter of 406 mm rotates at 900 rpm. The inlet and outlet blade angles measured from the radial flow direction are 75^0 and 83^0 respectively, while the depth of blade is 64 mm.
Assuming zero inlet whirl, zero slip and a hydraulic efficiency of 89%, calculate
i. the volume flow rate through the impeller.
ii. the stagnation and static pressure rise across the impeller.
iii. the power transferred to the fluid.
iv. the input power to the impeller.

(c) Show that pressure drop across Rotameter is invariant with flow rate of fluid.

4 + 5 + 3 = 12

Group - E

8. (a) Define sphericity.

(b) 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 970 kg/m^3 and the density of the solid cylinders is 1600 kg/m^3. Find
i. the void fraction.
ii. effective diameter, D_p of the particle.

(c) A solid particle of density ρ_p and diameter D_p is falling through a stagnant fluid of density ρ and viscosity μ under gravity. Obtain an expression of terminal velocity in Stokes law regime.

1 + 5 + 6 = 12

9. (a) What do you understand by minimum fluidization velocity? Find out its expression for very small particles with particle Reynolds number less than 1.0.

(b) Write down the applications of fluidization. What are the advantages of fluidization?

(c) A bed of ion-exchange beads (sphericity =1) 2.2 m deep is to be backwashed with water to remove dirt. The particles have a density of 1.25g/cm^3 and an average size of 1.2 mm. What is the minimum fluidization velocity using water at 20^0C?Given viscosity of water = 0.01P, porosity at minimum fluidization = 0.4.

(2 + 3) + (1 + 2) + 4 = 12

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) Fluid flow at increasing rate through a diverging channel is an example of ……. Flow.
(a) steady uniform (b) unsteady uniform
(c) steady non -uniform (d) unsteady non-uniform.

(ii) ---------- fluid is called shear thickening fluid
(a) Newtonian (b) Pseudoplastic
(c) Dilatant (d) Bingham plastic

(iii) Stokes law is valid when particle Reynolds no. is
(a) less than 1 (b) more than 1
(c) less than 10 (d) less than 100.

(iv) In case of turbulent flow of fluid in a pipe, kinetic energy correction factor is approx.
(a) 2 (b) 1/2 (c) 1 (d) 3/2.

(v) The hydraulic diameter of an annulus of inner and outer radii R_i and R_o respectively is
(a) $4(R_o - R_i)$ (b) $\sqrt{R_o - R_i}$ (c) $2(R_o - R_i)$ (d) $R_o + R_i$.

(vi) Flow separation is caused by
(a) Reduction of pressure than vapor pressure
(b) Reduction of pressure gradient to zero
(c) An adverse pressure gradient
(d) Boundary layer thickness reducing to zero.

(vii) Von –Karman equation can be used to calculate friction factor in
(a) laminar region (b) turbulent region
(c) both turbulent and laminar region (d) transition region.

(viii) In the fluid flow, the stagnation point is defined as a point, where the ..... is zero.
(a) pressure (b) flow velocity
(c) total energy (d) total head.

(ix) 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$\sqrt{RS}$.
Where, V= velocity of flow; R= hydraulic radius & S = Bottom slope

(x) For a series of curved radial vanes the work done by the vanes on unit weight of water per unit time is given by
(a) $\frac{1}{g}(V_{w1}u_1 + V_{w2}u_2)$ (b) $\frac{1}{g}(V_{w1}u_1 - V_{w2}u_2)$
(c) $\frac{1}{g}(V_{w2}u_2 - V_{w1}u_1)$ (d) $\frac{1}{g}(V_{w1}u_2 - V_{w2}u_1)$.
Where u_1 & u_2 = Impeller tangential velocity at entry & exit respectively
V_{w1}& V_{w2}= Tangential component of absolute velocity at entry & exit respectively.

Group – B

2. (a) The temperature of earth's atmosphere drops about 5^0C for every 1000 m of elevation above the earth surface. If the air temperature at ground level is 22^0C and the pressure is 760 mm of Hg, at what elevation is the pressure 380 mm of Hg. Assume air behaves as an ideal gas.

(b) A velocity field is given by **V**= 0.3x **i** – 0.4 y **j**. m/s
(i) Find the streamline passing through the point (1,6,0)
(ii) If the particle passing through the point (1,6,0) at time t_0 = 0, determine the location of the particle at time t = 5 sec. and also velocity at time t = 5 sec.

(c) How does the viscosity of a fluid change with temperature?

6 + (2 + 2) + 2 = 12

3. (a) A circular plate of diameter 1.8 m is submerged in water vertically such that its top surface is 1.2 m below the free surface of the water. Determine the total pressure force on the plate and the position of the centre of pressure.

(b) Discuss the working principle of an inclined tube manometer.

(c) With neat sketch, explain the development of boundary layer over a flat plate.

6 + 2 + 4 = 12

Group – C

4. (a) Water (density=10^3/Kg, viscosity=0.89 c.p.) is flowing at 10^0C through a long horizontal plastic pipe of inside diameter of 75 mm at a velocity of 2.45m/s. Calculate the pressure drop per 100m of pipe length. The relation between friction factor and Re.no. is given by :

$$f = 0.0014 + \frac{0.125}{\mathrm{Re}^{0.32}} \qquad [3{,}000 \le \mathrm{Re.no.} \le 3\times10^6]$$

(b) Obtain a relation of average velocity to maximum velocity for a fully developed laminar flow of a Newtonian fluid in a circular smooth conduit.

6+6= 12

5. (a) A pump requires 50 kW to supply water at a rate of 0.02 m^3/s to an overhead tank. The pipe connecting the delivery end of the pump to the overhead tank is 115 m long and 300 mm in diameter and has a friction factor f=0.02. A valve (loss coefficient= 5 under wide open condition) is inserted in the delivery pipe to control the flow rate. Water is supplied from a reservoir 2 m below the horizontal level of the pump through a suction pipe 6 m long and 400 mm in diameter having a friction factor f = 0.03. Determine the maximum height from the plane of the pump at which the overhead tank can be placed under this situation (pump efficiency = 80%)

(b) Water flows out through an opening of 20 cm in diameter, in the bottom of a constant level tank. The radius of the water jet is r at a depth Z below the tank bottom and H is the depth of the water in the tank. Obtain an expression for the profile of the jet expressing 'r' in terms of Z/H.

8 + 4 = 12

Group - D

6. (a) Narrate the advantages and disadvantages of Venturimeter, orificemeter & notch for the measurement of volumetric flow rate of a liquid.

(b) Express the relationship mathematically between static pressure, dynamic pressure and stagnation pressure in a fluid flow situation through a pitot tube.

(c) A 75^o 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.

4 + 2 + 6 = 12