(vi) The velocity field given by:
$\vec{V} = 5x^3\hat{\imath} + 15x^2y\hat{\jmath} + t\hat{k}$ represents:-
(a) incompressible flow (b) compressible flow
(c) rotational flow (d) ideal flow.

(vii) If there are n physical quantities and m fundamental dimensions in a particular process, the number of non dimensional parameter is
(a) m+n (b) n-m (c) mxn (d) m/n.

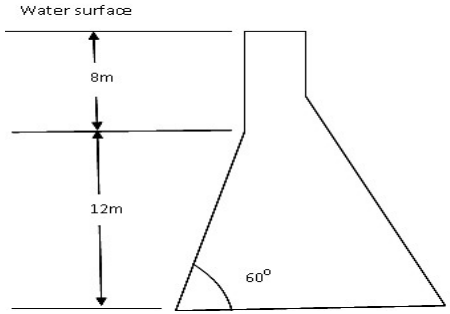
(viii) To ensure that water doesn't rise more than 100 cm above the crest for a discharge of 5.0 cumecs, the length of weir will be:
(a) 2.48 m (b) 2.49 m (c) 2.5 m (d) 2.51 m.

(ix) An error of 0.5% in measurement of head in a V-notch causes an error of:
(a) 1% in discharge (b) 1.5% in discharge
(c) 1.25% in discharge (d) 0.5% in discharge.

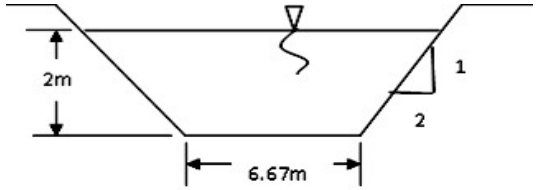
(x) The maximum discharge over a broad-crested weir occurs when:
(a) h = (3/4)H (b) h = (2/5)H
(c) h = (2/3)H (d) h = (1/3)H.

Group – B

2. (a) Determine the magnitude and direction of the resultant water pressure per meter length of the dam and its line of action.



(b) Compute the hydraulic radius, hydraulic depth and section factor of the trapezoidal channel as shown in Fig. Assume the depth of flow as 2m.



8 + 4 = 12

(b) The depth of the flow of water at a certain section of a rectangular channel 3 m wide is 0.25 m. The discharge through the channel is 1.8 cumecs. Determine whether a hydraulic jump will occur and if so find the height and loss of energy.

4 + 8 = 12

7. (a) What do you mean by similitude and what are the different types of similarities that must exist between a model and a prototype?

(b) The efficiency η of a fan depends on density ρ, dynamic viscosity μ of the fluid, angular velocity ω, diameter D of the rotor and the discharge Q. Express η in terms of dimensionless parameters.

2 + 10 = 12

Group – E

8. (a) Explain "*priming of a pump*" and why is it necessary?
Why are centrifugal pumps used sometimes in series and sometimes in parallel? Draw the following characteristic curves for a centrifugal pump: Head, power and efficiency *vs* discharge at constant speed.

(b) Calculate the vane angle at inlet of a centrifugal pump impeller having 300 mm diameter at inlet and 600 mm diameter at outlet. The impeller vanes are set back at an angle of 40^0 to the outer rim and the entry of the pump is radial. The pump runs at 900 r.p.m. and the velocity of flow through the impeller is constant at 2.5 m/s. Calculate the work done by the wheel per kg mass of water and the velocity and direction of water at outlet.

(c) Discuss the working principle of a centrifugal pump.

(2 + 4) + 4 + 2 = 12

9. (a) (i) Write a note on performance curves of turbine.
(ii) Draw a neat sketch to illustrate various parts of Pelton wheel turbine and explain the working principle of Pelton wheel turbine.

(b) A Francis turbine with overall efficiency of 76% and hydraulic efficiency of 80% is required to produce 150 kW. It is working under a head of 8m. The peripheral velocity is: $0.25\sqrt{2gH}$ and the radial velocity of flow at the inlet is: $0.95\sqrt{2gH}$. The wheel runs at 150 r.p.m. Assuming radial discharge, determine:-
(i) Flow velocity at outlet.
(ii) The wheel angle at inlet
(iii) Diameter and width of the wheel at inlet.

(3 + 3) + 6 = 12

FLUID MECHANICS
(CIVL 2204)

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) The resultant hydrostatic force acts through a point known as
(a) centre of gravity (b) centre of buoyancy
(c) centre of pressure (d) centre of force.

(ii) The condition of stable equilibrium for a floating body is
(a) the metacentre M coincides with the centre of gravity G
(b) the metacentre M is below the centre of gravity G
(c) the metacentre M is above the centre of gravity G
(d) the centre of buoyancy B is above the centre of gravity G.

(iii) Cavitation will take place if the pressure of the flowing fluid at any point is
(a) More than the vapour pressure of the fluid
(b) Equal to the vapour pressure of the fluid
(c) less than the vapour pressure of the fluid
(d) not related to the vapour pressure of the fluid.

(iv) If the Froude number in open channel flow is less than 1.0, the flow is called
(a) Critical flow (b) subcritical flow
(c) Supercritical flow (d) streamline flow.

(v) Specific energy of a flowing fluid per unit weight of an open channel is equal to
(a) $\left[\frac{p}{w}+\frac{v^2}{2g}\right]$ (b) $\left[\frac{p}{w}+h\right]$
(c) $\left[h+\frac{v^2}{2g}\right]$ (d) $\left[\frac{p}{w}+\frac{v^2}{2g}+h\right]$
Where, p = pressure, w = unit weight, v = velocity of flow, h = head of the water

3. A trapezoidal channel has side slope 1 in 1. It is required to discharge 15 m^3/s of water with a bed gradient 1 in 1000. If unlined the value of Chezy's C is 44. If lined with concrete its value is 60. The cost per m^3 of excavation is three times the cost of lining. The channel is to be most efficient one. Find whether the lined channel or the unlined channel will be cheaper. What will be the dimension of that most economic channel?

12

Group – C

4. (a) A rectangular weir channel 1.3 m wide has a rectangular weir at the end. If the length of the weir is 1.1 m and it's sill is 0.3 m wide from the bottom. The measured head over the crest is 0.3 m. Take C_d = 0.65 and α = 1.20. Find the discharge for the following cases:-
(i) Neglecting velocity approach and end contractions.
(ii) Consider velocity approach but neglect the end contractions.
(iii) Consider both velocity approach and end contractions.

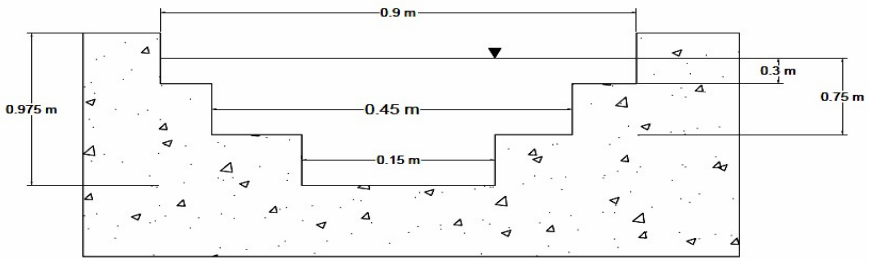
(b) A broad crested weir of length 40m, has 400 mm height of water above it's crest. Find the maximum discharge. Take C_d = 0.6. Neglect velocity of approach.
If the velocity of approach is to be taken into consideration, find the maximum discharge when the channel has a cross-sectional area of 40 m^2 on the upstream side.

(c) The following observations were made during the measurements on a rectangular model weir 0.5 metres long.

Head (mm)	80	100	150	200	250	300
Discharge (l/sec)	20.7	28.9	53.2	81.9	114.4	150.4

If the discharge equation be given as $Q = KH^n$, determine K and n. Find also the value of C_d for the weir (Use linear graph wherever necessary).

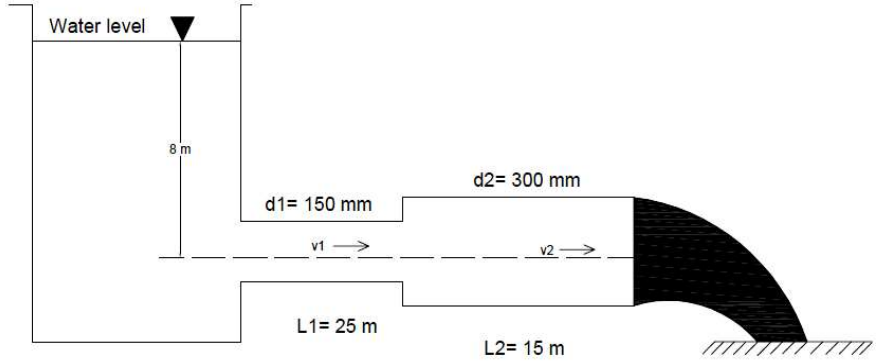
(d) A stepped rectangular notch is as shown below. Find the discharge through the notch if $C_d = 0.64$.



5 + 2 + 2 + 3 = 12

5. (a) Derive the expression for Darcy Weisbach equation in pipe flow. Also draw the necessary diagram required for proper illustration.

(b) A horizontal pipeline 40 m long is connected to a water tank at one end and it discharges freely into the atmosphere at the other end. For the first 25 m of it's length from the tank, the pipe is 150 mm diameter and it's diameter suddenly enlarged to 300 mm. The height of water level in the tank is 8 m above the centre of the pipe. Consider all losses of head, which occur. Determine the rate of flow (f = 0.01 for both). The diagram of the setup is given below.



(c) The friction factor for turbulent flow through rough pipes can be determined by Karman-Prandtl equation:-

$$\frac{1}{\sqrt{4f}} = 2log\frac{Ro}{k} + 1.74$$

where f = friction factor, Ro = pipe radius, k = average roughness.
Two reservoirs with a surface level difference of 20 metres are to be connected by a 1 metre diameter pipe 6 km long. What will be the discharge when a cast iron pipe of roughness k = 0.3 mm is used? What will be the percentage increase in the discharge if the cast iron pipe is replaced by a steel pipe of roughness k = 0.1 mm?
Neglect all the local losses.

5 + 3 + 4 = 12

Group – D

6. (a) Define specific energy curve along with its diagram. Derive expression for critical depth of flow.