CLASS TEST

S.No.:01SK_ABCD_210425

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HYDROLOGY

CIVIL ENGINEERING

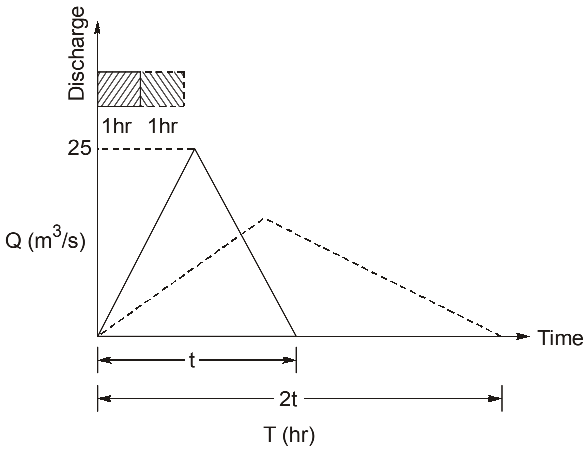
Date of Test : 21/04/2025

ANSWER KEY

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.	(a)
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.

3. (a)

$$\text{Lake evaporation} = C_P \times \text{Pan evaporation}$$

Average value of Pan coefficient C_P

Class A pan	0.70
ISI pan	0.80
Colorado Sunken pan	0.78

So for class *A* pan, C_P value is the minimum and , so for same lake evaporation, pan evaporation is maximum for class *A* pan.

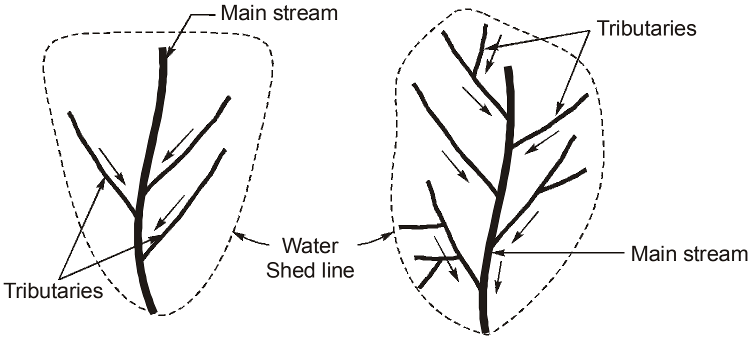
4. (a)
Since variation is more than 10%,

$$P_x = \frac{105}{3}\left[\frac{156}{155}+\frac{140}{150}+\frac{104}{120}\right]$$
$$= 98.2 \text{ cm}$$

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

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

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

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	Δy	6-*h* UH = (Δy × 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) Mean rainfall, $(\bar{P})$ = $\dfrac{\Sigma P}{n} = \dfrac{800+620+400+560}{4} = 595\,\text{mm}$

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

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

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

(v) Additional gauges required to be installed

= 8 – 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 $= \dfrac{103440}{400 \times 10^4} = 2.586 \times 10^{-2}\,\text{m}$ 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)

$\therefore$ $\phi_{\text{index}} = \dfrac{1.414}{4} = 0.35$ 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

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

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

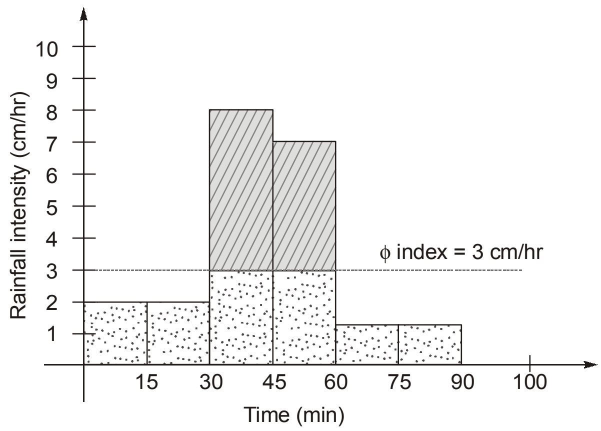
where, T = Return period = 50 years
n = Expected life = 25 years

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.

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

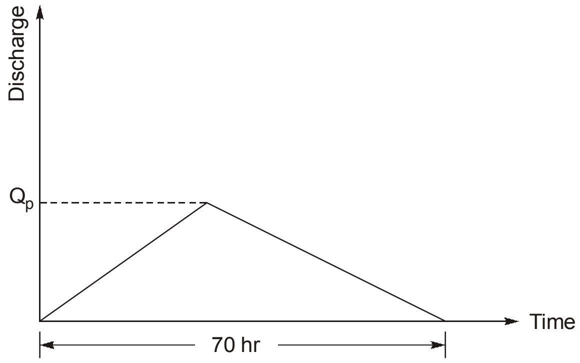
$$\text{Total precipitation} = 2\times\frac{15}{60} + 2\times\frac{15}{60} + 8\times\frac{15}{60} + 7\times\frac{15}{60} + 1.25\times\frac{15}{60} + 1.25\times\frac{15}{60}$$

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

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

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

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)

Horton's infiltration equation,

$$f_t = f_f + \left(f_i - f_f\right)e^{-k_h t}$$

where,
f_f = Final infiltration capacity
f_i = Initial infiltration capacity
k_h = Decay constant
f_t = Infiltration capacity at any time 't'

So, $$F = \int_0^t f_t dt = \int_0^t \left\{f_f + \left(f_i - f_f\right)e^{-k_h t}\right\}dt$$

$$\Rightarrow \quad 18 = \int_0^9 \left\{1 + (10-1)e^{-k_h t}\right\}dt$$

$$\Rightarrow \quad 18 = \int_0^9 \left(1 + 9e^{-k_h t}\right)dt$$

$$\Rightarrow \qquad 18 = \left(t + \frac{9e^{-k_h t}}{-k_h}\right)_0^9$$

$$\Rightarrow \qquad 18 = \left(9 + \frac{9e^{-k_h \times 9}}{-k_h}\right) - \left(0 + \frac{9}{-k_h}\right)$$

Now $\qquad e^{-9k_h} \simeq 0$

$$18 = 9 + \frac{9}{k_h}$$

$\therefore \qquad k_h \simeq 1\ \text{h}^{-1}$

Alternate Method:

Horton's infiltration equation

$$f_p = f_c + (f_0 - f_c)e^{-k_h t}$$

where, $\quad f_c$ = Final steady state infiltration capacity

f_o = Initial infiltration capacity

f_p = Infiltration capacity at any time 't'

k_h = Horton's Decay coefficient

For large value of 't'

The total depth of infiltration is given as

$$F_p = f_c t + \frac{f_o - f_c}{k_h}$$

Given, $\quad f_o = 10$ cm/h

$f_c = 1$ cm/hr

$t = 9$ hr

$f_p = 18$ cm

$$\therefore \qquad 18 = 1 \times 9 + \frac{10-1}{k_h}$$

$$k_h = \frac{9}{9} = 1\,\text{hr}^{-1}$$

27. (d)

Time base of both the unit hydrographs is same. Let it be t.

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

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

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

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
			$\Sigma O = 250$

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

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

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

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

29. (a)

The SCS-CN method is based on the water balance equation of the rainfall in a known interval of time Δt.

30. (c)

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

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

Using Muskingham equation

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

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

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

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