FLUID MECHANICS
(CIVL 2113)

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) A body in neutral equilibrium will rotate about
(a) centre of gravity and metacentre
(b) centre of pressure and metacentre
(c) centre of gravity and centre of buoyancy
(d) centre of gravity, centre of buoyancy and metacentre.

(ii) Which one of the following is non-dimensional parameter?
(a) Chezy's coefficient (b) Darcy-Weisbach friction factor
(c) Froude's number (d) Mach number.

(iii) Discharge through a Cipolletti weir is given by
(a) $\frac{2}{3}C_d\sqrt{2g}LH^{\frac{3}{2}}$ (b) $\frac{8}{15}C_d\sqrt{2g}tan\frac{\theta}{2}H^5$
(c) $\frac{2}{3}C_d\sqrt{2g}(L-0.2H)H^{\frac{3}{2}}$ (d) $\frac{2}{3}C_d\sqrt{2g}LH^{\frac{5}{2}}$

(iv) For a most hydraulically efficient trapezoidal section, the wetted perimeter, P is given in terms of bed width, b and depth of flow, h as
(a) P = b + h (b) P = b + 2.31h (c) P = b + 2h (d) P = b + 4h.

(v) The specific speed for turbines has the dimensions:
(a) $F^{1/2}L^{-3/4}T^{-3/2}$ (b) T^1 (c) $F^{1/2}L^{-5/2}T^{-3/2}$ (d) $FL^{-3/4}T^{-3/2}$

(vi) If the Reynold's number for a flow is 3000, then the type of flow is
(a) Laminar (b) Transitional (c) Turbulent (d) Vortex

(vii) Flow at a constant rate through a tapering pipe is
(a) steady and uniform flow (b) steady and non-uniform
(c) unsteady and uniform flow (d) unsteady and non-uniform flow.

(viii) Which of the following represents dimensions of pressure?
(a) $[MLT^{-2}]$ (b) $[ML^{-1}T^{-2}]$ (c) $[LT^{-2}]$ (d) $[ML^{-3}]$

(ix) The water flows fully through a rectangular channel with dimensions 4 m × 3 m. What is the velocity of flow (m/s) through the channel, if the slope of energy line and Chezy's constant given 0.0006 and 90, respectively?
(a) 1.5 (b) 2.4 (c) 4.6 (d) 5.

(x) Which one of the following represents the critical state of flow in non-rectangular channel?

(a) $y_o = (\frac{q^2}{g})^{1/3}$ (b) $\frac{Q^2}{g} = \frac{A^3}{T}$ (c) $\frac{Q^2}{g} = \frac{A^2}{T}$ (d) $\frac{Q^2}{g} = \frac{A}{T^3}$

Group - B

2. A trapezoidal channel shown in Fig.1, is 2 m wide at the bottom and 1 m deep has side slopes 1:1.
Determine (i) the total pressure and (ii) the centre of pressure on the vertical gate closing the channel when it is full of water. Derive the expression for centroid and moment of inertia of trapezoidal section if required. [(CO1)(Evaluate/HOCQ)]

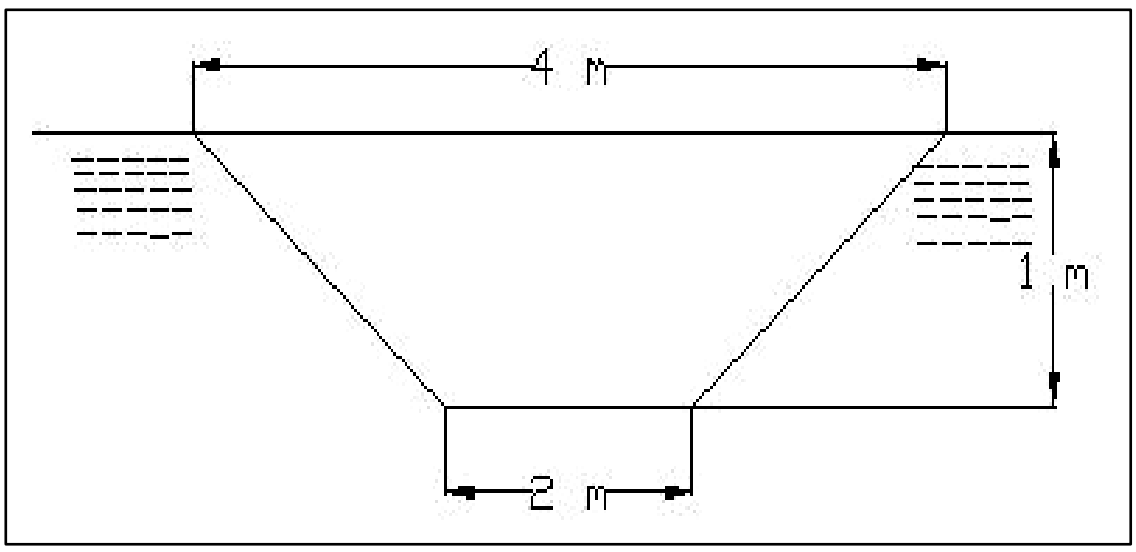

Fig. 1

12

3. (a) Outline the complete classification of open flow channel. [(CO4)(Understand/LOCQ)]
(b) A trapezoidal channel shown in Fig.2, has a bed width of 2.0 m and side slopes of 1.5 Horizontal: 1 vertical. The channel has a longitudinal slope of 1/4000. If the Manning's coefficient of the channel boundary is 0.018, calculate the mean velocity and discharge in the channel for a depth of 1.4 m. [(CO4)(Create/HOCQ)]

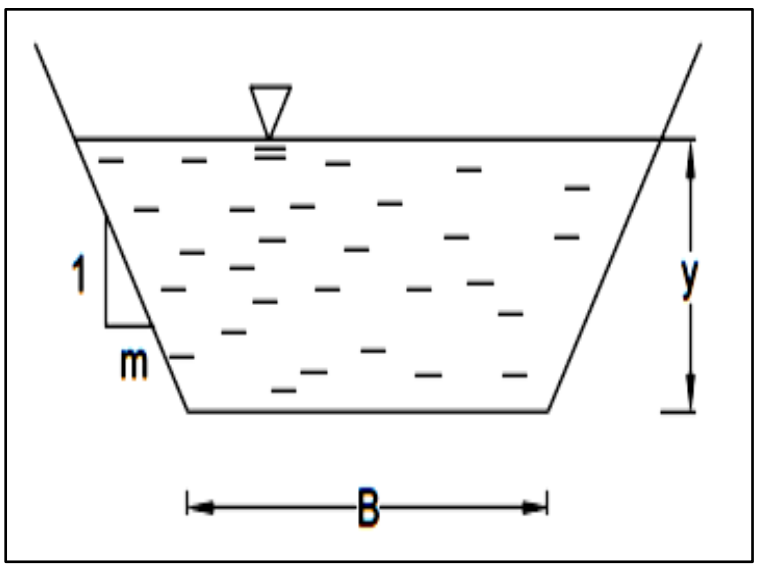

Fig.2

(c) Illustrate the following terms:
(i) Non-uniform flow
(ii) Gradually varied flow. [(CO4)(Understand/LOCQ)]

2 + 4 + (3 + 3) = 12

Group - C

4. (a) Explain and derive the expression for discharge through rectangular notch. Explain the term 'End contraction'. [(CO2,CO3)(Understand/LOCQ)]

(b) Water is flowing through a triangular weir with a head of H with central angle **θ** and discharge Q_0. If the head is increased by 3 times, then estimate the increase in discharge using the concept of Bernoulli's equation. Assume any value not provided.
[(CO2,CO3)(Evaluate/HOCQ)]
4 + 8 = 12

5. (a) A horizontal pipe line 40 m long is connected to a water tank at one end and discharges freely into the atmosphere at the other end. For the first 25 m of its length from the tank, the pipe is 150 mm diameter and its diameter is suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Considering all the losses of head which occur determine the rate of flow. Take f = 0.01 for both sections of the pipe. [(CO2,CO3)(Evaluate/HOCQ)]
(b) Explain drag and lift. [(CO6)(Understand/LOCQ)]
10 + 2 = 12

Group - D

6. (a) Distinguish between Specific Energy (E_c) and Critical depth flow (CDF).
[(CO4)(Analyze/LOCQ)]
(b) In a flow through a rectangular channel for a certain discharge, the Froude's number corresponding to the two alternate depths are Fr_1 and Fr_2.
Show that $(\frac{Fr_2}{Fr_1})^{\frac{2}{3}} = \frac{2+{Fr_2}^2}{2+{Fr_1}^2}$ [(CO4)(Evaluate/HOCQ)]
(c) Classify Froude's no. based on critical, subcritical and supercritical flow.
[(CO1)(Analyze/IOCQ)]
3 + 6 + 3 = 12

7. (a) Examine the effect of discharge on specific energy curve. [(CO4)(Analyze/IOCQ)]
(b) Define Buckingham's Π Theorem. List the repeating variables used in Buckingham's Π Theorem. [(CO5)(Remember/LOCQ)]
(c) Estimate the no. of Π terms for F=ø (D.V, ω, μ, P). Also find out Π_1 and Π_2 terms.
[(CO5)(Evaluate/LOCQ)]
3 + (3 + 3) + 3 = 12

Group – E

8. (a) What are the different types of turbines? [(CO6)(Remember/LOCQ)]
(b) With the help of a neat sketch of pelton wheel turbine, examine various components of Pelton wheel turbine and list their functions. [(CO6)(Analyze/IOCQ)]
6 + 6 = 12

9. A Pelton Wheel is working under a gross head of 400 m. The water is supplied through the penstock of diameter 1 m and length 4 km from reservoir to Pelton Wheel. The coefficient of friction for the penstock is 0.008. The jet of water of diameter 150 mm strikes the buckets of the wheel and gets deflected through an angle of 165^0. The relative velocity of water at the outlet is reduced by 15 % due to friction between inside surface of the bucket and water. If the velocity of buckets is 0.45 times the jet velocity at inlet and mechanical efficiency as 85%.

Determine:
(i) Power given to the runner
(ii) Shaft Power
(iii) Hydraulic and Overall efficiency. [(CO6)(Create/HOCQ)] **12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	33.33	12.51	54.16

Course Outcome (CO):

After going through this course, the students will be able to:
CIVL2113.1: Understand basic fluid properties (density, viscosity, bulk modulus), flow forces (pressure, shear stress, surface tension) and flow regimes (laminar/turbulent, compressible/ incompressible, steady/unsteady).
CIVL2113.2: Use and know limitations of steady and unsteady Bernoulli equation along and normal to a streamline.
CIVL2113.3: Explain the conservation of mass and momentum through differential analysis in simple geometries.
CIVL2113.4: Study scope, importance, characteristics and various types of flows in an open channel.
CIVL2113.5: Understand the techniques of dimensional analysis, similitude and modeling and introduce the important non-dimensional groups in fluid mechanics.
CIVL2113.6: Know the concepts to internal and external flows and introduce the boundary layer concept, lift and drag, flow separation, and drag reduction fundamentals.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.