CLASS TEST

Sl. : 03_SK_CE_S+G_18722[EG]

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# HYDROLOGY

## CIVIL ENGINEERING

**Date of Test : 18/07/2022**

## ANSWER KEY

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

## DETAILED EXPLANATIONS

**3. (c)**

Symon's raingauge is non-recording type raingauge.

**4. (b)**

Equilibrium discharge of S-curve,

$$Q = 2.78 \times \frac{A}{T}$$

where $A$ = Area of catchment in km$^2$

$T$ = Duration of unit hydrograph in hours

$Q$ = Discharge in m$^3$/s

$$Q = 2.78 \times \frac{400}{4} = 278 \text{ m}^3/\text{s}$$

**6. (a)**

$$\frac{1}{2} \times 250 \times 42 \times 60 \times 60 = 10^{-2} \times A$$

$\Rightarrow$ $A = 1890 \times 10^6$ m$^2$

$\Rightarrow$ $A = 1890$ km$^2$

**8. (c)**

An instantaneous unit hydrograph is a unit hydrograph of infinitestimal duration. It is mainly used when rainfall duration and intensity is variable because in that case we need to divide the rainfall in very small duration and find out the response of that of runoff.

**10. (c)**

Kirpich's equation is used to find time of concentration

$$t_c = 0.01947\ L^{0.77}\ S^{-0.385}$$

where, $L$ = Maximum length of travel

$$S = \frac{\Delta h}{l}$$

$\Delta h$ = Difference in elevation

**11. (c)**

$$m = 4, \quad \bar{P} = \frac{80 + 90 + 100 + 130}{4} = 100 \text{ cm}$$

Standard deviation, $\sigma_{m-1} = 21.60$

So, $$C_v = \frac{100 \times \sigma_{m-1}}{\bar{P}} = \frac{100 \times 21.60}{100} = 21.60$$

Now, for 10% accuracy, error is $\in$ = 100 – 10 = 90%

So, $$N = \left(\frac{C_v}{\in}\right)^2 = \left(\frac{21.60}{90}\right)^2 = 0.0576 \simeq 1$$

So for 10% accuracy, optimal no. of raingauge stations required is 1.

**12. (b)**

Normal annual precipitation at $A$ and $C$ are 120 cm and 100 cm respectively which vary more than 10% of normal annual precipitation at $B$ i.e., 0.9 × 80 = 72 cm and (1.1 × 80) = 88 cm.

So, annual precipitation at $B$ $= \frac{N_B}{m}\left(\frac{P_1}{N_1}+\frac{P_2}{N_2}\right)$

$$= \frac{80}{2}\left(\frac{120}{120}+\frac{150}{100}\right)$$

$$= 100 \text{ cm}$$

**13. (d)**

Infiltration capacity of an area depends on

1. Characteristics of soil
2. Moisture content
3. Vegetative cover
4. Water temperature infiltering through the soil

**14. (d)**

$$\phi\text{-index} = \frac{P-R}{t} = \frac{6-3}{6} = 0.5 \text{ cm/hr}$$

∴ $\phi$-index remains the same

$$\therefore \quad 0.5 = \frac{12-R}{9}$$

$$\Rightarrow \quad R = 12 - 4.5 = 7.5 \text{ cm}$$

**15. (c)**

(ii) Soluble salts when dissolved in water leads to decrement in rate of evaporation.

(iii) A deep water body/lake may store radiation energy received in summer and release it in winter causing less evaporation in summer and more evaporation in winter compared to a shallow lake exposed to a similar situation.

**16. (a)**

Current meters are only of two types viz. horizontal axis meter and vertical axis meter.

**17. (c)**

Duration of rainfall excess = 3-h

The depth of rainfall = 5.9 cm

Loss @ 0.3 cm/h for 3h = 0.9 cm

∴ Rainfall excess = 5.9 – 0.9 = 5 cm

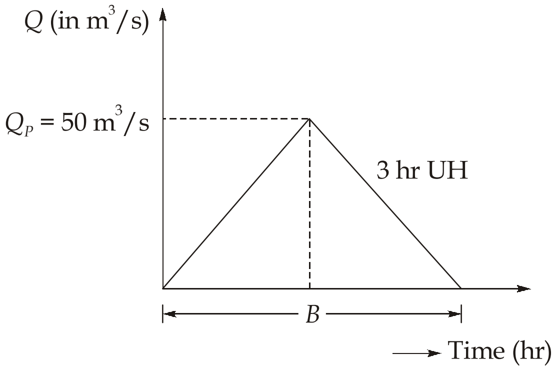
Peak of flood hydrograph = 270 $m^3/s$

Base flow = 20 $m^3/s$

∴ Peak of DRH = 270 – 20 = 250 $m^3/s$

$$\text{Peak of 3-h unit hydrograph} = \frac{250}{5} = 50 \text{ m}^3/\text{s}$$

Let '$B$' be the base width of 3-h, UH in hours




$\Rightarrow$ Area of 3 hr UH = (1 cm) × Acatchment

$$\frac{1}{2}\times Q_P\left(\text{in m}^3/\text{s}\right)\times B(\text{in hr})\times 3600 = 1 \times 10^{-2} \times 567 \times 10^6$$

$$\frac{1}{2}\times 50\times B\times 3600 = 1 \times 10^{-2} \times 567 \times 10^6$$

$$B = 63 \text{ hrs}$$

**18. (c)**

$$k = 12 \text{ h}, \Delta t = 6\text{h and } x = 0.2$$

So,
$$C_0 = \frac{-kx+0.5\Delta t}{k(1-x)+0.5\Delta t} = \frac{-12\times 0.2+0.5\times 6}{12(1-0.2)+0.5\times 6} = 0.0476$$

$$C_1 = \frac{kx+0.5\Delta t}{k(1-x)+0.5\Delta t} = \frac{12\times 0.2+0.5\times 6}{12(1-0.2)+0.5\times 6} = 0.428$$

$$C_0 + C_1 + C_2 = 1$$
$$C_2 = 1 - (0.0476 + 0.428) = 0.524$$

**20. (c)**

Lysimeter is used to measure evapotranspiration.

**21. (c)**

$\because$ $Q \; \alpha \; \sqrt{S}$

$\therefore$ $\frac{Q_2}{Q_1} = \sqrt{\frac{S_2}{S_1}}$ $\qquad S_1 = \frac{1}{5000}$

$\Rightarrow$ $\frac{Q_2}{180} = \sqrt{\frac{5000}{2000}}$ $\qquad S_2 = \frac{1}{2000}$

$\Rightarrow$ $Q_2 = 284.6 \text{ m}^3/\text{s}$ $\qquad \frac{S_2}{S_1} = \frac{5000}{2000}$

**22. (b)**

$$V_{0.2} = 0.5 \text{ m/s}$$
$$V_{0.8} = 0.3 \text{ m/s}$$
$$\therefore \quad V = \frac{V_{0.2}+V_{0.8}}{2} = \frac{0.5+0.3}{2} = 0.4 \text{ m/s}$$
$$\therefore \quad Q = AV = \frac{1}{2}\times 9\times 3\times 0.4 \text{ m}^3/\text{s} = 5.4 \text{ m}^3/\text{s}$$

**23. (b)**

$$\text{Total rainfall} = (1.4+3.2+4.3+2.6+2.3+1)\times\frac{1}{2}\text{cm} = 7.4 \text{ cm}$$

**Trial 1**
$$\phi_{index} = \frac{7.4-3}{3} = 1.467 \text{ cm/hr}$$

**Trial 2**
$$\phi_{index} = \frac{(3.2+4.3+2.6+2.3)\times\frac{1}{2}-3}{2} = 1.6 \text{ cm/hr}$$

**Check :**

$$\text{Runoff} = \left[(3.2-1.6)+(4.3-1.6)+(2.6-1.6)+(2.3-1.6)\right]\times 0.5$$
$$= 3 \text{ cm which is same as given in question}$$

**24. (b)**

The probability corresponding to 100 years return period

$$P = \frac{1}{100} = 0.01$$

The probability of the flood exceeding at least once in 50 years

$$R = 1-(1-P)^{50} = 1-0.99^{50}$$
$$= 39.49\% \simeq 40\%$$

**25. (c)**

| Time (hr) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |
|---|---|---|---|---|---|---|---|---|
| Q $(\text{m}^3/\text{s})$ | 5 | 15 | 35 | 55 | 35 | 25 | 15 | 5 |
| DRH ordinate $(\text{m}^3/\text{s})$ | 0 | 10 | 30 | 50 | 30 | 20 | 10 | 0 |

Runoff volume = Area under DRH

$$= \frac{1}{2}\begin{bmatrix}10\times10+(10+30)\times10+(30+50)\times10+(50+30)\\ \times10+(30+20)\times10+(20+10)\times10+10\times10\end{bmatrix}\times60\times60$$

$$= 54\times10^5 \text{ m}^3$$

$$\text{Excess rainfall} = \frac{54\times10^5}{200\times10^6}\times100 = 2.7 \text{ cm}$$

**26. (b)**

Risk, $\bar{R} = 1-\left(1-\frac{1}{T}\right)^n = 10\% = 0.10$

$\Rightarrow \quad 0.10 = 1-\left(1-\frac{1}{T}\right)^{25}$

$\Rightarrow \quad \left(1-\frac{1}{T}\right)^{25} = 0.90$

$\Rightarrow \quad T = 237.78 \simeq 238$ years

**27. (c)**

In Western Ghat, Maharashtra, the flood peak will be given by Inglis formula, which is

$$Q_p = \frac{124A}{\sqrt{A+10.4}}$$ where $A$ (in $km^2$), $Q_p$ (in $m^3/s$)

$$\Rightarrow \quad Q_p = \frac{124\times 53.6}{\sqrt{53.6+10.4}} = \frac{124\times 53.6}{8} = 830.8 \text{ m}^3/\text{s}$$

**28. (a)**

Duration of rainfall excess = 3h

Loss @ 0.5 cm/h for 3 hr = 1.5 cm

Total depth of rainfall = 7.5 cm

$\therefore$ Rainfall excess = 7.5 – 1.5 = 6 cm

Peak flow:

Peak of flood hydrograph = 300 $m^3/s$

Base flow = 25 $m^3/s$

Peak of DRH = 300– 25 = 275 $m^3/s$

$\therefore$ Peak of 3 h unit hydrograph (UH)

$$= \frac{\text{Peak of DRH}}{\text{Rainfall excess}} = \frac{275}{6} = 45.83 \text{ m}^3/\text{s}$$

**29. (b)**

Surface area = $6 \times 10^5$ $m^2$

$Q_{inflow}$ = 1.5 $m^3/s$

$\Delta S$ increase = $6.5 \times 10^3$ $m^3$

Precipitation, $P$ = 150 mm = 15 cm

Evaporation, $E$ = 350 mm = 35 cm

Given data is for a month then

$$\text{Depth of inflow,} \quad V_i = \frac{1.5\times 30\times 86400}{6\times 10^5} = 6.48 \text{ m} = 648 \text{ cm}$$

$$\text{Depth of storage increment} = \frac{6.5\times 10^5}{6\times 10^5} = 1.083 \text{ m} = 108.33 \text{ cm}$$

Applying water budget equation

Total inflow – Total outflow = Change in storage

$$(V_i + P) - (V_0 + E) = 108.33$$

$$(648 + 15) - (V_0 + 35) = 108.33$$

Depth of outflow, $V_0 = 519.67 \text{ cm} \simeq 520 \text{ cm} = 5.2 \text{ m}$

$$\text{Outflow discharge} = \frac{5.2 \times 6 \times 10^5}{30 \times 86400} = 1.2 \text{ m}^3/\text{s}$$

$$\text{Total inflow} = 648 + 15 = 663 \text{ cm}$$

**30.** **(b)**

$$\text{Average depth of rainfall} = \frac{15 \times 30 + \left(\frac{30+40}{2}\right) \times 250 + \left(\frac{40+50}{2}\right) \times 150 + \left(\frac{50+35}{2}\right) \times 180 + \left(\frac{35+60}{2}\right) \times 215 + 60 \times 60}{15 + 250 + 150 + 180 + 215 + 60}$$

$$= \frac{450 + 8750 + 6750 + 7650 + 10212.5 + 3600}{870}$$

$$= 43 \text{ mm}$$

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