CLASS TEST

Sl. : 02-IGCE-I+J+K-31072023

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HYDROLOGY

CIVIL ENGINEERING

Date of Test : 31/07/2023

ANSWER KEY

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

DETAILED EXPLANATIONS

1. (c)

Double mass curve technique is used to check the consistency of rainfall data.

2. (d)

$$\text{Rainfall, } P_1 = 6 \text{ cm}$$
$$\text{Runoff, } R_1 = 3 \text{ cm}$$

$\therefore$ $$\phi\text{-index, } \phi_1 = \frac{6-3}{6} = \frac{1}{2} \text{cm/hr}$$

since, $$\phi_1 = \phi_2$$

$\therefore$ $$\frac{1}{2} = \frac{12-R_2}{9}$$
$$R_2 = 7.5 \text{ cm}$$

3. (c)

S.No.	Soil type	Infiltration Capacity (mm/h)	Remarks
1.	Highly Clayey soils	1.25	Very Low
2.	Clayey soils	2.5 to 25	Low
3.	Sandy loam	12.5 to 25	Medium
4.	Deep sands	> 25	High

4. (b)

Equilibrium discharge, $$Q_e = 2.778 \times \frac{300}{3} = 277.8 \text{ m}^3/\text{s}$$

7. (d)

$$\text{Risk } \overline{R} = 1 - \left(1 - \frac{1}{T}\right)^n$$

Here, $$n = 25 \text{ years}$$
$$T = 100 \text{ years}$$

$\therefore$ $$\overline{R} = 1 - \left(1 - \frac{1}{100}\right)^{25} = 1 - \left(\frac{99}{100}\right)^{25}.$$

8. (b)

Station B is inoperative

$$N_B = 180 \text{ cm}$$
$$1.1N_B = 198 \text{ cm}$$
$$0.9N_B = 162 \text{ cm}$$
$$N_A = 175 \text{ cm} \quad N_C = 165 \text{ cm}$$

Since, N_A and N_C are within 10% of N_B

$\therefore$ $$P_B = \frac{P_A + P_C}{2} = \frac{150+135}{2} = 142.5 \text{ cm}$$

9. (c)

IS 4987: 1968 recommendation are

In plains: 1 station per 520 km^2

For 1040 km^2, no of stations required $= \dfrac{1040}{520} = 2.$

11. (b)

$$\text{Total rainfall, } P = 1.5 + 2.5 + 3.0 + 6.5 + 7.0 + 7.5 + 8.5 + 8.0 + 7.0 + 6.5 + 2.5 + 2.0$$
$$= 62.5 \text{ cm}$$
$$\text{Total runoff, } Q = 20.5 \text{ cm}$$
$$t_r = 12 \text{ hr}$$
$$\therefore \quad W_{\text{index}} = \frac{P-Q}{t_r} = \frac{62.5-20.5}{12} = 3.5 \text{ cm/hr}$$

For ϕ-index, the values lesser than 3.5 cm/hr are neglected i.e. 1.5, 2.5, 3, 2.5, 2.0 are neglected.

$$\therefore \quad P = 6.5 + 7.0 + 7.5 + 8.5 + 8.0 + 7.0 + 6.5 = 51$$
$$Q = 20.5 \text{ cm}$$
$$t_r = 12 - 5 = 7 \text{ hr}$$
$$\therefore \quad \phi_{\text{index}} = \frac{P-Q}{t_r} = \frac{51-20.5}{7} = 4.357 \text{ cm/hr} \simeq 4.36 \text{ cm/hr}$$
$$|W_{\text{index}} - \phi_{\text{index}}| = 4.36 - 3.5 = 0.86 \text{ cm/hr}$$

12. (a)

$$k = 0.60$$

Month	Temp.(F)	Percent sunshine hr(P_h)	$\Sigma P_h T_f$
Nov	60	2	120
Dec	55	8	440
Jan	50	7	350
Feb	60	6	360
			$\Sigma P_h T_f = 1270$

$$\therefore \quad \text{PET} = \frac{2.54\,K\,\Sigma P_h T_F}{100} = \frac{2.54 \times 0.6 \times 1270}{100}$$
$$\text{PET} = 19.35 \text{ cm}$$

13. (a)

For the second 30 minutes,

$$t_1 = 30 \text{ mins} = 0.5 \text{ hr}$$
$$t_2 = 60 \text{ mins} = 1\text{hr}$$

Total infiltration,
$$F_p = \int_{0.5}^{1} \left(4 + e^{-2t}\right) dt = \int_{0.5}^{1} 4\, dt + \int_{0.5}^{1} e^{-2t}\, dt$$
$$= [4t]_{0.5}^{1} + \left[-\frac{e^{-2t}}{2}\right]_{0.5}^{1} = 4 \times (1 - 0.5) + \frac{1}{2}\left[e^{-2\times 0.5} - e^{-2\times 1}\right]$$

$$= 2 + \frac{1}{2}\left[e^{-1} - e^{-2}\right]$$

$$= 2 + \frac{1}{2}\left[\frac{1}{e} - \frac{1}{e^2}\right] = 2 + \frac{1}{2} \times 0.232 = 2 + 0.116 = 2.116 \text{ cm}$$

14. (a)

$$\frac{U_c}{U_m} = \frac{1 \text{ cm}}{1 \text{ mm}}$$

$$\Rightarrow \quad \frac{U_c}{U_m} = \frac{1}{0.1}$$

$$\Rightarrow \quad U_c = 10\, U_m$$

$$\therefore \quad U_m = \frac{U_c}{10}$$

15. (d)

Distribution graph is basically a D-hr unit hydrograph with ordinate showing the percentage of surface runoff occurring in successive period of equal time intervals of D-hr.

16. (c)

Isohyet Interval	Average Isohyet Rainfall (mm)	Area between Isohyets (km^2)	PA
115 – 105	110	120	13200
105 – 95	100	150	15000
95 – 85	90	200	18000
85 – 75	80	250	20000
		$\Sigma A = 720$	$\Sigma PA = 66200$

Average rainfall, $$P_{avg} = \frac{\Sigma PA}{\Sigma A} = \frac{66200}{720} = 91.94 \text{ mm}$$

$$\text{Volume of runoff} = 0.7 \times 720 \times 10^6 \times 91.94 \times 10^{-3} = 46.34 \times 10^6 \text{ m}^3 = 46.34 \text{ Mm}^3$$

$$\text{Volume of losses} = (1 - 0.7) \times 720 \times 10^6 \times 91.94 \times 10^{-3}$$

$$= 19.86 \times 10^6 \text{ m}^3 = 19.86 \text{ Mm}^3$$

$\therefore$ Volume of runoff – Volume of losses = 46.34 – 19.86 = 26.48 Mm^3

17. (a)

In hydrologic routing, discharge is taken as a function of time.

19. (a)

As we know,

$$\frac{(Q)_{\text{unsteady}}}{(Q)_{\text{steady}}} = \sqrt{1 + \frac{dh/dt}{V_w \cdot S_o}}$$

$$\Rightarrow \quad (Q)_{\text{unsteady}} = 160 \times \sqrt{1 + \frac{11.2 \text{ cm/hr}}{2.0 \text{ m/s} \times 100 \times 3600 \times \frac{1}{3600}}} = 164.42 \text{ m}^3/\text{s}$$

20. (c)

Rainfall excess in 1st three hours, R_1 = 0.5 × 3 = 1.5 cm

Rainfall excess in 2nd three hours, R_2 = 1 × 3 = 3 cm

t(hr)	Ordinate of 3hr UH	DRH due to 1.5 cm ER	DRH due to 3 cm ER	Ordinate of final DRH	Base flow (m^3/s)	Ordinates of flood hydrograph (m^3/s)
0	0	0×1.5		0	7	7
3	10	10× 1.5	0 × 3	15	7	22
6	15	15 × 1.5	10 × 3	52.5	7	59.5
9	30	30 × 1.5	15 × 3	90	7	97
12	18	18 × 1.5	30 × 3	117	7	124
15	6	6 × 1.5	18 × 3	63	7	70
18	0	0 × 1.5	6 × 3	18	7	25
21			0 × 3	0	7	7

At t = 12 hr, ordinate of flood hydrograph is 124 m^3/s

21. (a)

Data normally required in the studies are

(i) Weather records in term of temperature, humidity and wind velocity

(ii) Precipitation data

(iii) Stream flow records

(iv) Evaporation and evapotranspiration data

(v) Infiltration characteristics of the study area

(vi) Soils of the area

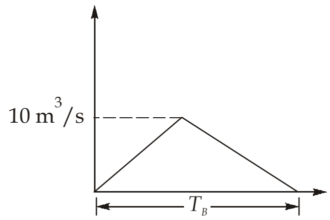
(vii) Land use and land cover

(viii) Ground water characteristics

(ix) Physical and geological characteristics of the area

(x) Water quality data

22. (c)



Unit hydrograph ⇒ R = 1 cm = 0.01 m

$$\frac{1}{2} \times T_B \times 100 \times 3600 = 90 \times 10^6 \times 0.01$$

$$T_B = 50 \text{ hours}$$

23. (c)

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

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

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

24. (c)

$$\mu = P_{av.} = \frac{800 + 520 + 440 + 420}{4} = 545 \text{ mm}$$

$$\sigma_{n-1} = \sqrt{\frac{\Sigma(P_i - P_{av})^2}{n-1}}$$

$$\Rightarrow \quad \sigma_{n-1} = \sqrt{\frac{(800-545)^2 + (520-545)^2 + (440-545)^2 + (420-545)^2}{4-1}}$$

$$\Rightarrow \quad \sigma_{n-1} = 175.404 \text{ mm}$$

$$\therefore \quad c_v = \frac{\sigma_{n-1}}{\mu} \times 100 = \frac{175.404}{545} \times 100 = 32.18\%$$

Now, No. of rainguages, $N = \left(\frac{c_v}{\varepsilon}\right)^2 = \left(\frac{32.18}{6}\right)^2 = 28.77$

i.e. $N = 29$

$\therefore$ Additional raingauge stations required = 29 – 4 = 25

25. (b)

Total rainfall volume $= 0.015 \times 8 \times 1.5 \times 10^6$

$= 180{,}000 \text{ m}^3$

Total infiltration volume = Total rainfall – Runoff

$= 180{,}000 - 35000$

$= 145000 \text{ m}^3$

$\therefore$ Infiltration depth $= \dfrac{145000}{1.5 \times 10^6} = 0.0967 \text{ m} = 9.67 \text{ cm}$

26. (b)

P = Input due to precipitation in 10 hours

$$= 200 \times 100 \times 100 \times \frac{9}{100} = 180000 \text{ m}^3$$

R = Runoff $= 2 \times 12 \times 3600 = 86400 \text{ m}^3$

Water not available to runoff $= 180000 - 86400 = 93600 \text{ m}^3$

28. (a)

Relative humidity, $R_H = \dfrac{e_a}{e_s}$

$$\Rightarrow \quad 0.5 = \frac{e_a}{34 \text{ mm}}$$

$\therefore \quad e_a = 17$ mm of Hg

Also, $\dfrac{v_9}{v_2} = \left(\dfrac{9}{2}\right)^{1/7} = 1.24$

$\therefore \quad v_9 = 1.24 \times 12 = 14.88$ kmph

So, daily evaporation, $E = k_m(e_s - e_a)\left(1 + \frac{v_9}{16}\right)$

$$= 0.36(34-17)\left(1+\frac{14.88}{16}\right) = 11.81 \text{ mm/day}$$

29. (c)

For the 1st hour rainfall, $P = 45$ mm

$$\text{Effective rainfall} = \frac{12\times(0)+7(45-30)+1(0)}{20} = 5.25 \text{ mm}$$

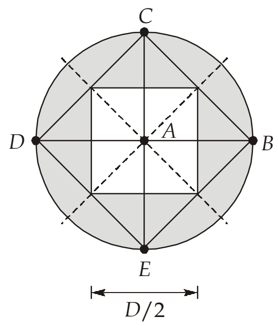
For the second hour rainfall, $P = 55$ mm

$$\text{Effective rainfall} = \frac{12(55-50)+7(55-30)+1(0)}{20} = 11.75 \text{ mm}$$

$\therefore$ Total effective rainfall = 5.25 + 11.75 = 17 mm

30. (d)

Basin diameter, $D = 15$ km



$$\text{Side of square around station } A = \frac{15}{2} = 7.5 \text{ km}$$

Area of station A = 7.5 × 7.5 = 56.25 km^2

$$\text{Total area of circular basin} = \frac{\pi}{4}(15)^2 = 176.7 \text{ km}^2$$

Area of station B = Area of station C = Area of station D = Area of station E

$$= \left(\frac{176.7-56.25}{4}\right) = 30.11 \text{ km}^2$$

$$\therefore \quad \text{Mean rainfall} = \frac{9\times 56.25+30.11(7+10+11+8)}{176.7}$$

$$= 8.99 \simeq 9 \text{ cm}$$

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