Class Test Solution (Hydrology) 08-09-2019

Answer key

1.	(d)	16.	(a)	31.	(b)	46.	(a)	61.	(c)
2.	(b)	17.	(c)	32.	(a)	47.	(c)	62.	(d)
3.	(b)	18.	(b)	33.	(c)	48.	(b)	63.	(a)
4.	(b)	19.	(b)	34.	(a)	49.	(a)	64.	(b)
5.	(d)	20.	(b)	35.	(d)	50.	(b)	65.	(d)
6.	(b)	21.	(d)	36.	(c)	51.	(a)	66.	(a)
7.	(a)	22.	(c)	37.	(b)	52.	(a)	67.	(b)
8.	(c)	23.	(d)	38.	(d)	53.	(b)	68.	(d)
9.	(b)	24.	(b)	39.	(d)	54.	(b)	69.	(c)
10.	(c)	25.	(c)	40.	(d)	55.	(c)	70.	(a)
11.	(b)	26.	(b)	41.	(a)	56.	(a)	71.	(b)
12.	(c)	27.	(d)	42.	(b)	57.	(a)	72.	(d)
13.	(c)	28.	(c)	43.	(c)	58.	(d)	73.	(a)
14.	(b)	29.	(d)	44.	(c)	59.	(c)	74.	(d)
15.	(a)	30.	(b)	45.	(b)	60.	(a)	75.	(a)

1. (d)

2. (b)

A_1 = at depth (10 m)

$A_1 = 100 \times 10^2 = 10000\ m^2$

$A_2 = 100 \times 9^2 = 8100\ m^2$

$$\text{Avg. surface area} = \frac{1}{3}\left[A_1 + A_2 + \sqrt{A_1 \times A_2}\right]$$

$$= 9033.33\ m^2$$

Total loss of water = $9033.33 \times 1 = 9033.33\ m^3$

Let evaporation loss = x

so, seepage loss = 0.4x

$\therefore$ x + 0.4x = Total loss

$1.4x = 9033.33\ m^3$

$$x = \frac{9033.33}{1.4} m^3$$

Rate of evaporation

$$= \frac{9033.33 \times 10^3}{1.4 \times 9033.33 \times 7 \times 24}$$

$= 4.25\ mm/h/m^2$.

3. (b)

$$p = \frac{1}{T} = \left(\frac{1}{8}\right)$$

n = 5 years

r = 2 times

$$q = 1 - p = \left(\frac{7}{8}\right)$$

$$P = {}^nC_r (p)^r q^{n-r}$$

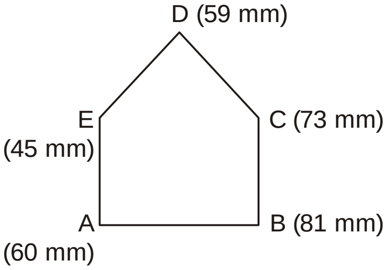
$$P = {}^5C_2\,(p)^2\, q^3$$

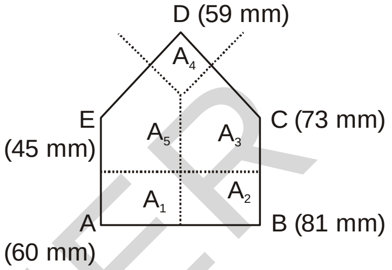
$$P = {}^5C_2 \times \left(\frac{1}{8}\right)^2 \times \left(\frac{7}{8}\right)^3$$

$$\boxed{P = 0.104}$$

4. (b)

5. (d)





$A_1 = 10 \times 10 = 100\ km^2$

$A_2 = 10 \times 10 = 100\ km^2$

$$A_3 = A_5 = 10 \times 10 + \frac{\sqrt{3}}{4} \times 20^2 \times \frac{1}{3}$$

$$= 157.7\ km^2$$

$$A_4 = \frac{\sqrt{3}}{4} \times 20^2 \times \frac{1}{3} = 57.7\ km^2$$

$$P_{avg.} = \frac{60 \times 100 + 81 \times 100 + 73 \times 157.7 + 59 \times 57.7 + 45 \times 157.7}{573.1}$$

$P_{avg.} = 63.01$ mm.

6. (b)

7. (a) $93\begin{cases} \to 93 \times 1.1 = 102.3 \\ \to 93 \times 0.9 = 83.7 \end{cases}$

Normal ratio method is used because normal precipitation at any of the selected stations is above 10% of that for station with missing data.

$$P_D = \frac{93}{3}\left[\frac{92}{90} + \frac{72.6}{67} + \frac{78.9}{77}\right] = 97.04\,\text{cm}$$

8. (c)

9. (b)

Arranging the data in descending order

order (m)	(Rainfall) (cm)
1	14.2
2	13.6
4	12.0
4	12.0
5	7.9
7	6.0
7	6.0
8	4.8
9	3.7
10	2.9

Return period for 6.0 cm annual rainfall using

(i) Hazen formula

$$T = \frac{N}{m-0.5} = \frac{10}{7-0.5} = \frac{10}{6.5} = \frac{100}{65} = \frac{20}{13}$$

(ii) Weibull formula

$$T = \frac{N+1}{m} = \frac{11}{7}$$

10. (c)

11. (b)

12. (c)

$$0.19 = 1-\left(1-\frac{1}{T}\right)^2$$

$$\sqrt{0.81} = 1-\frac{1}{T}$$

$$0.9 = 1-\frac{1}{T}$$

$$0.1 = \frac{1}{T}$$

T = 10 year

13. (c) $$P_{avg} = \frac{\left(\frac{P_1+P_2}{2}\right)A_1 + \left(\frac{P_2+P_3}{2}\right)A_2....}{A_I + A_2 + A_3 + A_4}$$

= 6.292 cm

14. (b)

15. (a) Flow duration curve of a stream is a plot of discharge against percentage of time the flow was equalled or exceeded.

A flow duration curve based on daily flow data will be steeper than a curve based on monthly flow data because the larger interval data will smoothen out the variations in shorter interval data.

16. (a) Flow mass curve is a plot of the cummulative discharge volume of a river against time plotted in chronogical order.

17. (c) Optimum number of raingauge stations (N) is given by

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

where, C_v = coefficient of variation = 40%

and ϵ = admissible error = 10%

$$\therefore \quad N = \left(\frac{40}{10}\right)^2 = 16$$

$$\therefore \quad N \simeq 16$$

18. (b)

Time (hr)	Rainfall (mm)	ϕ_{index} (mm/hr)	Effective rainfall (mm)
1	8	10	0
2	32	10	22
3	14	10	4
4	6	10	0
			26 mm

Runoff depth = 26 mm

19. (b)

Total rainfall in catchment

= 10 + 15 + 20 + 22 + 5 = 72 mm

Total volume of direct runoff

$$= 0.50 \times 60 \times 60 \times 24 = 43200\ \text{m}^3$$

$$\phi\ \text{index} = \frac{P-R}{t}$$

$$= \frac{72-8.64}{5} = 12.672\ \text{mm/hr}$$

Thus rainfall of 10 & 5 mm will not give runoff,

$$\text{Again} = \frac{72-10-5-8.64}{3} = 16.12\ \text{mm/hr}$$

∴ Rainfall of 15 mm will also not contribute to runoff,

$$= \frac{72-10-5-15-8.64}{2} = 16.68\ \text{mm/hr}$$

20.(b)

Total volume of rainfall

$$= 20 \times 10^{-3} \times 100 \times 10^{4} \times 6\ \text{m}^3$$

$$= 120000\ \text{m}^3$$

Precipitation not available to runoff

$$= 120000 - 30000$$

$$= 90000\ \text{m}^3$$

$$= \frac{90000}{100 \times 10^{4}} \times 100\ \text{cm} = 9\ \text{cm}$$

21. (d)

22. (c)

For a current meter, velocity of a stream is given by

$$v = aN + b$$

where v is in m/s, and N is the revolutions per second of the current meter; a and b are constants

$$\therefore \quad = \frac{12}{50} \times a + b = 0.25$$

$$\Rightarrow \quad 0.24a + b = 0.25 \qquad \text{....(i)}$$

$$\text{and}\ \frac{30}{50} \times a + b = 0.46$$

$$\Rightarrow \quad 0.6a + b = 0.46 \qquad \text{...(ii)}$$

Solving (i) and (ii), we get a = 0.583 and b = 0.11

$$\therefore \quad v = 0.583 \times \frac{50}{60} + 0.11 = 0.6\ \text{m/s}$$

23. (d)

$$\Delta h_0 = 12 - 11.65 = 0.35\ \text{m}$$

$$\Delta h_a = 12 - 11.02 = 0.98\ \text{m}$$

$$\frac{Q_a}{Q_0} = \left(\frac{\Delta h_a}{\Delta h_0}\right)^n$$

$$\Rightarrow \quad \frac{15.20}{9.50} = \left(\frac{0.98}{0.35}\right)^n$$

$$\therefore \quad n = 0.4565$$

Again, when auxiliary gauge reads 11.37 m

$$\Delta h_a = 12 - 11.37 = 0.63\ \text{m}$$

$$\frac{Q_a}{9.50} = \left(\frac{0.63}{0.35}\right)^{0.4565}$$

$$Q_a = 12.424\ \text{cumec}$$

24. (b)

$$\sum_{\text{inlet}} \gamma h_{\text{salt}} = \sum_{\text{outlet}} \gamma h_{\text{salt}}$$

$$(0.05)\left(25\frac{\text{kg}}{\text{s}}\right) + (0.15)\left(10\frac{\text{kg}}{\text{s}}\right)$$

$$= x\left(35\frac{\text{kg}}{\text{s}}\right)$$

Rearranging to solve for x, the salt concentration in the exit stream,

$$x = \frac{(0.05)\left(25\,\frac{kg}{s}\right)+(0.15)\left(10\,\frac{kg}{s}\right)}{35\,\frac{kg}{s}}$$

$$= 0.0786\ (7.9\%).$$

25. (c)

26. (b)

$$\phi_{index} = \frac{P-Q}{t}$$

For 1st storm

$$\left(\phi_{index}\right)_1 = \frac{8-4}{6} = \frac{2}{3}\,\frac{cm}{hr}$$

for 2nd storm

$$\left(\phi_{index}\right)_1 = \left(\phi_{index}\right)_2$$

$$\therefore \quad \frac{12-Q}{9} = \frac{2}{3}$$

$$\Rightarrow \quad Q = 6\ cm$$

27. (d)

Evapotranspiration ⟶ Lysimeter

Capillary potential ⟶ Tensiometer

28. (c)

29. (d)

30. (b) Specific yield

$$= \frac{\text{volume of water extracted}}{\text{Total volume of water in bearing strata}} \times 100$$

$$= \frac{5m^3}{2m \times 10m^2} \times 100$$

$$\boxed{S_y = 25\%}$$

31. (b)

$$\phi = 0.5\ cm/hr$$

$$\text{Rainfall} = \frac{2\ cm}{6\ hr} = 0.33\ cm/hr$$

Since rate of rainfall < Infiltration rate

Effective rainfall = 0

32. (a)

Rain fall = 1.6 + 5.4 + 4.1 = 11.1 cm

Runoff = 4.7 cm,

$$\phi = \frac{11.1-4.7}{3} = 2.133\,cm/hr$$

As 1.6 cm is rainfall of very low intensity, all rainfall will infilterate,

$$\phi\ \text{index} = \frac{(5.4+4.1)-4.7}{8\times 2}$$

$$= \frac{4.8}{16} = 0.3\ cm/hr$$

33. (c)

34. (a)

$$F = \int_0^{3/4} f\,dt = \int_0^{0.75}\left(6+16e^{-2t}\right)dt = \mathbf{10.72\ mm}$$

35. (d)

36. (c)

37. (b)

38. (d)

39. (d)

$$\phi \text{ index} = \frac{P-R}{t}$$

$$3 = \frac{(9+6.6+6)\times 20/60 - R}{(20\times 3/60)}$$

$$R = 4.2 \text{ mm}$$

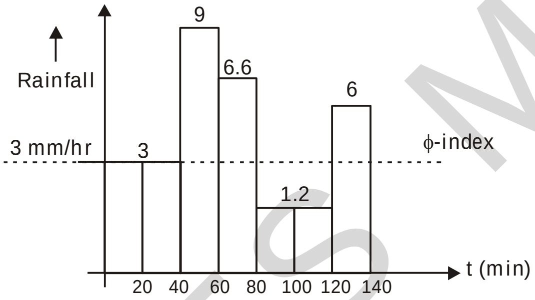
for W index,

$$= \left(\frac{P-R-\text{losses}}{t}\right)\text{effective}$$

$$= \frac{(9+6.6+6)\times\dfrac{20}{60}-4.2-0.8}{\left(20\times\dfrac{3}{60}\right)}$$

$$= 2.2 \text{ mm/hr}$$

40. (d)



Total rainfall

$$= (3+3+9+6.6+1.2+1.2+6.0)\times\frac{20}{60}$$

$$= 10 \text{ mm}$$

41. (a)

42. (b)

43. (c)

44. (c)

$$f(t) = f_c + (f_0 - f_c)e^{-kt}$$

$$f(t) = 1.4 + (9.2 - 1.4)\, e^{-0.8t}$$

$$\int_0^3 [1.4 + 7.8\, e^{-0.8t}]\,dt$$

$$= \boxed{13.065\,\text{cm}}$$

To get point of intersection of horton's curve and hyetograph,

$$4.9 = 1.4 + 7.8e^{-0.8t}$$

$$t = 1 \text{ hour}$$

thus, commulative runoff,

$$= 4.9\times(3-1) - \int_1^3 (1.4 + 7.8e^{-0.8t})\,dt$$

$$= 3.5 \text{ cm}$$

45. (b)

46. (a)

Top width of water level = 4 + 2 + 2 = 8 m

Total water spread in the canal in 10.0 km

$$= 8 \times 10 \times 1000$$

$$= 8 \times 10^4 \text{ m}^2$$

$$\text{Rate of evaporation} = 8\times 10^4 \times \frac{0.35}{1000}\times 24$$

$$= 672 \text{ m/day}$$

47. (c)

48. (b)

Time (hr)	Rainfall (mm)	ϕ_{index} (mm/hr)	Effective rainfall (mm)
1	8	10	0
2	32	10	22
3	14	10	4
4	6	10	0
			26 mm

Runoff depth = 26 mm

49. (a)

As per Indian Meterological Department

Decrease from normal precipitation	**Classification**
< 25	No drought effect
26-50%	Moderate
> 50%	Severe

- If the drought occurs in an area with a probability of $0.2 \le P \le 0.4$ the area is classified as a *drought prone area*.
- If the probability of occurrence of drought at an area is greater than 0.40, such an area is called as *chronically drought prone area*.

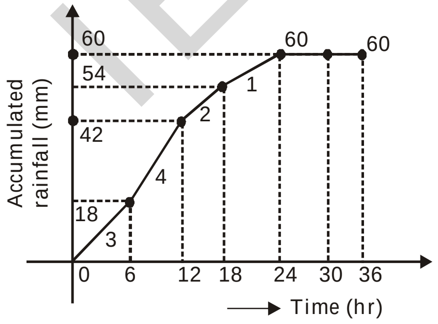
  IMD defines drought in any area when the rainfall deficiency in that area is $\geq$ 25% of its long term normal. It is further classified into moderate and severe drought depending upon whether the deficiency is between 25 to 50% and more than 50% respectively.

50. (b)

51. (a) Flow duration curve of a stream is a plot of discharge against percentage of time the flow was equalled or exceeded.

A flow duration curve based on daily flow data will be steeper than a curve based on monthly flow data because the larger interval data will smoothen out the variations in shorter interval data.

52. (a)



53. (b)

54. (b)

Duration of the rainstorm would not affect the maximum possible discharge from a small catchment corresponding to particular rainfall intensity.

55. (c)

56. (a)

57. (a)

58. (d)

59. (c)

Average rainfall= 3.5 cm

$$\text{loss in 3 hour} = 0.4 \times 3 = 1.2 \text{ cm}$$

$$\text{Runoff depth} = 3.5 - 1.2 = 2.3 \text{ cm}$$

Peak flow of flood hydrograph = 260 m^3/s

$$\text{base flow} = 35 \text{ m}^3/\text{s}$$

Peak flow of DRH = 260 – 35

$$Q_P = 225 \text{ m}^3/\text{s}$$

Peak flow of 3h unit hydrograph

$$= \frac{\text{Peak discharge of DRH}}{\text{Runoff depth}} = \frac{225}{2.3}$$

$$Q_P = 97.82 \text{ m}^3/\text{sec}$$

60. (a)

61. (c)

The equilibrium discharge is expressed as $Q_s = \frac{A}{D} \times 10^4 \, m^3/h$ where A is the area of catchement in km^2 and D is the duration in hours.

$$\therefore \quad Q_s = \frac{270}{3} \times 10^4$$

$$= 90 \times 10^4 \text{ m}^3/\text{h}$$

$$= \frac{90 \times 10^4}{3600} \text{m}^3/\text{s}$$

$$= 250 \text{ m}^3/\text{s}$$

62. (d)

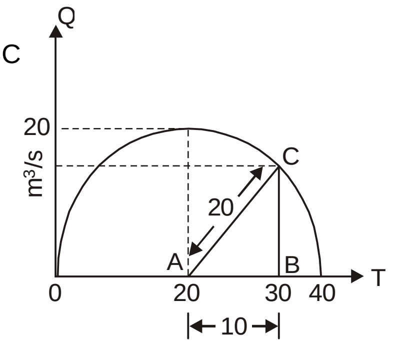
$$\text{Total rainfall} = 4.3 \text{ cm}$$

$$\text{infiltration} = 0.3 \text{ cm}$$

$$\text{Run off} = 4.3 - 0.3$$

$$\text{Run off} = 4.0 \text{ cm}$$

from DABC



$$AC^2 = AB^2 + BC^2$$

$$BC = \sqrt{AC^2 - AB^2}$$

$$BC = 17.32$$

Discharge of unit hydrograph corresponding to 30th hour.

For 4 cm effective rainfall

$$Q = 4 \times 17.32$$

$$\boxed{Q = 69.28 \text{ m}^3/\text{sec}}$$

∴ Ordinate of flood hydrograph = 69.28 + 20 = 89.28 m^2/sec

63. (a)

$$Q = 6.28 \text{ m}^3/\text{sec}$$

Let area of watershed is A

from equation

Depth of rainfall × catchment area

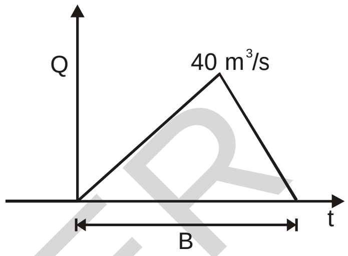
= Area Under U.H.

$$A \times 0.01 = \frac{1}{2} \times \Pi \times 20 \times 3600 \times 20$$

$$A = 226.08 \text{ km}^2$$

64. (b)

65. (d)



$$\frac{1}{2} \times 40 \times B = 1 \times 250 \times 10^6 \times 10^{-2}$$

$$B = \frac{250 \times 10^4 \times 2}{40} = 12.5 \times 10^4 \text{ sec}$$

$$A \times 1 \times 10^{-2} = \frac{1}{2} \times 80 \times 12.5 \times 10^4$$

$$A = 40 \times 12.5 \times 10^6$$

$$= 500 \times 10^6 \text{ m}^2$$

$$= 500 \text{km}^2$$

66. (a)

In very large catchment basins, storms may not meet the conditions of constant intensity within effective storm duration and uniform areal distribution. Therefore, each storm may give different direct runoff hydrograph under, otherwise, identical conditions. Therefore, unit hydrograph is considered applicable for catchments having area less than about 5000 km^2. Very large catchments are usually divided into smaller sub-basins and the hydrographs of these sub-basins are proceesed to obtain composite hydrograph at the basin outlet.

67. (b) Flow duration curve of a stream is a plot of discharge against the percent of time the flow was equalled or exceeded some of the important uses of flow duration curve are

1. In evaluating various dependable flows in planning of water resources projects.
2. In flood control studies.
3. In the design of drainage systems
4. In evaluating the hydropower potential of a river.

68. (d)

69. (c) Peak flow usually occurs after cessation of rainfall. This however is not always necessary.

The starting point of the recession limits, i.e., the point of inflection represents the condition of maximum storage.

Since the depletion of storage takes place after the cessation of rainfall, the shape of this part of hydrograph is independent of storm characteristics and depends entirely on the basin characteristics.

70. (a)

Perennial stream: one which always carries some flow. Ground water contributes throughout the year.

71. (b)

W-index : The W-index is a refined version of ϕ-index. It excludes the depression storage and interception from the total losses. It is the average infiltration rate during the time rainfall intensity exceeds the capacity rate. That is

$$W = \frac{F}{t} = \frac{(P-Q-S)}{t}$$

72. (d) Vegetation cover tends to increase infiltration by

(i) retarding surface flow and thus allowing more time for water to enter the soil,

(ii) shielding the soil surface from direct impact of rain drops, thereby reducing surface compaction.

73. (a) DAD curves are always a falling curve because as the area increases the average depth over the area decreases.

74. (d) **Theissen polygon method:** This method gives weightage to the various rainfall datas based on area close to the rain gauge station called theissen polygon areas. The method is fast when once the weights are known. But it does not take care of the variability in rainfall due to elevation difference. *(i.e.*, topographical influence are not taken care of). New polygon is required to be drawn when, due to addition or deletion of raingauges to the network, weight of each station changes.

75. (a)