CLASS TEST

Sl. : 01JP_CE_06082024

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CIVIL ENGINEERING

Open Channel FLow

Duration : 1:00 hr. **Maximum Marks : 50**

Read the following instructions carefully

1. This question paper contains **30** objective questions. **Q.1-10** carry one mark each and **Q.11-30** carry two marks each.
2. Answer all the questions.
3. Questions must be answered on Objective Response Sheet (**ORS**) by darkening the appropriate bubble (marked **A**, **B**, **C**, **D**) using HB pencil against the question number. Each question has only one correct answer. In case you wish to change an answer, erase the old answer completely using a good soft eraser.
4. There will be **NEGATIVE** marking. For each wrong answer **1/3rd** of the full marks of the question will be deducted. More than one answer marked against a question will be deemed as an incorrect response and will be negatively marked.
5. Write your name & Roll No. at the specified locations on the right half of the **ORS**.
6. No charts or tables will be provided in the examination hall.
7. Choose the **Closest** numerical answer among the choices given.
8. If a candidate gives more than one answer, it will be treated as a **wrong answer** even if one of the given answers happens to be correct and there will be same penalty as above to that questions.
9. If a question is left blank, i.e., no answer is given by the candidate, there will be **no penalty** for that question.

DO NOT OPEN THIS TEST BOOKLET UNTIL YOU ARE ASKED TO DO SO

Q.No. 1 to Q.No. 10 carry 1 mark each

Q.1 In defining the fraud's number applicable on channel flows, the length parameter used is
(a) Depth of flow
(b) Hydraulic mean depth
(c) Wetted perimeter
(d) Hydraulic depth

Q.2 In M_2 type of gradually varied flow profile
(a) $y_0 > y > y_c$ (b) $y > y_0 > y_c$
(c) $y_0 > y_c > y$ (d) $y_c > y > y_0$
Here, symbols have their usual mening

Q.3 A flow is taking place in a rectangular channel of width 4 m and depth of flow is 2 m. What will be the Manning's roughness coefficient of the channel if the Chezy's constant $C = 60$.
(a) 0.0167 (b) 0.0333
(c) 0.025 (d) 0.012

Q.4 A rectangular channel with bottom width of 3 m and bottom slope of 0.0005 has a discharge of 9.4 m^3/sec and is having normal depth of flow = 2.2 m.
At a point x, depth of water is 1.5 m. What will be the type of GVF profile?
(a) M_1 (b) S_1
(c) M_2 (d) S_2

Q.5 Hydraulic jump forms in a horizontal rectangular channel carrying a discharge per unit width of 5 m^3/sec/m at a depth of 30 cm. This jump can be classified as
(a) weak jump (b) oscillating jump
(c) steady jump (d) strong jump

Q.6 A wide rectangular channel has a longitudinal slope of 0.0004 and its Manning's roughness has been assessed as 0.02. Calculate the normal depth in this channel when the channel conveys a discharge intensity of 1.30 m^3/s/m.
(a) 1.17 m (b) 0.585 m
(c) 2.34 m (d) 0.293 m

Q.7 For a wide rectangular channel if manning's formula is used the differential equation of GVF becomes, dy/dx =
($y_0 \rightarrow$ normal depth, $y_c \rightarrow$ critical depth)
(a) $S_0\left[\dfrac{1-\left(\frac{y_0}{y}\right)^{3.33}}{1-\left(\frac{y_c}{y}\right)^{3.33}}\right]$ (b) $S_0\left[\dfrac{1-\left(\frac{y_0}{y}\right)^{3.33}}{1-\left(\frac{y_c}{y}\right)^{3}}\right]$
(c) $S_0\left[\dfrac{1-\left(\frac{y}{y_0}\right)^{3.33}}{1-\left(\frac{y}{y_c}\right)^{3}}\right]$ (d) $S_0\left[\dfrac{1-\left(\frac{y_0}{y}\right)^{3}}{1-\left(\frac{y_c}{y}\right)^{3.33}}\right]$

Q.8 In a triangular channel, the critical depth is 1.4 m. The corresponding least specific energy is
(a) 1.65 m (b) 1.75 m
(c) 2.1 m (d) 2.4 m

Q.9 In a gradually varied flow in a channel, the depth of flow and critical depth are y and y_c respectively. If E is the specific energy and $\frac{dy}{dx}$ is positive, then $\frac{dE}{dx}$ would be
(a) always negative (b) always positive
(c) positive if $y > y_c$ (d) negative if $y > y_c$

Q.10 Consider the following statements:
1. Hydraulic jump having Froude number between 1.7-2.5 is called undular jump.
2. Hydraulic jump having Froude number between 4.5-9.0 is called steady jump.
3. For Froude number less than 1, hydraulic jump is not possible.

Which of the above statement(s) is/are correct?
(a) 1 and 2 (b) 2 and 3
(c) 3 only (d) 1 and 3

Q.No. 11 to Q.No. 30 carry 2 marks each

Q.11 At critical flow
1. Specific energy is minimum for a given discharge
2. Specific force is minimum for a given discharge
3. Velocity head is equal to half the hydraulic depth
4. Discharge is minimum for a given specific energy

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

Q.12 If bed width of a most efficient trapezoidal channel is $4\sqrt{3}$ m then, what would be its hydraulic radius?
(a) 2.5 m (b) 3 m
(c) 6 m (d) 12 m

Q.13 Sequent depths of a hydraulic jump are 0.3 m and 1.2 m. What will be the relative energy loss if upstream velocity is 3 m/s?
(a) 50% (b) 67%
(c) 75% (d) 80%

Q.14 A 5 m wide rectangular channel came a discharge of 20 m^3/sec. What would be the depth of flow if Froude number of the flow is 0.74?
(a) 1.44 m (b) 1.20 m
(c) 1.68 m (d) 1.90 m

Q.15 The sequent depths ratio in the rectangular channel is 8. What will be the Froude number of the super critical flow?
(a) 3 (b) 4
(c) 5 (d) 6

Q.16 If 2.4 m and 0.5 m are alternate depth in a rectangular channel then what will be the critical depth of flow?
(a) 1.0 m (b) 1.2 m
(c) 1.1 m (d) 1.3 m

Q.17 Consider the following statements regarding channels with a hump:
1. In super critical flow, if the height of hump is increased then the flow depth over the hump will decrease and then it will become constant equal to the critical depth of the flow.
2. In subcritical flow, if the height of hump is increased then the flow depth over the hump will increase and then it will become constant equal to critical depth of flow.

Which of the statements given above is/are correct?
(a) 1 only
(b) 2 only
(c) 1 and 2 both
(d) neither 1 nor 2

Q.18 A 6 m wide rectangular channel conveys 15 m^3/sec. of water with a velocity of 2 m/sec. The specific energy head of the flow is:
(a) 1.25 m (b) 1.35 m
(c) 1.45 m (d) 1.55 m

Q.19 A rectangular channel is having a flow of 3.13 m^3/sec/m and specific energy of flow at a particular depth is 2.0 m. The maximum height of the hump that can be constructed without affecting upstream depth is ____.
(a) 0.25 m (b) 0.50 m
(c) 0.75 m (d) 1.00 m

Q.20 Consider the following statements:
1. The backwater curve produced by an obstruction to flow such as a weir is a typical example of rapidly varied flow.
2. For a given discharge Q in an channel, there will be two depth for a given specific energy E. These two depth are known as the critical depths.
3. For broad crested weirs with square entrance, C_d is about 0.85 and for rounded entrance weirs C_d is about 0.98.

Which of these statements is/are incorrect?
(a) 1 and 3 only (b) 3 only
(c) 1 and 2 only (d) 1, 2 and 3

Q.21 A 1.0 m diameter circular culvert is flowing half full and flow is in critical state. Estimate the flow in the culvert barrel.
(a) 0.77 m^3/s (b) 0.95 m^3/s
(c) 0.52 m^3/s (d) 0.34 m^3/s

Q.22 The sequent depths in a hydraulic jump formed in a 4.0 m wide rectangular channel are 0.2 m and 1.0 m. The discharge in the channel, (in m^3/s) is
(a) 1.085 (b) 1.53
(c) 4.34 (d) 6.137

Q.23 Consider the following statements:
1. In an open channel flow, for $E < E_{min}$, only one depth is possible.
2. In an open channel flow, for $E > E_{min}$, two depths of flow are possible.
3. E_{min} corresponds to the Froude number of unity.

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

Q.24 Which one of the following statements is not correct?
(a) Specific energy is the total energy above the floor of an open channel.
(b) For a given specific energy, two depths exist and these are called alternate depths.
(c) Velocity of flow is critical when specific energy is maximum.
(d) Critical velocity occurs at Froude number = 1.

Q.25 In a wide rectangular channel the full supply depth is 1.52 m. If 50% of the full supply discharge is flowing in this channel, the depth of flow will be [Given $1.515^{5/3} = 2.0$]
(a) 0.76 m (b) 0.90 m
(c) 1.00 m (d) 0.43 m

Q.26 A most efficient rectangular channel of bed width 2 m carries a discharge 20 m^3/s. Bed slope of the channel is
(a) Steep (b) Mild
(c) Horizontal (d) Critical

Q.27 Which of the following statements are correct?
1. There is only one specific curve for a given channel.
2. Alternate depths are the depths of flow at which specific energy is the same.
3. Critical flow occurs when the specific energy is minimum.

Choose the correct option using the codes given below:
(a) 1 and 2
(b) 1 and 3
(c) 2 and 3
(d) 1, 2 and 3

Q.28 A rectangular channel carries uniform flow of water at a rate of 7 m^3/sec/m at a depth of 1 m. What is the maximum rise in bed without causing afflux? (g= 10 m/s^2)
(a) 1.0 m
(b) 1.1 m
(c) 0.9 m
(d) 0.8 m

Q.29 Value of Chezy's constant if Reynold's number is 320 for fluid flowing in a pipe

$\left(\text{in } \frac{m^{1/2}}{s}\right)$ is

(a) 15 (b) 20
(c) 25 (d) 30

Q.30 For an efficient trapezoidal channel section, Top width is equal to the twice of side slope length where inclination of with respect to horizontal is equal to
(a) 30°
(b) 45°
(c) 60°
(d) Irrespective of the slope given

■■■■

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OPEN CHANNEL FLOW

CIVIL ENGINEERING

Date of Test : 06/08/2024

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (d)

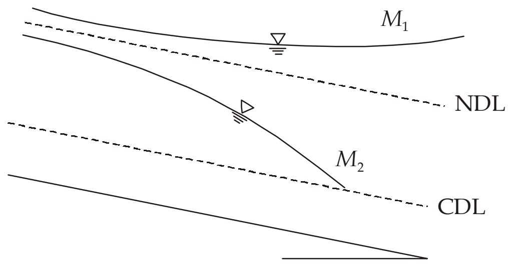
$$F_r = \frac{V}{\sqrt{gl}}$$

$$l = \frac{\text{Area (A)}}{\text{Top width (T)}}$$

Also known as hydraulic depth.

2. (c)

Mild slope profile.

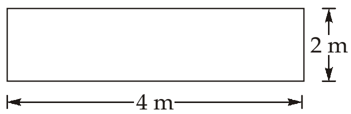


$\therefore \quad y_0 > y > y_c$

3. (a)

$$R = \frac{A}{P} = \frac{4\times 2}{4+2\times 2} = 1\text{ m}$$

$$C = \frac{1}{n}R^{\frac{1}{6}}$$



$$n = \frac{1}{C}R^{\frac{1}{6}} = \frac{1}{60}\times(1)^{\frac{1}{6}} = 0.0167$$

4. (c)

$$y = 1.5\text{ m}$$

$$y_n = 2.2\text{ m}$$

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{\left(\frac{9.4}{3}\right)^2}{9.81}\right)^{1/3} = (1)^{1/3}$$

$$y_c = 1\text{ m}$$

As $y_n > y_c$ mild slope

$$y_n > y > y_c$$

$\Rightarrow M_2$ profile.

5. **(d)**

$$F_1 = \sqrt{\frac{q^2}{gy^3}} = \sqrt{\frac{25}{9.81 \times (0.3)^3}}$$

$$F_1 = 9.72 > 9$$

⇒ Strong jump

6. **(a)**

For a wide rectangular channel, the hydraulic radius R = depth of flow y

Hence, discharge intensity, $$q = Vy = \left(\frac{1}{n} y^{2/3} S_0^{1/2}\right) y = \frac{1}{n} y^{5/3} S_0^{1/2}$$

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

$$y^{5/3} = 1.30$$

$$y = 1.17 \text{ m}$$

7. (b)

As, $$\frac{dy}{dx} = \frac{S_0 - S_b}{1 - \frac{Q^2 T}{gA^3}}$$

For wide rectangular channel

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

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

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

∴ $$s_p \propto \frac{1}{y^{10/3}}$$

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

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

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

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

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

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

8. (b)

For triangular channel,

Minimum specific energy = critical energy, $E_c = \frac{5}{4}y_c$

So, $E_c = 1.25 \times 1.4 = 1.75$ m

9. (c)

$$\frac{dE}{dx} = \left(1 - F^2\right)\frac{dy}{dx}$$

If $y < y_c$, i.e. supercritical flow ($F > 1$) and $\frac{dE}{dx}$ will be negative.

If $y > y_c$, i.e. subcritical flow ($F < 1$) and $\frac{dE}{dx}$ will be positive.

10. (b)

Depending on the values of Froude number (Fr) of incoming flow, there are five distinct type of hydraulic jump:

Type of jump	Froude number (Fr)
Undular	1.0 < Fr < 1.7
Weak	1.7 < Fr ≤ 2.5
Oscillating	2.5 < Fr ≤ 4.5
Steady	4.5 < Fr ≤ 9.0
Strong or Choppy	Fr > 9.0

11. (b)

3. At critical flow, $\frac{V}{\sqrt{gL}} = 1$

$\Rightarrow$ $V^2 = gL$

$\Rightarrow$ $\frac{V^2}{2g} = \frac{L}{2}$

Velocity head $= \frac{\text{Hydraulic depth}}{2}$

4. Discharge is maximum for a given specific energy.

12. (b)

For most efficient trapezoidal channel,

Bed width $= \frac{2y}{\sqrt{3}}$

$$\frac{2y}{\sqrt{3}} = 4\sqrt{3}$$

$$y = 6 \text{ m}$$

We know, hydraulic radius, $R = \frac{y}{2}$

$$R = \frac{6}{2} = 3 \text{ m}$$

13. (b)

$$y_1 = 0.3 \text{ m}$$
$$y_2 = 1.2 \text{ m}$$
$$V_1 = 3 \text{ m/s}$$

Energy loss in hydraulic jump,

$$E_l = \frac{(y_2 - y_1)^3}{4y_1y_2} = \frac{(1.2-0.3)^3}{4\times 0.3\times 1.2} = \frac{0.9^3}{4\times 0.3\times 1.2} = 0.50 \text{ m}$$

$$E_1 = y_1 + \frac{V_1^2}{2g} = 0.3 + \frac{3^2}{2\times 9.81} = 0.75 \text{ m}$$

$$\text{Relative energy loss} = \frac{E_l}{E_1}\times 100 = \frac{0.50}{0.75}\times 100 = 67\%$$

14. (a)

$$\text{Fr} = 0.74 = \frac{V}{\sqrt{gy}} = \frac{Q}{By\sqrt{gy}}$$

$$0.74 = \frac{20}{5\times\sqrt{9.81}\times y^{3/2}}$$

$$y^{3/2} = 1.726$$
$$y = (1.726)^{2/3}$$
$$1.726 \approx 1.728$$
$$y = 1.44 \text{ m}$$

15. (d)

Sequent depth ratio, $\frac{y_2}{y_1} = 8$

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

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

$\Rightarrow$ $289 = 1+8F_1^2$

$\Rightarrow$ $F_1^2 = 36$

$F_1 = 6$

16. (a)

$$y_c^3 = \frac{2y_1^2y_2^2}{(y_1+y_2)} = \frac{2\times 2.4^2\times 0.5^2}{2.4+0.5} = 0.993 \text{ m}^3$$

$\Rightarrow$ $y_c = 0.998 \text{ m}$

17. (d)

- In subcritical flow, if the height of hump is increased then the flow depth over the hump will decrease then it will become constant equal to critical depth of flow.
- In super critical flow, if the height of hump is increased then the flow depth over the hump will increase then it will become constant equal to critical depth of flow.

18. (c)

$\therefore$

$$Q = VA$$
$$15 = 2 \times 6 \times y$$
$$y = 1.25 \text{ m}$$
$$E = y + \frac{v^2}{2g} = 1.25 + \frac{2^2}{2 \times 9.81}$$
$$E = 1.45 \text{ m}$$

19. (b)

For a rectangular channel,
$$E_C = \frac{3}{2}y_c = \frac{3}{2}\left(\frac{q^2}{g}\right)^{1/3}$$
$$= \frac{3}{2}y_c = \frac{3}{2}\left(\frac{q^2}{g}\right)^{1/3} = \frac{8}{2}\left(\frac{3.13^2}{9.81}\right)^{1/3}$$

$\Rightarrow$ $E_c = 1.5$ m

$\Rightarrow$ $\Delta Z_{max.} = E_1 - E_C = 2 - 1.5$

$\Rightarrow$ $\Delta Z_{max.} = 0.5$ m

20. (c)

For a given discharge Q in a channel, there will be two depths for a given specific energy E. These two depths are known as the alternate depths.

21. (a)

For a critical flow condition

$$\frac{Q^2}{g} = \frac{A_C^3}{T_C}$$
$$A_C = \frac{\pi D^2}{8} = \frac{\pi (1.0)^2}{8} = 0.39 \text{ m}^2$$
$$T_C = D = 1.0 \text{ m}$$
$$\frac{Q^2}{g} = \frac{A_C^3}{T_C} = \frac{(0.39)^3}{1.0} = 0.06$$
$$Q^2 = 0.06 \times 10 = 0.6$$
$$Q = 0.77 \text{ m}^3/\text{s}$$

22. (c)

$$B = 4.0 \text{ m}$$

$$y_1 = 0.2 \text{ m and } y_2 = 1.0 \text{ m}$$

We know that,

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

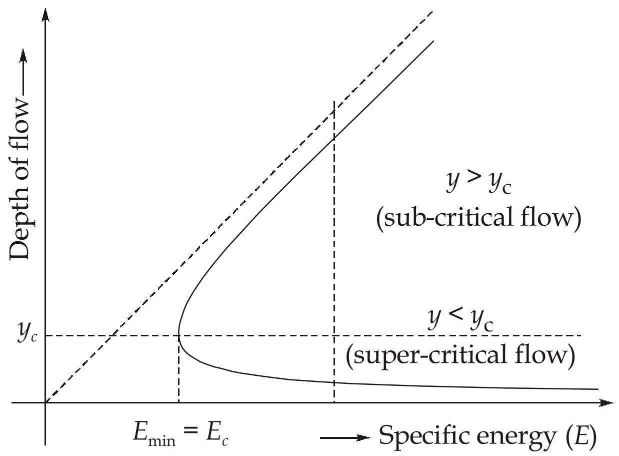
$$q = \sqrt{\frac{9.81 \times 0.2 \times 1 \times (1.2)}{2}} = 1.085 \text{ m}^3/\text{s/m}$$

$\therefore$

$$Q = qB = 1.085 \times 4 = 4.34 \text{ m}^3/\text{s}$$

23. (b)

Specific energy curve:



For a given discharge, specific energy is minimum, flow will be critical i.e., Froude number is unity.

24. (c)

At critical depth (velocity), specific energy is minimum.

25. (c)

Manning's equation

$$Q = \frac{1}{n} A R^{2/3} S^{1/2}$$

$$Q_{full} = \frac{1}{n} S^{1/2} B y_{full} \left(y_{full}\right)^{2/3}$$

$$Q_{full} = \frac{1}{n} (S)^{1/2} B \left(y_{full}\right)^{5/3}$$

$$Q_{half} = \frac{1}{n} (S)^{1/2} B \left(y_{half}\right)^{5/3}$$

$\because$

$$\frac{Q_{full}}{Q_{half}} = 2$$

$\Rightarrow$

$$\frac{Q_{full}}{Q_{half}} = \left(\frac{y_{full}}{y_{half}}\right)^{5/3}$$

$\Rightarrow$

$$(2)^{3/5} = \frac{y_{full}}{y_{half}}$$

$$\Rightarrow \qquad y_{half} = \frac{y_{full}}{(2)^{3/5}} = \frac{1.52}{1.515} \simeq 1.00 \text{ m}$$

26. (a)

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

$B = 2 \text{ m}$

For most efficient rectangular channel,

Normal depth, $B = 2y_n$

$y_n = B/2 = 2/2 = 1 \text{ m}$

Fro critical depth, $y_c = \left(\frac{q^2}{g}\right)^{1/3}$ (For rectangular channel)

$$y_c = \left(\frac{(20/2)^2}{9.81}\right)^{1/3}$$

$$= \left(\frac{100}{9.81}\right)^{1/3} = 2.168 \text{ m}$$

i.e., $y_c > y_n$ $\therefore$ Steep slope.

27. (c)

28. (c)

The specific energy at 1 m depth

$$E = y + \frac{V^2}{2g} = y + \frac{q^2}{2gy^2}$$

$$= 1.0 + \frac{(7)^2}{2 \times 10 \times (1.0)^2} = 3.45 \text{ m}$$

Critical depth for rectangular channel

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left(\frac{7^2}{10}\right)^{1/3} = 1.698 \text{ m}$$

Critical specific energy $(E_C) = 1.5y_c$

$= 2.55 \text{ m}$

$(\Delta Z)_{max} = E - E_C = 3.45 - 2.55$

$= 0.9 \text{ m}$

29. (c)

We know that Chezy's constant,

$$C = \sqrt{\frac{8g}{f}}$$

As given R_e i.e. is 320 is less than 2000, the flow would be laminar.

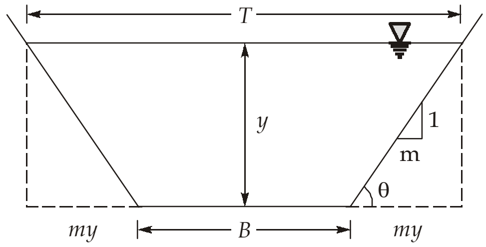
For laminar flow, $$f = \frac{64}{R_e}$$

$$f = \frac{64}{320} = \frac{1}{5}$$

$$C = \sqrt{\frac{8 \times 9.81}{\frac{1}{5}}}$$

$$C = 19.80\frac{\sqrt{m}}{s} \simeq 20\frac{\sqrt{m}}{s}$$

30. (d)



$$A = \frac{1}{2}(B+T)\cdot y = \frac{1}{2}[B+(B+2my)]\cdot y$$

$$A = (B + my)y$$

$$P = B+\left(2\sqrt{1+m^2}\right)y$$

$$P = \left(\frac{A}{y}-my\right)+\left(2\sqrt{1+m^2}\right)y$$

For channel to be efficient, $\frac{dP}{dy} = 0$

$$\frac{dP}{dy} = \frac{-A}{y^2} - m + 2\sqrt{1+m^2} = 0$$

$$2\sqrt{1+m^2} = m+\frac{(B+my)y}{y^2}$$

$$B + 2my = 2(y\sqrt{1+m^2})$$

Top width = 2 × side slope length

∴ Condition is true for any particular slope.

■■■■