Open Channel Flow

Q.1 For a wide rectangular channel using Manning's formula, the differential equation of gradually varied flow (with the usual notations) is given by

(a) $\frac{dy}{dx} = S_0 \frac{\left[1-\left(\frac{y_c}{y}\right)^{10/3}\right]}{\left[1-\left(\frac{y_0}{y}\right)^3\right]}$

(b) $\frac{dy}{dx} = S_0 \frac{\left[1-\left(\frac{y_0}{y}\right)^{10/3}\right]}{\left[1-\left(\frac{y_c}{y}\right)^3\right]}$

(c) $\frac{dy}{dx} = S_0 \frac{\left[1-\left(\frac{y_0}{y}\right)^3\right]}{\left[1-\left(\frac{y_c}{y}\right)^3\right]}$

(d) $\frac{dy}{dx} = S_0 \frac{\left[1-\left(\frac{y_c}{y}\right)^3\right]}{\left[1-\left(\frac{y_0}{y}\right)^3\right]}$

Q.2 Water surface profiles that are asymptotic at one end and terminated at the other end would include

(a) H_2 and S_2 (b) H_3 and S_2

(c) M_2 and H_2 (d) M_2 and H_3

Q.3 A hydraulic jump is always needed in case of

(a) an A_2 profile followed by an A_3 profile

(b) an A_3 profile followed by an A_2 profile

(c) an H_2 profile followed by an M_2 profile

(d) an M_1 profile followed by an M_3 profile

Q.4 Consider the following statements in regard to the critical flow:

1. Specific energy is maximum for a given discharge.
2. Specific force is maximum for a given discharge
3. Discharge is maximum for a given specific force.
4. Discharge is maximum for a given specific energy.

Which of these statements are correct?

(a) 1, 2, 3 and 4 (b) 1 and 2

(c) 2 and 3 (d) 3 and 4

Q.5 If F_1 and F_2 are the Froude numbers of flow before and after the hydraulic jump occurring in a rectangular channel, then

(a) $F_2^2 = \frac{F_1^2}{\left(-1+\sqrt{1+8F_1^2}\right)^3}$

(b) $F_2^2 = \frac{8F_1^2}{\left(-1+\sqrt{1+8F_1^2}\right)^3}$

(c) $F_2^2 = \frac{F_1^2}{\left(-0.5+\sqrt{1+8F_1^2}\right)^3}$

(d) $F_2^2 = \frac{8F_1^2}{\left(-0.5+\sqrt{1+8F_1^2}\right)^3}$

Q.6 Match the following [Column-A (Froude Number) with Column-B (Type of hydraulic jump)]

Column-A	Column-B
A. 1.6	1. Strong jump
B. 2.0	2. Undullar jump
C. 5.0	3. Weak jump
D. 10.0	4. Steady jump

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	2	4	3	1
(c)	1	3	4	2
(d)	2	3	4	1

Q.7 A hydraulically efficient trapezoidal section of open channel flow carries water at the optimal depth of 0.6 m. Chezy coefficient is 75 and bed slope is 1 in 250. What is the discharge through the channel?

(a) 1.44 m^3/s (b) 1.62 m^3/s
(c) 1.92 m^3/s (d) 2.24 m^3/s

Q.8 Flow depths across a sluice gate are 2.0 m and 0.5 m. What is the discharge (per metre width)?

(a) 1.0 m^2/s (b) 1.4 m^2/s
(c) 2.0 m^2/s (d) 2.8 m^2/s

Q.9 Match List-I (Flow section type) with List-II (Critical discharge is proportional to) where y is the depth of flow and select the correct answer using the codes given below the lists:

List-I	List-II
A. Shallow parabolic	1. $y(z^{1/2})$
B. Triangular	2. $y^{3/2}$
C. Rectangular	3. $y^{5/2}$
D. Trapezoidal	4. y^2

Codes:

	A	B	C	D
(a)	2	3	4	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	4	3	2	1

Q.10 A hydraulic jump occurs at the top of a spillway. The depth before jump is 0.2 m. The sequent depth is 3.2 m. What is the energy dissipated in *m* (approximate)?

(a) 27 (b) 10.5
(c) 15 (d) 42

Q.11 Most efficient channel section is

(a) half hexagon in the form of trapezoid
(b) triangular
(c) rectangular
(d) semicircular

Q.12 A rectangular channel is 5 m wide and 3 m deep. Water is flowing in the channel for a depth of 2.5 m. The hydraulic radius is

(a) 0.50 (b) 1.25
(c) 2.00 (d) None of these

Q.13 Which one of the following is the correct representation of the sequence of surface profiles if the channel slope changes from mild to steep

(a) M_1, S_1 (b) M_3, S_2
(c) M_2, S_2 (d) M_2, S_3

Q.14 The Chezy's constant C in the Chezy's equation for mean velocity in open channels is

(a) is a dimensionless constant
(b) has a constant value for different types of channels
(c) has dimension $L^{1/2}T^{-1}$
(d) does not depend on the quality of channel surface

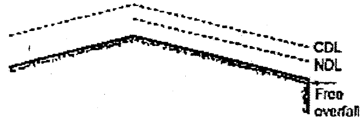
Q.15 The conveyance *K* of a channel is a measure of its carrying capacity. In terms of *K*, the discharge *Q* is given by

(a) $KC\sqrt{S_0}$ (b) $K\sqrt{S_0}$
(c) $KAS_0^{1/3}$ (d) $K\sqrt{RS_0}$

Q.16 The flow characteristic before and after a hydraulic jump are such that:

(a) specific forces are equal but specific energies are unequal
(b) specific forces are unequal but specific energies are equal
(c) neither specific forces nor specific energies are equal
(d) specific forces as well as specific energies are equal

Q.17 The figure below shows a gradually varied flow situation in an open channel with a break in bed slope. Types of water surface profiles occurring from left to right are



(a) H_2, S_3 (b) H_2, S_2
(c) H_2, M_3 (d) H_3, M_2

Q.18 An open channel carries water with a velocity of 0.605 m/s. If the average bed shear stress is 1.0 N/m^2, then the Chezy's constant *C* is equal to

(a) 500 (b) 50
(c) 60 (d) 6.0

Q.19 In a subcritical flow, as the specific energy in a channel is decreased, the depth of flow

(a) also decrease (b) increases
(c) does not vary (d) None of these

Q.20 If the specific energy at the upstream section of a rectangular channel is 3 m and minimum specific energy is 2.5 m, the maximum height of jump without causing afflux will be

(a) 0.50 m (b) 1.20 m
(c) 2.50 m (d) 5.50 m

Q.21 The depth of flow for maximum velocity in a circular channel section with diameter equal to 1.5 m is

(a) 0.75 m (b) 1.065 m
(c) 1.215 m (d) 1.425 m

Q.22 The critical depth of flow in a most economical triangular channel section for a discharge of 1 m^3/sec is given by

(a) $\left(\frac{1}{9.8}\right)^{1/5}$ metre (b) $\left(\frac{1}{9.8}\right)^{1/3}$ metre
(c) $\left(\frac{1}{4.9}\right)^{1/5}$ metre (d) $\left(\frac{1}{4.9}\right)^{1/3}$ metre

Q.23 If the Froude number of flow in a rectangular channel at a depth of flow of y_0 is F_0, then y_c/y_0 is equal to?

(a) $F_0^{1/3}$ (b) $F_0^{2/3}$
(c) $F_0^{3/2}$ (d) $F_0^{-1/2}$

Q.24 If the alternate depths of flow in a rectangular horizontal channel are 0.5 m and 2.0 m respectively then the critical depth of flow will be

(a) $\left(\frac{5}{4}\right)^{1/3}$ (b) $\left(\frac{2}{3}\right)^{1/3}$
(c) $\left(\frac{1}{4}\right)^{1/3}$ (d) $\left(\frac{4}{5}\right)^{1/3}$

Q.25 Shallow waves in open channels propagate with velocity equal to

(a) $\sqrt{2gy}$ (b) $\sqrt{gy}$
(c) $\sqrt{gy+V}$ (d) $\sqrt{y}+\sqrt{\frac{E}{\rho}}$

Q.26 Match List-I (Surface profile) with List-II (Description of the profile) and select the correct answer using the codes given below the lists:

List-I	List-II
A. M_2	1. Convex upwards; asymptotic horizontal at d/s end; depth increasing with d/s
B. S_3	2. Convex downwards; upstream asymptotic to normal depth with depth decreasing in d/s direction
C. C_1	3. Depth increasing downstream and meeting at a angle to CDL; a curve with an inflection point
D. A_3	4. Convex upwards and depth increasing in flow direction; asymptotic to NDL at d/s end

Codes:

	A	B	C	D
(a)	2	4	1	3
(b)	2	1	4	3
(c)	3	4	1	2
(d)	3	1	4	2

Q.27 In a wide rectangular channel if the normal depth is increased by 20%, the percentage increase in the discharge will be

(a) 35% (b) 40%
(c) 33.3% (d) 66.7%

Q.28 Gradually varied flow in open channel is caused when

(a) there is an equilibrium between the forces causing the flow and those opposing it
(b) the pressure forces and the change in momentum are different from each other
(c) the force causing the flow is not equal to the resistance force
(d) the channel slope is equal to the normal slope

Q.29 A wide channel is 1 m deep and has a velocity of flow V is 2.13 m/s. If a disturbance is caused, an elementary wave can travel upstream with a velocity of

(a) 1.00 m/s (b) 2.13 m/s
(c) 3.13 m/s (d) 5.26 m/s

Q.30 The specific energy 'E' in a critical flow at depth y_c occurring in a triangular channel is given by

(a) $E = 1.25y_c$ (b) $E = 1.5y_c$
(c) $E = 1.75y_c$ (d) $E = 2y_c$

Q.31 Most economical section of a circular channel for maximum discharge should satisfy the condition

(a) depth of water = 0.95 diameter of circular section
(b) hydraulic mean depth = 0.286 diameter of circular section
(c) wetted perimeter = 2.6 diameters of circular section
(d) All of the above

Q.32 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I
A. Passage of tidal bore
B. Flow in a river emptying into a lake
C. Flow in a channel at a bend
D. Flow in a channel with a side weir

List-II
1. Rapidly varied flow
2. Uniform flow
3. Gradually varied flow
4. Rapidly varied unsteady flow
5. Spatially varied flow

Codes:

	A	B	C	D
(a)	4	3	1	2
(b)	3	4	1	5
(c)	4	3	1	5
(d)	4	2	3	5

Q.33 For the flow conditions in channels listed in List-I the corresponding discharges are given in List-II. Match List-I (Description and data) with List-II (Discharge in m^3/s) and select the correct answer using the codes given below the lists:

List-I
A. Rectangular channel, 1 m wide, with specific energy at critical depth = 1.0 m
B. Triangular channel of side slope 1 horizontal: 1 vertical, with specific energy at critical depth = 1.0 m
C. Rectangular channel, 1 m wide, with critical depth = 1.0 m
D. Triangular channel having 90° vertex angle and critical depth = 1.0 m

List-II
1. 1.27
2. 1.71
3. 2.21
4. 3.13

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	2	1	4	3
(c)	2	1	3	4
(d)	1	2	4	3

Q.34 Match List-I (Channel surface characteristics) with List-II (Range of Manning's n) and select the correct answer using the codes given below the lists:

List-I
A. Concrete channel trowel finish
B. Earth channel straight, uniform, clear, recently finished
C. Earth channel with dense weeds as high as flow depth
D. Mountainous stream-clear loose cobbles, variable section

List-II
1. 0.016-0.020
2. 0.011-0.015
3. 0.03-0.04
4. 0.04-0.05
5. 0.100-0.125

Codes:

	A	B	C	D
(a)	1	4	3	5
(b)	2	4	5	5
(c)	2	1	5	3
(d)	2	1	3	4

Q.35 Following two lists contain information relating to the areas of most efficient channel section of different shapes in terms of depth of flow y_{cm}. Match List-I (Channel shape) with List-II (Area of most efficient channel section) and select the correct answer using the codes given below the lists:

List-I
A. Rectangular
B. Trapezoidal
C. Triangle

List-II
1. $1\sqrt{3}y^2_{cm}$
2. $\sqrt{3}y^2_{cm}$
3. y^2_{cm}
4. $2y^2_{cm}$

Codes:

	A	B	C
(a)	2	4	3
(b)	4	3	2
(c)	4	2	3
(d)	1	2	3

Q.36 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I
A. dy/dx is positive and $y > y_n > y_c$
B. dy/dx is negative and $y_n > y > y_c$
C. dy/dx is negative and $y_c > y > y_n$
D. dy/dx is positive and $y_c > y_n > y$

List-II
1. S_1
2. S_2
3. M_1
4. M_2

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	4	3	2	1
(c)	3	4	1	2
(d)	1	3	4	2

Q.37 A 2.0 m wide rectangular channel flowing at its normal depth of 1.2 m carries a discharge of 6.0 m^3/s. If at a section, the depth of flow is y, then match List-I (Value of y) with List-II (Type of water surface profile) and select the correct answer using the codes given below the lists:

List-I	List-II
A. 0.63 m	1. M_1
B. 0.90 m	2. M_2
C. 1.10 m	3. M_3
D. 1.42 m	4. S_2
	5. S_3

Codes:

	A	B	C	D
(a)	5	3	2	1
(b)	5	4	2	1
(c)	3	2	2	4
(d)	3	3	2	1

Q.38 Match List-I with List-II pertaining to the following statement :

In a channel conveying a discharge Q, at section 1, the flow depth is y_1, specific energy is E_1 and specific force is P_1. In this channel

List-I
A. Depth y_2 at which the specific energy is E_1 is called
B. Depth y_3 at which the specific force is minimum is
C. Depth y_4 at which the specific energy is minimum is
D. Depth y_5 at which the discharge Q moves with water surface parallel to the bed is
E. Depth y_6 at the edge of a free fall is

List-II
1. Brink depth
2. Alternate depth
3. Normal depth
4. Critical depth
5. Conjugate depth

Codes:

	A	B	C	D	E
(a)	3	1	5	2	4
(b)	5	2	4	3	1
(c)	1	5	4	3	2
(d)	2	5	4	3	1

Q.39 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I
A. Positive surge travelling upstream
B. Positive surge travelling downstream
C. Negative surge travelling upstream
D. Negative surge travelling downstream

List-II
1. Occurs on upstream of gate that is partly closed suddenly
2. Occurs on downstream of gate that is partly closed suddenly
3. Occurs on upstream of gate that is opened suddenly
4. Occurs on downstream of gate that is opened suddenly

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	1	2	3	4
(c)	3	4	1	2
(d)	3	4	2	1

Q.40 Assertion (A) : Any discharge will flow as critical flow in a wide rectangular channel whose bed slope is 1 in C^2/g.
Reason (R) : The critical depth of flow through a wide rectangular channel is $(q^2/g)^{1/3}$.
(a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

Q.41 Consider the following statements:
1. Specific energy increases with the increase in depth of flow.
2. For prismatic channel, the section factor is a function of the depth of flow.
3. For critical state of flow through a channel, Froude's number should be less than one

Which of these statements is/are correct?
(a) Both 1 and 3 (b) Only 3
(c) Both 1 and 2 (d) 1, 2 and 3

Q.42 Supercritical flow can occur in
1. steep slope profile S_2
2. mild slope profile M_3
3. critical slope profile C_3
4. adverse slope profile A_2

Which of these statements are correct?
(a) 1, 2 and 4 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 1, 2, 3 and 4

Q.43 Subcritical flow can occur in
1. horizontal slope profile H_2
2. steep slope profile S_3
3. mild slope profile M_1
4. critical slope profile C_3

Which of these statements is/are correct?
(a) Only 1 (b) Both 3 and 4
(c) Both 1 and 3 (d) Both 2 and 3

Q.44 The given table shows the specific energy of flow *(E)* at various stages of flow, *(d)* (both *E* and d are in meters):

d	0.6	0.7	0.74	0.8	1.0
E	1.17	1.14	1.11	1.12	1.2

The unit discharge in this case can be infered as nearly
(a) 1.25 m²/s (b) 1.62 m²/s
(c) 2.0 m²/s (d) 2.08 m²/s

Q.45 Before passage of a surge, the depth and velocity of flow at a section are 1.8 m and 3.72 m/s and after passage, they are 0.6 m and 7.55 m/s respectively. The speed of the surge is
(a) +1.8 m/s (b) –2.7 m/s
(c) +3.6 m/s (d) –4.5 m/s

Q.46 Which of the following statements are correct?
1. In rigid boundary channels, the shape and roughness factor is not a function of flow parameter.
2. In rigid boundary channels only depth of flow may vary with space and time depending on the nature of flow.
3. The degree of freedom for rigid and mobile boundary channels are 1 and 4 respectively.

(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) All of these

Q.47 Which of the following type of GVF (Gradually Varied Flow) profiles do not exist?
(a) C_2, H_1, A_2 (b) C_2, H_2, A_1
(c) C_1, H_1, A_2 (d) C_1, H_1, A_1

Q.48 Consider the following statements regarding specific energy of flow in an open channel.
1. There is only one specific energy curve for a given channel.
2. Alternate depths are the depths of flow at which the specific energy is same.
3. Critical flow occurs when specific energy is the minimum.

Which of these statements are correct?
(a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

Q.49 An irrigation canal has a steady discharge *Q* at a section where a cross regulator (gate) is provided for control purposes. If the gate of the regulator, which is normally closed is suddenly lifted up to a half-open position, then a rapidly varied unsteady flow results, both upstream and downstream of the gate. In such a case, it would take the form of a
(a) +ve surge moving upstream and a –ve surge moving downstream
(b) +ve surge moving downstream and a –ve surge moving upstream
(c) +ve surge moving upstream and a +ve surge moving downstream
(d) –ve surge moving upstream and a –ve surge moving downstream

Q.50 Consider the following statements:
A hydraulic jump occurs in an open channel
1. when the Froude number is equal to or less than one.
2. at the toe of a spillway.
3. downstream of a sluice gate in a canal.
4. when the bed slope suddenly changes.

Which of these are correct?
(a) 1, 2, 3 and 4 (b) 1, 2 and 3
(c) 2, 3 and 4 (d) 1 and 4

Q.51 The velocity distribution in a rectangular channel is approximated as $v = 3.0\sqrt{y}$. The width of channel is *B* and depth of flow y_0. The kinetic energy correction factor is
(a) 1.15 (b) 1.25
(c) 1.35 (d) 1.45

Q.52 A circular culvert having diameter 1.0 m is flowing half full and the flow is in critical state. The flow in the culvert barrel is
(a) 0.672 m³/s (b) 0.517 m³/s
(c) 0.771 m³/s (d) 0.823 m³/s

Q.53 A wide rectangular channel has a longitudinal slope of 0.0004 and its manning's roughness has been assessed as 0.02. The normal depth of this channel when it conveys a discharge intensity of 1.30 m³ per sec per metre is
(a) 0.87 m (b) 2.13 m
(c) 1.17 m (d) 1.97 m

Q.54 A triangular channel carries a discharge of 3.0 m³/sec. It has a vertex angle of 120°. The critical depth for this discharge is
(a) 0.821 m (b) 0.906 m
(c) 0.641 m (d) 0.986 m

Comprehension:
A hydraulic jump is formed in a 5 m wide outlet at short distance downstream of the control gate. If the flow depth just downstream of the gate is 2 m and outlet discharge is 150 m³/s.

Q.55 The flow depth downstream of the jump is
(a) 11.47 m (b) 8.47 m
(c) 11.63 m (d) 8.63 m

Q.56 The thrust on the gate is
(a) 2434.5 kN (b) 1464.25 kN
(c) 2812.65 kN (d) 2121.60 kN

Q.57 The velocity distribution in a channel section may be approximated by the equation, $V = V_0(y/y_0)^n$ in which V is the flow velocity at depth y; V_0 is flow velocity at depth y_0 and n = a constant. The expression for momentum coefficients is

(a) $\frac{(n+1)^3}{2n+1}$ (b) $\frac{(n+1)^3}{3n+1}$ (c) $\frac{(n+1)^2}{3n+1}$ (d) $\frac{(n+1)^2}{2n+1}$

Q.58 A 4 m wide rectangular channel is carrying 10 m^3/sec at depth of 2.5 m. There is step rise of 0.20 m in the channel bottom. Assuming there are no losses at the transition, the flow depth downstream of the bottom step is:
(a) 2.51 m (b) 2.49 m
(c) 2.48 m (d) 2.52 m

■■■■

Answers Open Channel Flow

1. (b)	2. (c)	3. (d)	4. (d)	5. (b)	6. (d)	7. (b)	8. (d)	9. (d)	10. (b)
11. (a)	12. (b)	13. (c)	14. (c)	15. (b)	16. (a)	17. (b)	18. (c)	19. (a)	20. (a)
21. (d)	22. (c)	23. (b)	24. (d)	25. (b)	26. (a)	27. (c)	28. (c)	29. (d)	30. (a)
31. (d)	32. (c)	33. (b)	34. (d)	35. (c)	36. (a)	37. (d)	38. (d)	39. (a)	40. (a)
41. (c)	42. (b)	43. (c)	44. (c)	45. (a)	46. (d)	47. (d)	48. (d)	49. (b)	50. (c)
51. (c)	52. (c)	53. (c)	54. (b)	55. (d)	56. (a)	57. (d)	58. (b)		

Explanations Open Channel Flow

1. (b)

$$\frac{dy}{dx} = S_0\frac{1-(y_0/y)^N}{1-(y_c/y)^M}$$

For Chezy's formula $N = 3$; $M = 3$
For Manning's formula $N = 10/3$; $M = 3$

N is related to conveyance $\left(\frac{1}{n}AR^{2/3}\right)$.

2. (c)
The curves which are asymptotic at one end and terminated at the other end are M_2 and H_2

From $$\frac{dy}{dx} = \frac{S_0 - S_f}{1-\frac{Q^2T}{gA^3}} = S_0\frac{1-\left(\frac{y_n}{y}\right)^{10/3}}{1-\left(\frac{y_c}{y}\right)^3}$$

Using Manning's equation for wide rectangular channel:

(i) As $y \to y_0$; $\frac{dy}{dx} \to 0$ i.e. the water surface approaches normal depth line asymptotically

(ii) As $y \to y_c$; $\frac{dy}{dx} \to \infty$ i.e. the water surface meets the critical depth line vertically in region 2 and 3.

(iii) As $y \to \infty$, $\frac{dy}{dx} \to 0$; i.e. the water surface meets a very large depth as horizontal asymptote in region 1.

(iv) As $y \to 0$, $\frac{dy}{dx} \to \infty$ it means that the surface profile meets the channel bed vertically in region 3.

Thus
(i) M_1, M_2, S_2 and S_3 meet y_0 line asymptotically
(ii) M_1 and S_1 curve tend to horizontal as $y \to \infty$
(iii) M_2, M_3 and S_2 meet y_c line normally
(iv) M_3 and S_3 meet channel bed normally.
The slope of:
- C_1 and C_3 curves comes out to be equal to critical slope of the bed, if Chezy's equation is used. Otherwise they are slightly curved.

3. (d)
Hydraulic jump is needed when critical depth line is to be crossed.

4. (d)
At critical flow, specific energy and specific force is minimum for a given discharge. In other words for a given specific energy or specific force, discharge is maximum at critical flow.

5. (b)

$$\frac{y_2}{y_1} = \frac{\left(-1+\sqrt{1+8F_1^2}\right)}{2} \quad ...(i)$$

and $$\frac{y_1}{y_2} = \frac{\left(-1+\sqrt{1+8F_2^2}\right)}{2} \quad ...(ii)$$

Equating the equation (i) with inverse of equation (ii) we get

$$F_2^2 = \frac{8F_1^2}{\left(-1+\sqrt{1+8F_1^2}\right)^3}$$

$$F_1^2 = \frac{8F_2^2}{\left(-1+\sqrt{1+8F_2^2}\right)^3}$$

7. (b)
$Q = CA\sqrt{RS}$
For hydraulically efficient trapezoidal section,

$A = \sqrt{3}\,y_e^2 = \sqrt{3} \times (0.6)^2 = 0.624$ m

$R = \frac{y_0}{2} = \frac{0.6}{2} = 0.3$ m

$\therefore Q = 75 \times 0.624 \times \sqrt{0.3 \times \frac{1}{250}} = 1.62\ m^3/s$

8. (d)

$$\frac{q^2}{g} = \frac{2y_1^2y_2^2}{y_1+y_2}$$

$$\Rightarrow \frac{q^2}{9.81} = \frac{2\times(2)^2\times(0.5)^2}{2+0.5}$$

$\Rightarrow q^2 = 0.8 \times 9.81$
$\Rightarrow q = 2.8\ m^2/s$

10. (b)
The energy dissipation is given by

$$E_L = \frac{(y_2-y_1)^3}{4y_1y_2} = \frac{(3.2-0.2)^3}{4\times0.2\times3.2} = 10.55 \text{ m}$$

12. (b)

$$R = \frac{\text{Wetted Area}}{\text{Wetted Perimeter}} = \frac{A}{P}$$

$$= \frac{5\times2.5}{5+2\times2.5} = 1.25$$

14. (c)
Chezy's equation, $V = C\sqrt{RS}$
Substituting dimensions of each term in above equation.

$LT^{-1} = C\sqrt{L\times1}$
$\Rightarrow C = L^{1/2}T^{-1}$

15. (b)
Conveyance $K = \frac{1}{n}AR^{2/3}$. It expresses the discharge capacity of the channel per unit longitudinal slope

16. (a)
The loss of energy in a hydraulic jump leads to unequal specific energies at downstream and upstream sections.

18. (c)
As we know

$\tau_0 = \gamma RS_0$ ...(i)
$V = C\sqrt{RS_0}$
$\Rightarrow V^2 = C^2(RS_0)$ ...(ii)

Dividing (i) by (ii) we get

$$\frac{\tau_0}{V^2} = \frac{\gamma}{C^2}$$

$$\Rightarrow \quad c^2 = \frac{\gamma V^2}{\tau_0}$$

$$\Rightarrow \quad c^2 = \frac{9.81\times10^3 \times 0.605^2}{1}$$

$$\Rightarrow \quad c \cong 60$$

21. (d)

For maximum discharge,

$y = 0.95\ D = 0.95 \times 1.5$
$= 1.425$ m

22. (c)

We know,

$$\frac{Q^2T}{gA^3} = 1$$

$$\frac{Q^2 \times 2y_c}{g \times y_c^6} = 1$$

$$\Rightarrow \quad y_c^5 = \frac{2Q^2}{g}$$

$$\Rightarrow \quad y_c = \left(\frac{2}{9.81}\right)^{1/5} = \left(\frac{1}{4.9}\right)^{1/5}$$

23. (b)

$$F_0 = \frac{V}{\sqrt{gy_0}} = \frac{q}{\sqrt{gy_0^3}} \quad \text{and} \quad y_c^3 = q^2/g$$

$$\therefore \quad \frac{y_c}{y_0} = F_0^{2/3}$$

24. (d)

$y_1 = 0.5$ m, $y_2 = 2.0$ m

$$y_c^3 = \frac{2y_1^2y_2^2}{(y_1+y_2)} = \frac{2\times\left(\frac{1}{2}\right)^2\times(2)^2}{\left(2+\frac{1}{2}\right)}$$

$$\therefore \quad y_c = \left(\frac{4}{5}\right)^{1/3}$$

26. (a)

Specific energy,

$$E = y + \frac{v^2}{2g}$$

For critical flow,

$$F = \frac{V}{\sqrt{gD}} = 1$$

$$D = \frac{y}{2} \quad \text{(for triangular channel)}$$

$$V^2 = gD$$

$$V^2 = \frac{gy}{2}$$

$$E = y_c + \frac{gy_c/2}{2} = y_c + \frac{1}{4}y_c$$

$$E = \frac{5}{4}y_c = 1.25y_c$$

27. (c)

$$Q = AV = (by)\,\frac{1}{n}\,y^{2/3}\,s^{1/2} = k\,y^{5/3}$$

$$dQ = \frac{5}{3}\,k\,y^{2/3}\,dy$$

$$\frac{dQ}{Q} = \frac{5}{3}\frac{dy}{y} = \frac{5}{3}\times 20\% = 33.3\%$$

28. (d)

If the flow is subcritical, then after the introduction of hump the specific energy will decrease by ΔZ (height of hump).

$$E_c \le E_1 - \Delta Z$$

$$\Rightarrow \quad \Delta Z \le E_1 - E_c$$

29. (d)

Froude number,

$$F = \frac{V}{\sqrt{gy}} = \frac{2.13}{\sqrt{9.81\times1}} = 0.68 < 1$$

Thus, the flow is subcritical.

$$C = \sqrt{gy} = \sqrt{9.81\times1} = 3.13 \text{ m/s}$$

Upstream velocity

$$= V + C = 2.13 + 3.13 = 5.26 \text{ m/s}$$

30. (a)

Specific energy,

$$E = y + \frac{v^2}{2g}$$

For critical flow,

$$F = \frac{V}{\sqrt{gD}} = 1$$

$$D = \frac{y}{2} \text{ (for triangular channel)}$$

$$V^2 = gD$$

$$V^2 = \frac{gy}{2}$$

$$E = y_c + \frac{gy_c/2}{2}$$

$$E = y_c + \frac{1}{4}y_c$$

$$E = \frac{5}{4}y_c$$

$$E = 1.25y_c$$

33. (b)

Specific energy, $E = y = \dfrac{Q^2}{2gA^2}$

For rectangular channel $y_c = \dfrac{2}{3}E$

For triangular channel $y_c = \dfrac{4}{5}E$

37. (d)

$$y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

$$q = \frac{6}{2} = 3 \text{ m}^3\text{/s/m}$$

$$y_c = \left(\frac{3^2}{9.8}\right)^{1/3} = 0.972 \text{ m}$$

$$y_n = 1.2 \text{ m}$$

A → $y = 0.63$ m, $y_n = 1.2$ m, $y_c = 0.97 \Rightarrow M_3$
B → $y = 0.90$ m, $y_n = 1.2$ m, $y_c = 0.97 \Rightarrow M_3$
C → $y = 1.10$ m, $y_n = 1.2$ m, $y_c = 0.97 \Rightarrow M_2$
D → $y = 1.42$ m, $y_n = 1.2$ m, $y_c = 0.97 \Rightarrow M_1$

40. (a)

For a wide rectangular channel,
hydraulic radius $R = y$ (depth of flow)
hydraulic depth $D = y$ (depth of flow)
For critical flow

$$\frac{V}{\sqrt{gD}} = \frac{V}{\sqrt{gy}} = 1$$

$$\Rightarrow \quad V = \sqrt{gy} \qquad \text{(i)}$$

From chezy's equation

$$V = C\sqrt{RS}$$

$$\Rightarrow \quad V = C\sqrt{yS} \qquad \text{(ii)}$$

From (i) and (ii)

$$S = \frac{1}{C^2/g}$$

44. (c)

E is min at $d = 0.74$ m

$$\therefore \quad E_{min} = 1.11 \text{ m}$$

$$\Rightarrow \quad 1.11 = \frac{V_c^2}{2g} + 0.74$$

$$\Rightarrow \quad V_c = 2.69 \text{ m/s}$$

$$q = V_c y = 2.69 \times 0.74$$

$$\simeq 2 \text{ m}^3\text{/s/m}$$

46. (d)

In rigid boundary channel, only depth of flow may vary with space and time depending on nature of flow. In mobile boundary channels, depth, bed width, bed slope and layout changes with space and time.

50. (c)

Hydraulic jump occurs if super critical flow approaches sub critical flow. Hence statement (1) is wrong, without (1), only option 'c' is correct.

51. (c)

Area of cross-section,

$$A = B\,y_0$$

Average velocity,

$$V = \frac{1}{B\,y_0}\int_0^{y_0} v(B\,dy)$$

$$= \frac{1}{y_0}\int_0^{y_0}\left(3\sqrt{y}\right)B\,dy = 3\times\frac{2}{3}\sqrt{y_0}$$

$$= 2\sqrt{y_0}$$

Kinetic energy correction factor,

$$\alpha = \frac{\int_0^{y_0} v^3(B\,dy)}{BV^3y_0} = \frac{\int_0^{y_0} 27y^{3/2}B\,dy}{B\left(2\sqrt{y_0}\right)^3\times y_0}$$

$$\Rightarrow \quad \alpha = \frac{27}{8}\times\frac{y_0^{5/2}}{1}\times\frac{2}{5}\times\frac{1}{y_0^{3/2}\times y_0}$$

$$\Rightarrow \quad \alpha = \frac{27}{20} = 1.35$$

52. (c)

For critical flow,

$$\frac{Q^2}{g} = \frac{A_c^3}{T_c}$$

For circular conduit flowing half full,

$$A = \frac{\pi D^2}{8} = \frac{\pi(1)^2}{8} = 0.3927\ m^2$$

Top width, $T_C = D = 1.0$ m

Hence,

$$\frac{Q^2}{g} = \frac{A_c^3}{T_c} = \frac{(0.3927)^3}{1.0} = 0.0606$$

⇒ $Q^2 = 0.0606 \times 9.81 = 0.5941$

⇒ $Q = 0.771\ m^3/sec$

53. (c)

For wide rectangular channel, the hydraulic radius

R = depth of flow y

Using Manning's equation,

Discharge intensity,

$$q = V_y = \frac{1}{n} y^{2/3} S_0^{1/2} \times y = \frac{1}{n} y^{5/3} S_0^{1/2}$$

∴ $1.30 = \frac{1}{0.02} \times y^{5/3} \times (0.0004)^{1/2}$

⇒ $y^{5/3} = 1.30$

⇒ $y = 1.17$ m

54. (b)

$2\theta = 120°$

Let y_c = critical depth

Top width,

$T_c = 2y_c \cdot \tan\theta$

Area, $A_c = y_c^2 \tan\theta$

All critical depth,

$$\frac{Q^2}{g} = \frac{A_c^3}{T_c}$$

$$\Rightarrow \frac{y_c^5 \tan^3\theta}{2y_c \tan\theta} = \frac{1}{2} y_c^5 \tan^2\theta$$

$$y_c = \left(\frac{2Q^2}{g} \times \frac{1}{\tan^2\theta}\right)^{1/5}$$

$$= \left(\frac{2\times(3)^2}{9.81\times(\tan 60°)}\right)^{1/5}$$

⇒ $y_c = 0.906$ m

55. (d)

Unit discharge,

$$q = \frac{150}{5} = 30\ m^3/sec/m$$

$$\therefore V_2 = \frac{q}{y^2} = \frac{30}{2} = 15\ m/sec$$

$$F_2^2 = \frac{V_2^2}{g y_2} = \frac{(15)^2}{9.81\times 2} = 11.47$$

Depth downstream of jump

$$y_3 = \frac{y_2}{2}\left(\sqrt{1+8F_2^2} - 1\right) = 8.63\ m$$

56. (a)

The depth upstream of gate can be determined by applying energy equation between 1 and 2.

$$y_1 + \frac{y_1^2}{2g} = y_2 + \frac{y_2^2}{2g}$$

By substituting the value, we get,

$y_1 = 13.468$ m

$$P_f = F_{s1} - F_{s2}$$

$$= \left(\frac{y_1^2}{2} + \frac{q^2}{g y_1}\right) - \left(\frac{y_2^2}{2} + \frac{q^2}{g y_2}\right)$$

$$= \left[\frac{(13.68)^2}{2} + \frac{(30)^2}{9.81\times 13.468}\right] - \left[\frac{(2)^2}{1} + \frac{(30)^2}{(9.81\times 2)}\right]$$

$= 49.634\ m^2$

Thruston gate $= YP_f \times$ gate width

$= 2434.5$ kN

57. (d)

Mean velocity,

$$V_m = \frac{\int v\,dy}{\int dy} = \frac{\int_0^{y_0} V_0\left(\frac{y}{y_0}\right)^n dy}{\int_0^{y_0} dy}$$

$$= \left[\frac{V_0 y^{n+1}}{y_0^n \times (n+1)}\right]_0^{y_0} = \frac{V_0}{n+1}$$

$$\beta = \frac{\int_0^{y_0} V_0^2\left(\frac{y}{y_0}\right)^{2n} dy}{\left[\frac{V_0}{(n+1)}\right]^2 \int_0^{y_0} dy} = \frac{(n+1)^2}{2n+1}$$

58. (b)

$$V_1 = \frac{Q}{A_1} = \frac{10}{4\times 2.5} = 1\ m/s$$

$$E_1 = y_1 + \frac{V_1^2}{2g} = 2.5 + \frac{(1)^2}{2\times 9.81}$$

$= 2.55$ mm

∵ There are no losses;

⇒ $E_2 = E_1 - 0.02$

$= 2.55 - 0.2 = 2.35$ m

$$\therefore y_2 + \frac{Q^2}{2gA_2^2} = 2.35\ m$$

$$y_2^3 - 2.35y_2^2 + 0.32 = 0$$

⇒ $y_2 = 2.29$ m ⇒ $(2.29 + 0.20)$ m

Water level d/s of the transition = 2.49 m.

■■■■