CLASS TEST

Sl. : 01SKCE_ABCD_04092025

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OPEN CHANNEL FLOW

CIVIL ENGINEERING

Date of Test : 04/09/2025

ANSWER KEY

1.	(d)	7.	(a)	13.	(a)	19.	(b)	25.	(c)
2.	(c)	8.	(a)	14.	(b)	20.	(a)	26.	(b)
3.	(b)	9.	(a)	15.	(a)	21.	(c)	27.	(a)
4.	(a)	10.	(b)	16.	(a)	22.	(d)	28.	(a)
5.	(b)	11.	(b)	17.	(a)	23.	(a)	29.	(b)
6.	(b)	12.	(a)	18.	(a)	24.	(a)	30.	(c)

DETAILED EXPLANATIONS

1. (d)
As some flow is taken out from system it will spatially varied flow.

2. (c)
Neglecting variation in transverse direction.

3. (b)
Given, $Q = 40 \text{ m}^3/\text{s},\ B = 4 \text{ m}$

$$q = \left(\frac{Q}{B}\right) = 10 \text{ m}^3/\text{s}$$

$$\text{Critical depth} = \left(\frac{q^2}{g}\right)^{1/3} = 2.168 \text{ m}$$

$$\text{For rectangular channel, } E_C = 1.5\, y_c = 3.25 \text{ m}$$

5. (b)
as for triangular channel, $E_C = 1.25\, y_c$

9. (a)
Strickler formula, $n = \dfrac{d_{50}^{1/6}}{21.1},\ d_{50}$ in meter

Given, $d_{50} = 2\text{mm} = 0.002 \text{ m}$

$$n = \frac{(0.002)^{1/6}}{21.1} = 0.017$$

10. (b)
As,
$$\frac{dy}{dx} = \frac{S_0 - S_b}{1 - \dfrac{Q^2T}{gA^3}}$$

For wide rectangular channel

$$Q = \frac{1}{n}(By)R^{2/3}\sqrt{s_b}$$

$$Q = \frac{1}{n}BR^{5/3}\sqrt{s_b} \qquad \text{(for wide rectangular channel, } R = y\text{)}$$

$$Q = \frac{1}{n}By^{5/3}\sqrt{s_b}$$

$$\therefore \quad s_p \propto \frac{1}{y^{10/3}}$$

(a) $y_0 = \text{Normal depth } s_b = s_0$

$$\frac{s_b}{s_0} = \left(\frac{y_0}{y_1}\right)^{10/3} \qquad \text{. . . (i)}$$

(b)

$$\frac{Q^2T}{A^3g} = \frac{Q^2T}{B^3y^3g} \quad \text{for rectangular channel, } T = B$$

$$= \left(\frac{y_c}{y}\right)^3$$

as

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

$\therefore$

$$\frac{dy}{dx} = so\left[\frac{1-\frac{S_b}{S_o}}{1-\frac{Q^2T}{gA^3}}\right] = so\left[\frac{1-\left(\frac{y_0}{y}\right)^{10/7}}{1-\left(\frac{y_c}{y}\right)^3}\right]$$

11. (b)

$$Q_1(\text{upstream discharge}) = ?$$

$$Q_2(\textit{downstream}\text{ discharge}) = 25 \text{ m}^3/\text{s}$$

We know the for unsteady flow, continuity equation

$$\frac{dQ}{dx}+T\frac{dy}{dt} = 0$$

$$\frac{Q_2-Q_1}{dx}+T\frac{dy}{dt} = 0$$

$$T = 20 \text{ m (given)}$$

$$\frac{dy}{dt} = 0.5 \text{ m/hr} = 1.388 \times 10^{-4} \text{ m/sec}$$

$\therefore$

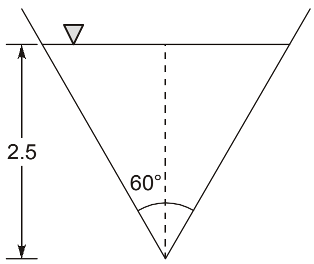
$$\frac{25-Q_1}{2000}+20\times 1.388\times 10^{-4} = 0$$

$$Q_1 = 30.55 \text{ m}^3/\text{s}$$

12. (a)

$$\text{Specific energy} = \frac{y_1^2+y_1y_2+y_2^2}{(y_1+y_2)} = \frac{(2)^2+2\times 3+(3)^2}{(2+3)} = 3.8 \text{ m}$$

13. (a)



$$\text{Section factor } (z) = A\sqrt{\frac{A}{T}}$$

A = area, T = top width

$$\tan 30^\circ = \frac{\frac{T}{2}}{2.5}$$

$\Rightarrow$

$$T = 2.88 \text{ m}$$

$$A = \left[\frac{1}{2}\times 2.88\times 2.5\right] = 3.6 \text{ m}^3$$

$$Z = A\sqrt{\frac{A}{T}} = 3.6\times\sqrt{\frac{3.6}{2.88}} = 4.02$$

14. (b)

$$F = \frac{V}{\sqrt{gy}} = 2$$

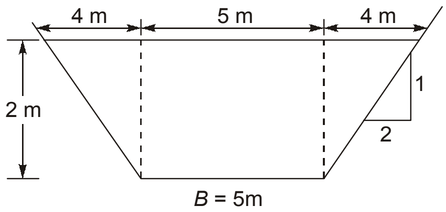
Given, $y = 0.63 \text{ m}$

$\Rightarrow$ $V = 4.97 \text{ m}$

$\Rightarrow$ $q = Vy = 3.13$

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

15. (a)



$$A = \left(\frac{5+13}{2}\right)\times 2 = 18 \text{ m}^2$$

Given, $Q = 20 \text{ m}^3/\text{s}$

$$V = \frac{Q}{A} = 1.11 \text{ m/s}$$

$$T = 13 \text{ m}$$

$$\text{Froude Number} = \frac{V}{\sqrt{\frac{gA}{T}}} = \frac{1.11}{\sqrt{\frac{9.81\times 18}{13}}} = 0.301$$

16. (a)

We know that at critical flow over hump specific energy will correspond to critical specific energy.

E_1 = specific energy at upstream section

$E_2 = E_c$, OZ_m = maximum hump height

$\Rightarrow$ $E_1 = E_2 + OZ_m$

$\Rightarrow$ $E_1 = E_c + OZ_m$

$$E_C = 1.5\, y_c,\; y_c = \left(\frac{q^2}{g}\right)^{1/3}$$

given, $Q = 12 \text{ m}^3/\text{s}$, B = 3.5 m, $y_1 = 1.2$ m

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left[\frac{\left(\frac{12}{3.5}\right)^2}{9.81}\right]^{1/3} = 1.062 \text{ m}$$

$\Rightarrow$ $E_c = 1.5\, y_c = 1.593 \text{ m}$

$$E_1 = y_1 + \left(\frac{v^2}{2g}\right) = 1.2 + \left[\frac{\left(\frac{12}{3.5 \times 1.2}\right)^2}{2 \times 9.81}\right] = 1.616 \text{ m}$$

$$E_1 = E_C + \Delta z_{max}$$

$$\Delta z_{max} = (1.616 - 1.593) = 0.023 \text{ m}$$

18. (a)

- Supercritical state profiles are : S_2, S_3 and M_3
- If $\frac{dy}{dx}$ is positive, $\frac{dE}{dx}$ is positive only if $y > y_c$.

19. (b)

Discharge through channel

$$Q = (AV)$$

$$Q = (By)\left[\frac{1}{n} R^{2/3} \sqrt{s}\right]$$

For wide rectangular channel, ($R = y$)

$$Q = \frac{1}{n} B\sqrt{s} y^{5/3}$$

as normal depth increase by 20%

$$y' = 1.2 \text{ y}$$

$$Q' = \frac{1}{n} B\sqrt{s}(1.2y)^{5/3} = \frac{1.355}{\left(\frac{1}{n} B\sqrt{s} y^{5/3}\right)} = 1.355 \text{ Q}$$

$$\% \text{ increase in discharge} = \left(\frac{Q' - Q}{Q}\right) \times 100 = 35.5\%$$

20. (a)

For most efficient channel

$$A = \sqrt{3} y^2$$

$$R = \frac{y}{2}$$

$$R = \frac{A}{P} \Rightarrow P = 2\sqrt{3}\, y$$

$$T = 2l,\ l = \text{slant height}$$

$$l = \frac{P}{3} = \frac{2}{\sqrt{3}} y$$

$$T = \frac{4}{\sqrt{3}} y$$

21. (c)

$$q = 1.2 \text{ m}^3/\text{s/m}$$

$$\text{Critical depth } (y_c) = \left(\frac{q^2}{g}\right)^{1/3} = 0.528 \text{ m}$$

Now for wide rectangular channel

$$q = \frac{1}{n} y^{5/3} \sqrt{s}$$

$$1.2 = \frac{1}{0.013}(y)^{5/3}\sqrt{0.004}$$

$$y = 0.43$$

as $y < y_c$, slope will be steep

23. (a)

Give,

$$Q = 7.8 \text{ m}^3/\text{s},\ B = 5 \text{ m}$$

$$y_1 = 0.32 \text{ m}$$

$$F_1 = \frac{V_1}{\sqrt{gy_1}}$$

$$V_1 = \left(\frac{Q}{A}\right) = \frac{7.8}{(5 \times 0.32)} = 4.875 \text{ m/s}$$

$$F_1 = \frac{4.875}{\sqrt{9.81 \times 0.32}} = 2.751$$

We know that

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_1^2}\right]$$

$$= \frac{1}{2}\left[-1 + \sqrt{1 + 8 \times 2.751^2}\right]$$

$$y_2 = 1.095 \text{ m}$$

24. (a)

$$y_2 = 2.5 \text{ m},\ V_2 = 1.5 \text{ m/s}$$

$$\frac{y_1}{y_2} = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_2^2}\right]$$

$$F_2 = \frac{V_2}{\sqrt{gy_2}} = \frac{1.5}{\sqrt{9.81 \times 2.5}} = 0.303$$

$$\frac{y_1}{2.5} = \frac{1}{2}\left[-1 + \sqrt{1 + 8 \times 0.303^2}\right]$$

$$y_1 = 0.396 \text{ m}$$

from continuity equation, $V_1 y_1 = V_2 y_2$

$$V_1 = 9.46 \text{ m/s}$$

25. (c)

If,

$$y_2 < y_t = \text{submerged jump will occur}$$
$$y_2 > y_t = \text{repelled jump}$$
$$y_t = y_2 \Rightarrow \text{free jump}$$

26. (b)

We know that, $$\frac{q^2}{g} = \frac{1}{2}\left[y_1 y_2 (y_1 + y_2)\right]$$

$\Rightarrow$ $$y_1 = 0.2,\ y_2 = 2 \text{ m}$$

$\Rightarrow$ $$\frac{q^2}{9.81} = \frac{1}{2}\times 0.2\times 2\times 2.2$$

$$q = 2.078 \text{ m}^3\text{/s/m}$$

27. (a)

Given, $y_1 = 0.5\text{m},\ V_1 = 5$ m/s

$$F_1 = \frac{V_1}{\sqrt{gy_1}} = \frac{5}{\sqrt{9.81\times 0.5}} = 2.26$$

$$\frac{y_2}{y_1} = \frac{1}{2}\left[-1+\sqrt{1+8\times 2.26^2}\right]$$

$$y_2 = 1.371$$

$$\text{Length of jump} = 6.9\,(y_2 - y_1) = 6.9\times(1.31 - 0.5) = 6\text{m}$$

29. (b)

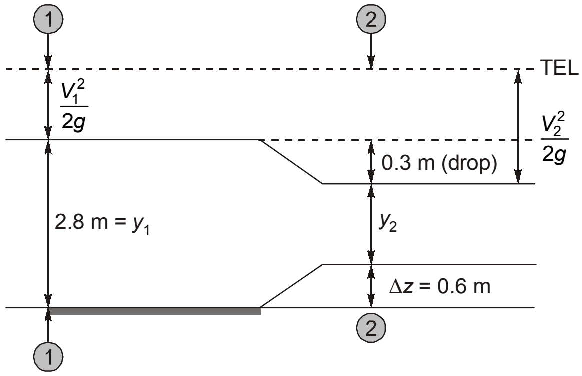
We know that

$$\text{Celerity} = \sqrt{\frac{1}{2}g\frac{y_2}{y_1}(y_1 + y_2)}$$

$$\text{given, } y_1 = 2,\ y_2 = 2.8$$

$$\text{Celerity} = \sqrt{\frac{9.81}{2}\times\frac{2.8}{2}(2+2.8)} = 5.74 \text{ m/s}$$

30. (c)



$$y_1 = y_2 + \Delta z + 0.3$$

Given, $y_1 = 2.8$ m, $\Delta z = 0.6$ m, drop in water level = 0.3 m

$\therefore$ $y_2 = 2.8 - 0.6 - 0.3 = 1.9$ m

As there is no loss

$$\text{Total energy at (1) – (1)} = \text{Total energy at (2) – (2)}$$

$$y_1 + \frac{V_1^2}{2g} = y_2 + \Delta z + \frac{V_2^2}{2g}$$

$$2.8 + \frac{Q^2}{2g(A_1)^2} = y_2 + \Delta z + \frac{Q^2}{2(A_2)^2 g}$$

$$2.8 + \frac{Q^2}{2 \times 9.8(2.8 \times 4.8)^2} = 1.9 + 0.6 + \frac{Q^2}{2 \times 9.81(3.6 \times 1.9)^2}$$

$$2.8 + \frac{Q^2}{3544.03} = 2.5 + \frac{Q^2}{917.93}$$

$$Q = 19.278 \text{ m}^3/\text{s}$$

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