

**Module 1 and 2**

1. Write the differences between pipe flow and Open channel Flow?
2. What do you understand by (a) steady and unsteady flow; (b) uniform and non-uniform flow in the case of channels.
3. List and explain the types of flows in Open Channel?
4. Classify the following open – channel flow situations:
  - a) Flow from a sluice gate
  - b) Flow in a main irrigation canal
  - c) A river during flood
  - d) Breaking of a dam
  - e) Flow over a spillway
  - f) Sudden opening of a sluice gate
  - g) Spreading of irrigation water on field
  - h) Flow in sewer.
5. Explain and draw typical patterns of velocity distribution in various channel sections.
6. What is Chezy's formula? How it is derived? Show that Chezy's coefficient  $C = \frac{R^{1/2}}{n}$ , where R is hydraulic radius and n is Manning's roughness coefficient.
7. Explain the significance of channels of most efficient section.
8. Show that for a trapezoidal channel of given area of flow, the condition of maximum flow requires that hydraulic mean depth is equal to one half the depth of flow.
9. State the conditions under which the rectangular section of an open channel will be most economical. Derive these conditions.
10. Show that the discharge formula for a trapezoidal channel, having Manning's coefficient  $n = 0.0126$  and carrying a maximum flow is given by

$$Q = 100 y^{8/3} \left( \sqrt{1 + Z^2} - \frac{Z}{2} \right) S_0^{1/2}$$

11. An open channel is V- shaped, each side being inclined at  $45^\circ$  to the vertical. If it carries a discharge of  $0.04 \text{ m}^3/\text{s}$ , when the depth of flow at the centre is  $225 \text{ mm}$ , calculate the slope of the channel assuming that Chezy's  $C = 50$ .
12. Determine the most efficient section of a trapezoidal channel with side slopes 1V:2H, carrying a discharge of  $11.25 \text{ m}^3/\text{s}$  with a velocity of  $0.75 \text{ m/s}$ . What should be the bed slope of the channel? Take Manning's  $n = 0.025$ .
13. A trapezoidal channel of side slope 2:1 has bottom width of  $2 \text{ m}$  and depth of flow is  $1 \text{ m}$ ,  $S_0$  is  $1 \text{ in } 625$ , and manning's  $n = 0.013$ . Find boundary shear, flow rate and value of friction factor.
14. The width of horizontal rectangular channel is reduced from  $3.5 \text{ m}$  to  $2.5 \text{ m}$  and floor is raised by  $0.25 \text{ m}$  in elevation at a given section. At the upstream section, the depth of flow is  $2.0 \text{ m}$  and kinetic energy correction factor ' $\alpha$ ' is  $1.15$ . If the drop in water surface elevation at the contraction is  $0.20 \text{ m}$ , by neglecting energy loss calculate the discharge in  $\text{m}^3/\text{sec}$ ? [' $\alpha$ ' at the contracted section may be assumed to be unity].
15. The width of horizontal rectangular channel is reduced from  $3.5 \text{ m}$  to  $2.5 \text{ m}$  and floor is raised by  $0.25 \text{ m}$  in elevation at a given section. At the upstream section, the depth of flow is  $2.0 \text{ m}$  and kinetic energy correction factor ' $\alpha$ ' is  $1.15$ . If the drop in water surface

- elevation at the contraction is 0.20 m, calculate the discharge in  $\text{m}^3/\text{sec}$  if the energy loss is one -tenth of the upstream velocity head? [ $\alpha$  at the contracted section may be assumed to be unity].
16. Define specific energy and explain in detail with neat sketch of specific energy curve?
  17. A 2.5 m wide rectangular channel has a specific energy of 1.50 m when carrying a discharge of  $6.48 \text{ m}^3/\text{s}$ . Calculate the alternate depths and corresponding Froude numbers.
  18. Calculate the critical depth and the corresponding specific energy for a discharge of  $5.0 \text{ m}^3/\text{s}$  in the following channels:
    - a) Rectangular channel,  $B=2.0 \text{ m}$
    - b) Triangular channel,  $m = 0.5$
    - c) Trapezoidal channel,  $B = 2.0 \text{ m}$ ,  $m = 1.5$
    - d) Circular channel,  $D = 2.0 \text{ m}$
  19. Calculate bottom width of a channel required to carry a discharge of  $15.0 \text{ m}^3/\text{s}$  as a critical flow at a depth of 1.2 m, if the channel section is (a) rectangular, and (b) trapezoidal with side slope 1.5 horizontal: 1 vertical.
  20. A rectangular channel has a width of 2.0 m and carries a discharge of  $4.80 \text{ m}^3/\text{s}$  with a depth of 1.6 m. At a certain section a small, smooth hump with a flat top and of height 0.10 m is proposed to be built. Calculate the likely change in the water surface. Neglect energy loss.
  21. A 2.5 m wide rectangular channel carries  $6.0 \text{ m}^3/\text{s}$  of flow at a depth of 0.50 m. Calculate the minimum height of streamlined, flat-topped hump required to be placed at a section to cause critical flow over the hump. The energy loss over the hump. The energy loss over the hump can be taken as 10% of the upstream velocity head.
  22. A rectangular channel is 3.5 m wide and conveys a discharge of  $15.0 \text{ m}^3/\text{s}$  at depth of 2.0 m. It is proposed to reduce the width of the channel at a hydraulic structure. Assuming the transition to be horizontal and the flow to be frictionless determine the water surface elevations upstream and downstream of the constriction when the constriction width is (a) 2.50 m, and (b) 2.20 m.
  23. A trapezoidal channel is 10.0 m wide and has side slope of 1.5 horizontal: 1 vertical. The bed slope is 0.0003. The channel is lined with smooth concrete of  $n = 0.012$ . Compute the mean velocity and discharge for depth of flow of 3.0 m.
  24. In the channel of example 23, find the bottom slope necessary to carry only  $50 \text{ m}^3/\text{s}$  of the discharge at a depth of 3.0 m.
  25. A concrete-lined trapezoidal channel ( $n=0.015$ ) is to have a side slope of 1.0 horizontal: 1 vertical. The bottom slope is to be 0.0004. Find the bottom width of the channel necessary to carry  $100 \text{ m}^3/\text{s}$  of discharge at a normal depth of 2.50 m.

### Module 3

1. Define gradually varied flow (GVF). What are the few typical examples of GVF? Explain the two basic assumptions in the analysis of GVF?
2. Derive differential equation of GVF in different forms?
3. Classify the different GVF profiles with neat sketches and explain in detail?
4. A rectangular channel with bottom width of 4.0 m and a bottom slope of 0.0008 has a discharge of  $1.50 \text{ m}^3/\text{s}$ . In a gradually varied flow in this channel, the depth at a certain location is found to be 0.30 m. Assuming  $n = 0.016$ , Determine the type of GVF profile.
5. A rectangular channel of 4.0 m width has a Manning's coefficient of 0.025. For a discharge of  $6.0 \text{ m}^3/\text{s}$  in this channel, identify the possible GVF profiles produced in the following grades. a)  $S_{01} = 0.0004$  to  $S_{02} = 0.015$ ; b)  $S_{01} = 0.005$  to  $S_{02} = 0.0004$

**Note:** Refer Appendix 3A; Table 3A-1, Values of  $\Phi$  for different trapezoidal channels from page no 154-156 of textbook titled "Flow in Open Channels" by K Subramanya.

6. In a rectangular channel, two reaches M and N are in series, with reach M being upstream of reach N. These channel reaches have the following characteristics:

Reach	Width (m)	Discharge (m <sup>3</sup> /s)	Slope	n
M	5.0	15.0	0.0004	0.025
N	4.0	15.0	0.0003	0.015

Sketch the resulting GVF Profile due to the change in the channel characteristics as above.

7. Using basic differential equation of GVF, show that  $dy/dx$  is positive for  $S_1$ ,  $M_3$ , and  $S_3$  profiles.
8. In a very long, wide rectangular channel the discharge intensity is 3.0 m<sup>3</sup>/s/metre width. The bed slope of the channel is 0.004 and Manning's  $n = 0.015$ . At a certain section in this channel, the depth of flow is observed to be 0.90 m. What type of GVF profile occurs in the neighborhood of this section?
9. A long and wide rectangular channel ( $n = 0.016$ ) has a discharge intensity of 4.0 m<sup>3</sup>/s per meter width. If the bed slope of the channel is 0.02 and a 1.5 m high weir ( $C_d = 0.7$ ) is built on the downstream end of the channel.
10. Sketch the GVF profiles produced on the upstream and downstream of a sluice gate introduced in a, a) Steep slope, b) Mild slope, c) Horizontal bed channel.
11. Explain the concept of Hydraulic Jump with neat sketch of it?
12. Derive the general momentum equation for the hydraulic jump with neat sketch?
13. Derive an equation for sequent depth ratio and energy loss for hydraulic jump in horizontal rectangular channel?
14. Classify the different hydraulic jumps based on Froude's number and explain in detail with neat sketches?
15. In a hydraulic jump occurring in a rectangular channel of 3.0 m width, the discharge is 7.8 m<sup>3</sup>/s and the depth before the jump is 0.28 m. Estimate (i) Sequent depth, and (ii) the energy loss in the jump.
16. A rectangular channel carrying a supercritical stream is to be provided with a hydraulic jump type of energy dissipater. It is desired to have an energy loss of 5.0 m in the hydraulic jump when the inlet Froude number is 8.5. What are the sequent depths of this jump?
17. A hydraulic jump takes place in a horizontal rectangular channel with sequent depths of 0.25 m and 1.50 m at the beginning and end of the jump respectively. Estimate the (i) Discharge per unit width of the channel and (ii) Energy loss.
18. A hydraulic jump occurs in a horizontal rectangular channel at an initial Froude number of 10.00. What percentage of initial energy is lost in this jump?
19. A hydraulic jump occurs in a horizontal rectangular channel with sequent depths of 0.70 m and 4.2 m. Calculate the rate of flow per unit width, energy loss and initial Froude number.
20. A hydraulic jump in a rectangular channel has the Froude number at the beginning of the jump  $F_1 = 5$ . Find the Froude number  $F_2$  at the end of the jump.
21. Derive an expression of force exerted by jet striking a stationary flat plate,  
 a) When plate makes a 90° angle with jet?  
 b) When plate makes an angle other than 90° angle with jet?
22. Derive an expression of force exerted by jet striking a curved plate?
23. Derive an expression of force exerted by jet striking a moving plate?  
 a) Plate may be flat.  
 b) Plate may be curved.
24. Derive an expression of force exerted by jet striking a series of flat or curved plates?
25. A rectangular plate 1 m x 1 m x 5 mm size is suspended vertically by a hinge on its top edge. Specific gravity of plate material is 7.66. A horizontal jet of water 40 mm diameter strikes the plate 100 mm below the c. g. of the plate. Find the velocity of the jet if the plate is deflected through 30°.

26. A jet of water having a velocity of 19 m/s and diameter of 15 cm strikes a curved blade. The inlet and outlet angles of the blade are  $0^\circ$ , and  $45^\circ$  respectively. When the blade is stationary find the resultant force and find change in force when blade moves at 6 m/s in direction of jet.
27. A jet of water, 40 mm diameter, strikes a hinged vertical plate of 800 N weight, normally at its centre at 15 m/s. Find i) angle of deflection; ii) force F that must be applied at lower edge to keep the plate vertical.
28. A jet of water having velocity of 40 m/s strikes series of curved vanes moving at 12 m/s. If angle of jet at inlet  $\alpha = 20^\circ$ ,  $V_{r1} = V_{r2}$  and velocity of outlet is normal to the wheel, find vane angles at inlet and outlet, and efficiency.
29. A 15 cm diameter jet of water strikes a flat plate at an angle of  $30^\circ$  to the normal. If jet velocity is 16 m/s, find the force exerted on the plate?
30. A 20 cm diameter jet of water strikes a flat plate normally. The plate is moving with a velocity of 3 m/s in direction of jet. Calculate absolute velocity of jet if the force exerted on the plate is 3370 N?

#### Module 4

1. Draw neat sketch of Hydroelectric power plant and explain its working?
2. Classify the turbines and explain them in detail?
3. Draw neat sketch of Pelton wheel and explain its working?
4. Draw neat sketch of Francis turbine and explain its working?
5. Define draft tube and sketch different types of draft tubes?
6. Draw neat sketch of Kaplan turbine and explain its working?
7. Define surge tank? Why it is provided and sketch different types of surge tanks?
8. Explain the concept of Cavitation and define Thomas Cavitation number?
9. Explain the following terms:
  - a) Unit speed
  - b) Unit discharge
  - c) Unit Power of hydraulic turbine. Derive expressions for each of them?
10. Explain the following terms:
  - a) Specific speed
  - b) Unit speed
  - c) Unit Power as applied to hydraulic turbines. Derive expressions to indicate their values?

#### Module 5

1. Write short note on centrifugal pumps?
2. What are the advantages of centrifugal pumps over reciprocating pump?
3. What are the components of centrifugal pumps and explain them in detail with neat sketch?
4. Explain the working of centrifugal pump?
5. What are the types of centrifugal pumps based on type of casing provided?
6. Explain the troubles commonly experienced during the operation of centrifugal pumps and the remedial measures to be taken for the same?
7. Write short note on Reciprocating pumps?
8. What are the components of reciprocating pumps and explain them in detail with neat sketch?
9. What are the types of reciprocating pumps and explain in detail with sketch?
10. If a centrifugal pump does not deliver any water when started, what may be the probable causes and how can they be remedied?
11. Define static and manometric head of a centrifugal pump. State the different types of head losses which may occur in a pump installation.
12. What are the different efficiencies of a centrifugal pump?

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