CLASS TEST

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ENGINEERING HYDROLOGY

CIVIL ENGINEERING

Date of Test : 26/11/2025

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

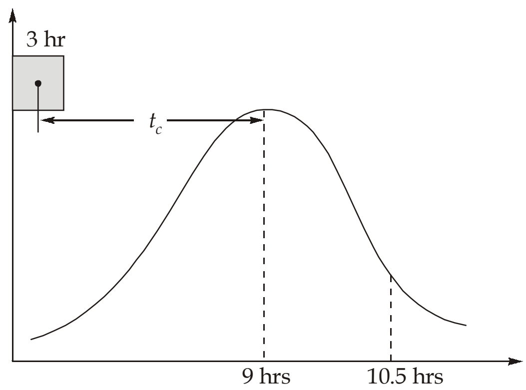
Time duration (hr)	Rainfall (cm)	Rainfall intensity (cm/hr)	Runoff (cm)
0 – 0.5	2	$\frac{2}{0.5} = 4\,\text{cm/hr}$	$(4-4)\times\frac{1}{2} = 0\,\text{cm}$
0.5 – 1	4	$\frac{4}{0.5} = 8\,\text{cm/hr}$	$(8-4)\times\frac{1}{2} = 2\,\text{cm}$
1 – 1.5	3	$\frac{3}{0.5} = 6\,\text{cm/hr}$	$(6-4)\times\frac{1}{2} = 1\,\text{cm}$

Total runoff = (2 + 1) cm = 3 cm

2. (b)

Due to urbanization, infiltration and storage capacity of soil reduces which leads to the following:
1. increase in peak discharge
2. decrease in time base and time of concentration
3. increase in the volume of runoff

3. (b)



$$\text{Time of concentration} = \left(9 - \frac{3}{2}\right)\text{hr} = 7.5\,\text{hr}$$

4. (b)

5. (b)

6. (d)

$$V_h \propto h^{1/7}$$

$$\Rightarrow \quad \frac{V_4}{V_{10}} = \left(\frac{4}{10}\right)^{1/7}$$

$$\Rightarrow \quad \frac{16}{V_{10}} = (0.4)^{1/7}$$

$$\Rightarrow \quad V_{10} = 18.2376\ \text{kmph}$$

$$= 5.066\ \text{m/s}$$

7. (b)

8. **(b)**

9. **(c)**

Given, Time period, $T = 60$ years,

So, $$p = \frac{1}{T} = \frac{1}{60}$$

Now, $$q = 1 - p = 1 - \frac{1}{60} = \frac{59}{60}$$

Now, probability of 1 hour rainfall greater than 10 cm once in 30 years = ${}^{30}C_1\, p^1 q^{(30-1)}$

$$= {}^{30}C_1 \left(\frac{1}{60}\right)\left(\frac{59}{60}\right)^{29} = \frac{30!}{29!1!}\left(\frac{1}{60}\right)^1\left(\frac{59}{60}\right)^{29} = 0.307$$

10. **(b)**

Using normal ratio method, missing annual rainfall at station X is given by

$$p = \frac{N_x}{n}\left[\frac{P_A}{N_A} + \frac{P_B}{N_B}\right]$$

where m is total number of neighboring stations,

$$\therefore \quad p = \frac{250}{2}\left[\frac{140}{200} + \frac{270}{300}\right] = 200 \text{ mm}$$

11. **(c)**

Effective rainfall is difference of the total rainfall and losses such as infiltration, evapo-transpiration etc.

The given rainfall is during 1 hr intervals, so they can be considered as rainfall intensity.

Since ϕ-index is 12 cm/hr, so rainfall during 1st and 4th hour is not considered in effective rainfall as it infiltrates.

Effective rainfall depth = (20 – 12) × 1 + (40 – 12) × 1 = 36 cm

12. **(b)**

Inflow – Outflow = Change in storage

$$(I + R) - (O + S + E) = \Delta S$$

$$\left(\frac{15\times30\times24\times3600}{30\times10^6} + \frac{15}{100}\right) - \left(\frac{20\times30\times24\times3600}{30\times10^6} + \frac{2}{100} + E\right) = -\frac{20\times10^6}{30\times10^6}$$

$$1.296 + 0.15 - 1.728 - 0.02 - E = -0.667$$

$$E = 0.365 \text{ m} = 36.5 \text{ cm}$$

13. **(a)**

Given, ϕ-index = 1 cm/hr

Base flow = 10 m^3/s

Excess rainfall in first 2 hours = 2 cm – ϕ × Δt

= 2 cm – 1 cm/hr × 2 = 0 cm

Excess rainfall in second 2 hours = 6 cm – ϕ × Δt

= 6 cm – 1 cm/hr × 2

= 4 cm

Excess rainfall in third 2 hours = 4 cm – ϕ × Δt

= 4 cm – 1 cm/hr × 2

= 2 cm

The calculation are tabulated below:

Time (hr)	Ordinate of 2-h UH (m^3/s)	Ordinate of 0 cm DRH Col. 2 × 0	Ordinate of 4 cm DRH (Col. 2 lagged by 2h) × 4	Ordinate of 2 cm DRH (Col. 2 lagged by 4h) × 2	Ordinate of 6 cm DRH (Col. 3 + Col. 4 + Col. 5)
1	2	3	4	5	6
0	0	0	–	–	0
2	4	0	0	–	0
4	8	0	16	0	16
6	16	0	32	8	40
8	10	0	64	16	80
10	8	0	40	32	72
12	6	0	32	20	52
14	0	0	24	16	40
			0	12	12
				0	0

Hence, peak flow of 6 cm DRH = 80 m^3/s

So, peak flow of flood hydrograph = 80 + 10 = 90 m^3/s

14. (a)

$$F_p = \int_1^2 \left(2 + e^{-2t}\right) dt = \left[2t + \frac{e^{-2t}}{-2}\right]_1^2$$

$$= \left(2 \times 2 - \frac{e^{-4}}{2}\right) - \left(2 \times 1 - \frac{e^{-2}}{2}\right)$$

$$= 4 - \frac{1}{2e^4} - 2 + \frac{1}{2e^2} = 2.0585 \text{ cm} \simeq 2.06 \text{ cm}$$

15. (d)

Mean precipitation, $\bar{x} = \dfrac{115.5 + 106.8 + 125.4 + 95.6 + 90.4}{5} = 106.74$ cm

Standard deviation, $\bar{\sigma} = \sqrt{\dfrac{\Sigma\left(x_i - x^{-2}\right)}{n-1}}$

$$\Rightarrow \quad \bar{\sigma} = \sqrt{\frac{\left[\begin{array}{l}(106.74 - 115.5)^2 + (106.74 - 106.8)^2 + (106.74 - 125.4)^2 \\ + (106.74 - 95.6)^2 + (106.74 - 90.4)^2\end{array}\right]}{4}}$$

$\Rightarrow \quad \bar{\sigma} = 14.283$

Hence, $C_v = \dfrac{\bar{\sigma}}{\bar{x}} \times 100$

$\Rightarrow \quad C_v = \dfrac{14.283}{106.74} \times 100 = 13.38\ \%$

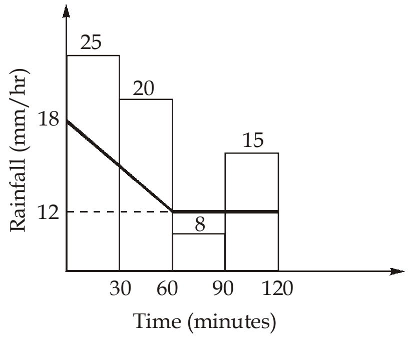
Number of optimum rainguages,

$$N = \left(\frac{C_v}{\epsilon}\right)^2$$

$$\Rightarrow \quad N = \left(\frac{13.38}{5}\right)^2 = 7.16 \simeq 8$$

Number of additional rain gauges = 8 – 5 = 3

16. (b)



For first hour,

$$\text{Total precipitation} = \left(25 \times \frac{30}{60}\right) + 20\left(\frac{30}{60}\right) = 22.5 \text{ mm}$$

$$\text{Total infiltration} = \frac{1}{2}(18+12)\left(\frac{60}{60}\right) = 15 \text{ mm}$$

$$\text{Runoff for first hour} = 22.5 - 15 = 7.5 \text{ mm}$$

For 60 min to 90 min,

$$\text{Total precipitation} = 8 \times \frac{30}{60} = 4 \text{ mm}$$

$$\text{Total infiltration} = 12 \times \frac{30}{60} = 6 \text{ mm}$$

Note: Since rate of infiltration is more, hence total infiltration will be equal to total precipitation and surface runoff will be zero.

For 90 minutes to 120 minutes,

$$\text{Total precipitation} = 15 \times \frac{30}{60} = 7.5 \text{ mm}$$

$$\text{Total infiltration} = 12 \times \frac{30}{60} = 6 \text{ mm}$$

$$\therefore \quad \text{Runoff} = 7.5 - 6 = 1.5 \text{ mm}$$

$$\text{Now, total infiltration} = 15 + 4 + 6 = 25 \text{ mm}$$

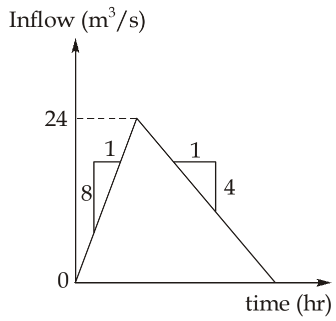
$$\text{Total runoff} = 7.5 + 1.5 = 9 \text{ mm}$$

$$\therefore \quad \text{Required Ratio} = \frac{25}{9} = 2.778 \simeq 2.78$$

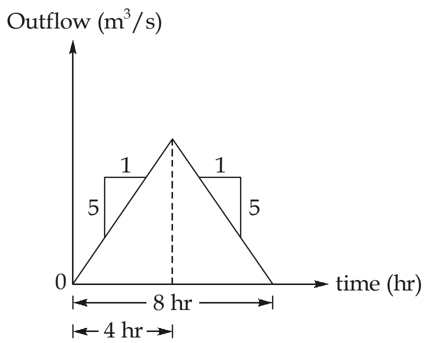
17. (c)

Time (hr)	2-hr UH (m^3/s)	Offset S-curve ordinate	S-curve ordinate	S-curve ordinate lagged by 3 hr	Δy	3-hr UH (m^3/s) $\Delta y \cdot \frac{2}{3}$
0	0	-	0	-	0	0
1	36	-	36	-	36	24
2	91	0	91	-	91	60.67
3	76	36	112	0	112	74.67
4	40	91	131	36	95	63.33
5	25	112	137	91	46	30.67
6	6	131	137	112	25	16.67
7	0	137	137	131	6	4
	0	137	137	137	0	0

18. (a)



Time at peak flow of inflow hydrograph = $\frac{1}{8} \times 24 = 3$ hr



Peak of outflow hydrograph = $4 \times 5 = 20$ m^3/s

Therefore, Peak lag = $4 - 3 = 1$ hr

Peak attenuation = $24 - 20 = 4$ m^3/s

19. (b)

Given, saturation vapour pressure,

$$e_s = 16.84 \text{ mm of Hg}$$

$\because$ Relative humidity = $\dfrac{\text{Actual vapour pressure}}{\text{Saturation vapour pressure}}$

$$\Rightarrow \qquad 0.75 = \frac{e_a}{e_s}$$

$$\Rightarrow \qquad e_a = 0.75 \times 16.84 = 12.63 \text{ mm of Hg}$$

Now, wind velocity at height of 9 m above ground surface,

$$V_9 = V_1(9)^{1/7}$$

$$= 15 \times 9^{1/7} = 20.53 \text{ kmph}$$

From Meyer's method,

$$\text{Evaporation loss, } E_L = k_m(e_s - e_a)\left(1 + \frac{V_9}{16}\right)$$

$$= 0.5(16.84 - 12.63)\left(1 + \frac{20.53}{16}\right) = 4.81 \text{ mm/d}$$

20. **(a)**

The area of the hyetograph above the infiltration curve represents the runoff volume.

21. **(b)**

Coalescence process occurs through electrostatic attraction amongst the oppositely charged cloud particles.

In the ice-crystal process, the water droplets may exist in clouds at subfreezing temperatures down to –40°C. In this range, solidification occurs in connection with certain particles which are called freezing nuclei.

22. **(b)**

Since k = 12 hr and 2 kx = z × 12 × 0.2 = 4.8 hr

Δt should be such that 12h > Δt > 4.8 hr

Taking Δt = 6 hr

$$C_0 = \frac{-kx + 0.5\Delta t}{k(1-x) + 0.5\Delta t} = \frac{-12 \times 0.2 + 0.5 \times 6}{12 - 12 \times 0.2 + 0.5 \times 6} = 0.048$$

$$C_2 = \frac{k(1-x) - 0.5\Delta t}{k(1-x) + 0.5(\Delta t)} = \frac{12 - 12 \times 0.2 - 0.5 \times 6}{12 - 12 + 0.5 \times 6} = 0.524$$

23. **(d)**

As per dilution technique,

Discharge in stream, $$Q = \frac{Q_1[C_1 - C_2]}{C_2 - C_0}$$

where,

Q_1 = 35 × 10^{-3} m^3/sec.

C_0 = 15 ppm = 15 mg/L

C_1 = 300 g/l = 300 × 10^3 mg/L

C_2 = 70 ppm = 70 mg/L

$$\therefore \qquad Q = \frac{35 \times 10^{-3}\left[300 \times 10^3 - 70\right]}{70 - 15} = 190.86 \simeq 191 \text{ m}^3/\text{sec}$$

24. **(b)**

Given: Radius of well, r_w = 0.225 m [∵ diameter of well, D_w = 0.45 m]

Discharge in well, Q = 1500 l/min = 0.025 m^3/sec

Thickness of aquifer, H = 45 m

Now, at $r_A = 10$ m

Drawdown, $s_A = 5$ m

So, $h_A = 45 - 5 = 40$ m

At, $r_B = 30$ m

Drawdown, $s_B = 2$ m

So, $h_B = 45 - 2 = 43$ m

Now, as we know,

$$Q = \frac{\pi k\left(h_B^2 - h_A^2\right)}{\ln\left(\frac{r_B}{r_A}\right)} \quad \text{...(i)}$$

where k is proportionality of soil

$$\Rightarrow \quad 0.025 = \frac{\pi \times k \times (43^2 - 40^2)}{\ln\left(\frac{30}{10}\right)}$$

$$\Rightarrow \quad k = 3.511 \times 10^{-5} \text{ m/s}$$

Again,

$$Q = \frac{\pi k\left(h_B^2 - h_w^2\right)}{\ln\left(\frac{r_B}{r_w}\right)}$$

$$\Rightarrow \quad 0.025 = \frac{\pi \times 3.511 \times 10^{-5} \times (43^2 - h_w^2)}{\ln\left(\frac{30}{0.225}\right)}$$

$$\Rightarrow \quad h_w = 27.203$$

So, Drawdown in well, $s_w = H - h_w = 45 - 27.203 = 17.8$ m

25. (c)

Isochrone is an imaginary line joining the points having same value of time of concentration. Line joining equal depth of rainfall on a map is called iso-pluvial/isohyetal line.

26. (a)

$$P = [10 + 30 + 40 + 50 + 25 + 8] \times \frac{30}{60} = 81.5 \text{ mm}$$

$$R = 38 \text{ mm}$$

$$W_{\text{index}} = \frac{P - R}{t} = \frac{81.5 - 38}{\left(\frac{180}{60}\right)} = 14.5 \text{ mm/hr}$$

Now, from $t = 0$ to 30 minutes and from $t = 150$ to 180 minutes, rainfall intensity is less than W_{index}.

So,

$$\phi_{\text{Index}} = \frac{81.5 - 38 - \left((10 + 8) \times 0.5\right)}{\frac{[180 - 30 - 30]}{60}} = 17.25 \text{ mm/hr}$$

27. (d)

Equivalent uniform rainfall depth

$$P = \frac{\left(\frac{14+12}{2}\right)20+\left(\frac{12+10}{2}\right)25+\left(\frac{10+8}{2}\right)15+\left(\frac{8+6}{2}\right)35+\left(\frac{6+4}{2}\right)20}{(20+25+15+35+20)}$$

$$\Rightarrow \quad P = \frac{13\times20+11\times25+9\times15+7\times35+5\times20}{(20+25+15+35+20)}$$

$$\Rightarrow \quad P = 8.83 \text{ cm}$$

$\therefore$ Runoff depth, $R = kP = 0.4 \times 8.83 = 3.53$ cm

$\therefore$ Volume of runoff = 3.53 × (Area of the catchment)

$$= 3.53\times[20+25+15+35+20]\times\frac{10^6}{10^2} \text{ m}^3$$

$$= 4059500 \text{ m}^3 = 405.95 \text{ ha-m}$$

28. (a)

Muskingum equation for storage is given by,

$$S = k\left[xI^m + (1-x)Q^m\right]$$

For natural reservoir, $m = 1$

For linear storage or linear reservoir, $x = 0$

$$S = kQ$$

29. (b)

Given : $T = 2$ years

$$\therefore \quad P = \frac{1}{T} = \frac{1}{2}$$

$$P = \frac{M-0.5}{N} = \frac{1}{2}$$

Here, $N = 7$

$$\therefore \quad M = \frac{7}{2} + 0.5 = 4 \text{ (order number)}$$

Arranging the given data in descending order

Rainfall (cm)	15	14.1	13.8	13	12.7	11.3	11
Order number (m)	1	2	3	4	5	6	7

For M = 4

Rainfall = 13 cm

30. (d)

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