S.No. : 01 PT_CE_A+B_090819

Engineering Hydrology

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# CLASS TEST 2019-2020

## CIVIL ENGINEERING

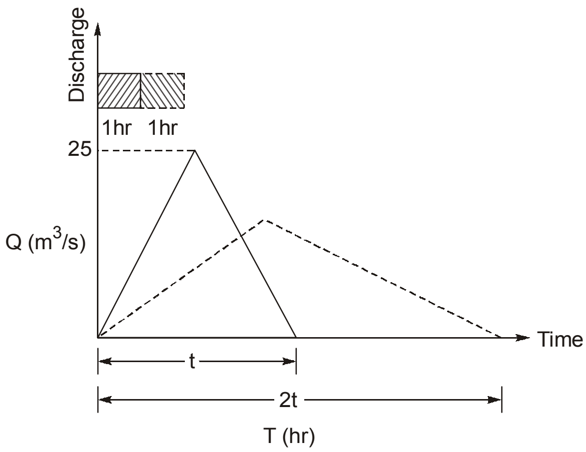
**Date of Test : 09/08/2019**

## ANSWER KEY ➤ Engineering Hydrology

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

## Detailed Explanations

1. (b)




For 2-hr UH, the base time will increase, hence peak will go down.

2. (d)
Certain chemicals such as cetyl alcohol (hexadecanol) and stearyl alcohol (octadecanol) forms monomolecular layers on a water surface. These layers act as evaporation inhibitors by preventing the water molecules to escape past them.

4. (a)
Since variation is more than 10%,

$$P_x = \frac{105}{3}\left[\frac{156}{155}+\frac{140}{150}+\frac{104}{120}\right]$$

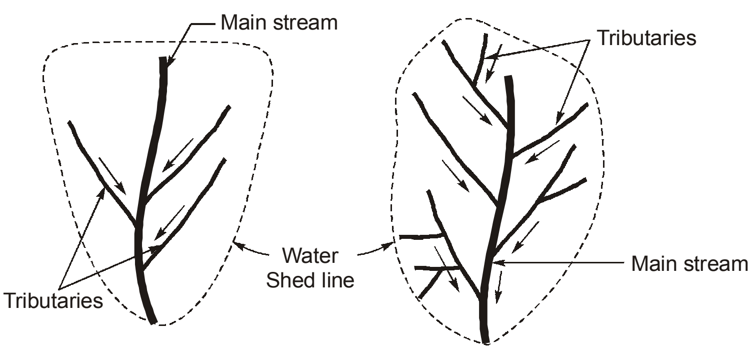
$$= 98.2 \text{ cm}$$

5. (a)

$$Q_{\text{equilibrium}} = 2.78\frac{A}{T}$$

$$= 2.78 \times 360 \times \frac{1}{4} \simeq 250 \text{ cumecs}$$

6. (a)




(Fan Shaped Catchment) (Fern Leaf Catchment)

7. (c)
The limiting case of a UH of zero duration is known as IUH (Instantaneous Unit Hydrograph). The ordinate of one IUH at any time '*t*' is the slope of *S*-curve of intensity 1 cm/hr.

8. (a)

Isopleth is a line on a map connecting points having same numerical values of a certain quantity such as population figure or geographical measurement. Isobars are contour lines that connects different points with same constant pressure. Isochrones are lines on a map connecting points relating to equal time of travel of surface runoff or equal time of concentration.

11. (c)

$$\text{Peak of DRH} = 135 - 10 = 125 \text{ m}^3/\text{s}$$

$$P = 54 \text{ mm}, \quad \phi = 4 \text{ mm/hr}$$

$$\therefore \quad n = P - \phi \times t = 54 - 4 \times 1 = 50 \text{ mm} = 5 \text{ cm}$$

$$\therefore \quad \text{Peak of 1 hr. UH} = \frac{125}{5} = 25 \text{ m}^3/\text{s}$$

12. (a)

$$n = 2 + 3 = 5 \text{ cm}$$

For DRH, $$(\Sigma O) = (1 + 7 + 26 + 37 + 27 + 13 + 1) - 7 = 105$$

$$n = \frac{0.36 \Sigma Ot}{A}$$

$$\Rightarrow \quad A = \frac{0.36 \times 105 \times 1}{5} = 7.56 \text{ km}^2$$

13. (c)

$$P = 5 \times 2 = 10 \text{ cm}$$

$$= 10 \times 10^{-2} \times 100 \times 10^4 = 10^5 \text{ m}^3$$

$$R = 1 \text{ m}^3/\text{s} \times 10 \times 60 \times 60 = 36000 \text{ m}^3$$

$$\therefore \quad \text{Runoff coefficient} = \frac{R}{P} = \frac{36000}{10^5} = 0.36$$

14. (a)

| Time (hr) | 4-*h* UH (m$^3$/s) | *S*-curve addition | *S*-curve | Offset *S*-curve | $\Delta y$ | 6-*h* UH = ($\Delta y$ × 4/6) |
|---|---|---|---|---|---|---|
| 0 | 0 | – | 0 | – | 0 | 0 |
| 2 | 9 | – | 9 | – | 9 | 6 |
| 4 | 20 | 0 | 20 | – | 20 | 13.33 |
| 6 | 35 | 9 | 44 | 0 | 44 | 29.33 |
| 8 | 43 | 20 | 63 | 9 | 54 | 36 |
| 10 | 22 | 44 | 66 | 20 | 46 | 30.67 |
| | | 63 | | 44 | | |
| | | 66 | | 69 | | |
| | | | | 66 | | |

15. (c)

(i) $$\text{Mean rainfall, } (\bar{P}) = \frac{\Sigma P}{n} = \frac{800 + 620 + 400 + 560}{4} = 595 \text{ mm}$$

(ii) $$\text{Standard deviation, } \sigma = \sqrt{\frac{(P - \bar{P})^2}{n - 1}} = 165.23$$

(iii) $$\text{Coefficient of variation, } c_v = \frac{100\,\sigma}{\bar{P}} = \frac{100 \times 166.93}{595} = 27.77$$

(iv) Optimum number of rain gauges, $(N) = \left(\frac{C_V}{\in}\right)^2 = \left(\frac{28.29}{10}\right)^2 \Rightarrow 7.7113 \approx 8\text{Nos}$

(v) Additional gauges required to be installed

$= 8 - \text{Existing 4 gauges}$

$= 8 - 4 = 4$

16. (d)

| Time (1) | Total Stream flow in cumecs (2) | Base flow in cumecs (3) | Direct run off = column (2) – 4.8 (4) |
|---|---|---|---|
| 0 | 4.8 | 4.8 | 0 |
| 2 | 5.1 | 4.8 | 0.3 |
| 4 | 6.5 | 4.8 | 1.7 |
| 6 | 7.4 | 4.8 | 2.6 |
| 8 | 10.2 | 4.8 | 5.4 |
| 10 | 8.8 | 4.8 | 4.0 |
| 12 | 7.4 | 4.8 | 2.6 |

Using Simpson's rule, the area enclosed by this discharge hydrograph

$$= \frac{H}{3}\left[\frac{1^{st} + \text{last ordinate}}{2} + 4 \times \text{Even ordinates} + 2 \times \text{odd ordinates}\right]$$

$$= \frac{2 \times 60 \times 60}{3}\left[\frac{0 + 2.6}{2} + 4(0.3 + 2.6 + 4.0) + 2(1.7 + 5.4)\right]$$

$= 103440 \text{ m}^3$

$\therefore$ Depth of water in the hydrograph $= \frac{103440}{400 \times 10^4} = 2.586 \times 10^{-2}\text{m}$ or 2.586 cm

Rainfall = 4 cm

Runoff = 2.586 cm

$\therefore$ Infiltration including basin recharge $= 4 - 2.586 = 1.414$ cm

$t_r$ = 4 hr (given)

$\therefore \quad \phi_{index} = \frac{1.414}{4} = 0.35$ cm/hr

17. (b)

$$\text{Loss} = \text{Rainfall} - \text{Runoff} = \frac{0.8}{100} \times 6 - \frac{256000}{8.6 \times 10^6} = 0.01823 \text{ m} = 1.823 \text{cm}$$

$$\text{Rate of loss} = \frac{1.823}{6} = 0.304 \text{cm/hr}$$

18. (b)

The probability of occurrence of an event $(x \geq x_T)$ at least once over a period of n successive years is called the risk, $\bar{R}$.

Hence, risk is given by

$$\bar{R} = 1 - (\text{Probability of occurence of the event } x \geq x_T \text{ in } n \text{ years})$$

$$= 1 - \left(1 - \frac{1}{T}\right)^n = 1 - \left(1 - \frac{1}{50}\right)^{25} = 0.397 \simeq 0.40$$

where, $T$ = Return period = 50 years

$n$ = Expected life = 25 years

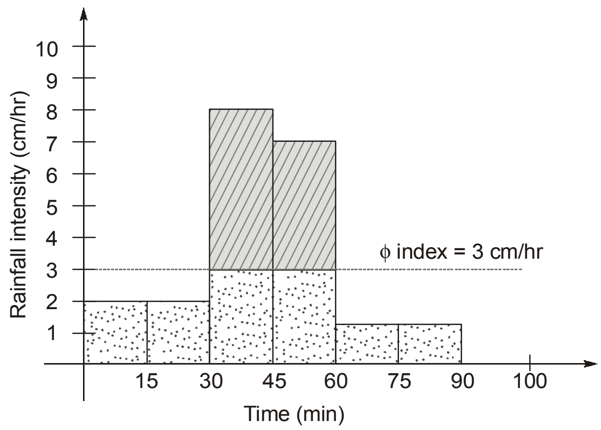
19. (b)

**Thiessen Polygon Method:** In this method, the rainfall recorded at each station is given a weightage on the basis of an area closest to the station.

$$P_{avg} = \frac{P_1A_1 + P_2A_2 + \ldots + P_nA_n}{A_1 + A_2 + \ldots + A_n}$$

where, $P_1, P_2, \ldots P_n$ are the rainfall data of areas $A_1, A_2 \ldots A_n$.

20. (b)




Hatched portion shows the total runoff and dotted portion shows the total infiltration.

$$\therefore \quad \text{Total runoff} = (8-3)\times\frac{15}{60} + (7-3)\times\frac{15}{60} = [(8-3)+(7-3)]\times\frac{15}{60} = 2.25\,\text{cm}$$

$$\text{Total precipitation} = 2\times\frac{15}{60} + 2\times\frac{15}{60} + 8\times\frac{15}{60} + 7\times\frac{15}{60} + 1.25\times\frac{15}{60} + 1.25\times\frac{15}{60}$$

$$= (2+2+8+7+1.25+1.25)\times\frac{15}{60} = 5.375\text{ cm}$$

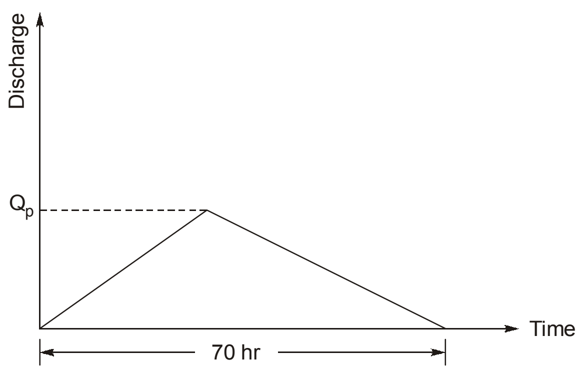
$$W\text{-index} = \frac{\text{Total precipitation} - \text{Runoff}}{\text{Duration of rainfall in hr}} = \frac{5.375 - 2.25}{90/60}$$

$$= 2.083\text{ cm/hr} \simeq 2.08\text{ cm/hr}$$

24. (c)

Let the peak of the UH be $Q_P$.

The UH can be shown as




Area of DRH gives the volume of rainfall,

$$\frac{1}{2}\times 70\times 60\times 60\times Q_P = \frac{1}{100}\times 756\times 10^6$$

$$\Rightarrow \quad Q_p = 60 \text{ m}^3/\text{s}$$

$$\therefore \quad \text{Peak of DRH} = n \times \text{peak of UH} = 5\times 60 = 300 \text{ m}^3/\text{s}$$

25. (d)

$$\text{Total rainfall} = 0.5 + 1.8 + 2.9 = 5.2 \text{ cm}$$

$$\text{Infiltration} = 5.2 - 2 = 3.2 \text{ cm}$$

$$\text{Excess rainfall duration, } t_e = 2\times 3 = 6 \text{ hrs.}$$

$$\phi\text{-index} = \frac{3.2}{6} = 0.533 \text{ cm/hr}$$

This value being more than 0.5 cm/hr,
The excess rainfall duration will reduce by 2 hrs.

$$\therefore \quad t_e = 4 \text{ hrs.}$$

$$\text{Infiltration} = (1.8 + 2.9) - 2 = 2.7 \text{ cm}$$

$$\phi\text{-index} = \frac{2.7}{4} = 0.675 \text{ cm/hr}$$

26. (c)

$$\bar{x} = \frac{1}{n}\Sigma n_i = \frac{80+90+100+60+70}{5} = 80 \text{ cm}$$

The standard deviation of the rainfall is given by

$$\sigma = \sqrt{\frac{(x-\bar{x})^2}{n-1}}$$

$$\sigma = 15.81$$

$$\Rightarrow \quad C_V = \frac{\sigma}{\bar{x}}\times 100 = 19.76$$

$$N = \left(\frac{C_V}{\epsilon}\right)^2 = \left(\frac{19.76}{6}\right)^2 = 10.85 \simeq 11$$

Thus, additional number of rainguages = 11 – 5 = 6

27. (d)
Time base of both the unit hydrographs is same. Let it be $t$.

$$\therefore \quad \frac{1}{2}\times 30\times t\times\frac{1}{235} = \frac{1}{2}\times 90\times t\times\frac{1}{A_2}$$

$$\Rightarrow \quad A_2 = 235\times 3$$

$$\Rightarrow \quad A_2 = 705 \text{ km}^2$$

28. (a)

The calculations are tabulated below:

| Time (hr) | FH ($m^3/s$) | Base Flow ($m^3/s$) | DRH ($m^3/s$) |
|---|---|---|---|
| Col. (1) | Col. (2) | Col. (3) | Col. (4) |
| 0 | 5 | 5 | 0 |
| 12 | 15 | 5 | 10 |
| 24 | 40 | 5 | 35 |
| 36 | 80 | 5 | 75 |
| 48 | 60 | 5 | 55 |
| 60 | 50 | 5 | 45 |
| 72 | 25 | 5 | 20 |
| 84 | 15 | 5 | 10 |
| 96 | 5 | 5 | 0 |
| | | | $\Sigma O = 250$ |

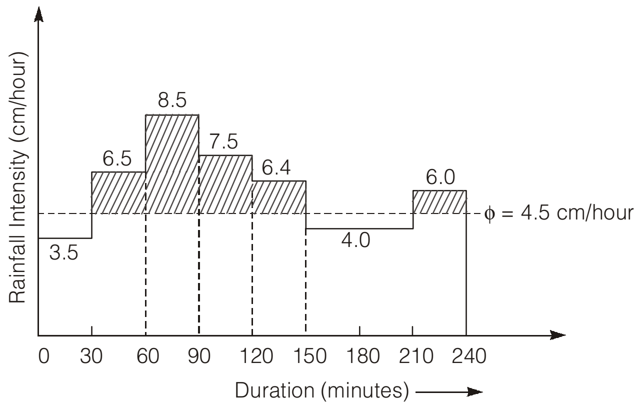
$$\text{Base flow} = 5 \text{ m}^3/\text{sec}$$

Now, direct runoff depth, $DRD = \dfrac{0.36 \times \Sigma O \times t}{A}$

where $\Sigma O = 250 \text{ m}^3/\text{s};\ t = 12 \text{ hr};\ A = 450 \text{ km}^2$

$\therefore$ $$DRD = \frac{0.36 \times 250 \times 12}{450} = 2.4 \text{ cm}$$

29. (c)




Rainfall excess is shown by hatched area.

Total rainfall

$$P = (3.5 + 6.5 + 8.5 + 7.5 + 6.4 + 4.0 + 4.0 + 6.0) \times \frac{30}{60} = 23.2 \text{ cm}$$

Total rainfall excess

$$R = [(6.5 - 4.5) + (8.5 - 4.5) + (7.5 - 4.5) + (6.4 - 4.5) + (6.0 - 4.5)] \times \frac{30}{60}$$

$$= (2 + 4 + 3 + 1.9 + 1.5) \times \frac{1}{2} = 6.2 \text{ cm}$$

$$W\text{-index} = \frac{P - R}{t} = \frac{23.2 - 6.2}{4} = 4.25 \text{ cm/hour}$$

30. (c)

| Time(hr) | 0 | 12 | 24 | 36 | 48 |
|---|---|---|---|---|---|
| Inflow($m^3/s$) | 100 | 750 | 780 | 470 | 270 |

$$Q_{\text{initial}} = 100 \text{ m}^3/\text{s}$$
$$k = 18 \text{ hours}$$
$$x = 0.3$$
$$2kx < \Delta t < k$$
$$2 \times 18 \times 0.3 < \Delta t < 18$$
$$\Delta t = 12 \text{ hrs}$$

Using Muskingham equation

$$C_0 = \frac{-kx + 0.5\,\Delta t}{k(1-x) + 0.5\,\Delta t} = \frac{-18 \times 0.3 + 0.5 \times 12}{18(1-0.3) + 0.5 \times 12} = 0.0323$$

$$C_1 = \frac{kx + 0.5\,\Delta t}{k(1-x) + 0.5\,\Delta t} = \frac{18 \times 0.3 + 0.5 \times 12}{18(1-0.3) + 0.5 \times 12} = 0.613$$

$$C_2 = \frac{k(1-x) - 0.5\,\Delta t}{k(1-x) + 0.5\,\Delta t} = \frac{18(1-0.3) - 0.5 \times 12}{18(1-0.3) + 0.5 \times 12} = 0.355$$

■■■■