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CHAPTER

Precipitation

Q.1 A tropical cyclone is a
(a) low-pressure zone that occurs in the northern hemisphere only
(b) high-pressure zone with high winds
(c) zone of low pressure with clockwise winds in the northern hemisphere
(d) zone of low pressure with anticlockwise winds in the northern hemisphere

Q.2 Orographic precipitation occurs due to air masses being lifted to higher altitudes by
(a) the density difference of air masses
(b) a frontal action
(c) the presence of mountain barriers
(d) extratropical cyclones

Q.3 Variability of annual rainfall in India is
(a) least in regions of scanty rainfall
(b) largest in regions of high rainfall
(c) least in regions of high rainfall
(d) largest in coastal areas

Q.4 The following recording raingauge does not produce the mass curve of precipitation as a record
(a) Symon's raingauge
(b) Tipping-bucket type rain gauge
(c) Weighing-bucket type rainguage
(d) Natural siphon gauge

Q.5 The monthly rainfall at a place *A* during September 1982 was recorded as 55 mm above normal. Here, the term normal means
(a) the rainfall in the same month in the previous year
(b) the rainfall was normally expected based on previous month's data
(c) the average rainfall computed from past 12 month's record
(d) The average monthly rainfall for September computed from a specific 30 years of past record

Q.6 The Thiessen polygon is
(a) a polygon obtained by joining adjoining raingauge stations
(b) a representative area used for weighting the observed station precipitation
(c) an area used in the construction of depth-area curves
(d) the descriptive term for the shape of a hydrograph

Q.7 An isohyet is a line joining points having
(a) equal evaporation value
(b) equal barometric pressure
(c) equal height above the MSL
(d) equal rainfall depth in a given duration

Q.8 By DAD analysis the maximum average depth over an area of 10^4 km^2 due to one day storm is found to be 47 cm. For the same area the maximum average depth for a three day storm can be expected to be
(a) <47 cm
(b) >47 cm
(c) = 47 cm
(d) inadequate information to conclude

Q.9 Depth-Area-Duration curves of precipitation are drawn as
(a) minimizing envelopes through the appropriate data points
(b) maximizing envelopes through the appropriate data points
(c) best fit mean curves through the appropriate data points
(d) best fit straight lines through the appropriate data points

Q.10 A study of the isopluvial maps revealed that at Calcutta a maximum rainfall depth of 200 mm in 12 h has a return period of 50 years. The probability of a 12 h rainfall equal to or greater than 200 mm occurring at Calcutta at least once in 30 years is
(a) 0.45 (b) 0.60
(c) 0.56 (d) 1.0

Q.11 A 6 h rainfall of 6 cm at a place A was found to have a return period of 40 years. The probability that as a 6h rainfall of this or larger magnitude will occur at least once in 20 successive years is
(a) 0.397 (b) 0.603
(c) 0.309 (d) 0.025

Q.12 The probability of a 10 cm rain in 1 hour occurring at a station *B* is found to be 1/60. What is the probability that a 1 hour rain of magnitude 10 cm or larger will occur in station *B* once in 30 successive years is
(a) 0.396 (b) 0.307
(c) 0.604 (d) 0.500

Q.13 A one day rainfall of 18 hours at Station *C* was found to have a return period of 50 years. The probability that a one-day rainfall of this or larger magnitude will not occur a station *C* during next 50 years is
(a) 0.636 (b) 0.020
(c) 0.364 (d) 0.371

Q.14 If the maximum depth of a 50 years 15 h rainfall depth at Bhubaneshwar is 260 mm, the 50 yeas 3 h maximum rainfall depth at the same place is
(a) < 260 mm
(b) > 250 mm
(c) = 260 mm
(d) inadequate date to conclude anything

Q.15 The probable maximum depth of precipitation over a catchment is given by the relation $PMP =$
(a) $\bar{P}+KA^n$ (b) $\bar{P}+K\sigma$
(c) $\bar{P}\exp(-KA^n)$ (d) $m\bar{P}$

Q.16 Match List-I (Hydrological Terms) with List-II (Relationship/Nature of Curve) and select the correct answer using the codes given below the lists:

List-I
A. Theissen Polygon
B. Mass Curve
C. Hyetograph
D. DAD curve

List-II
1. Average depth of rainfall over an area
2. Relationship of rainfall intensity and time
3. Relationship of accumulated rainfall and time
4. Relationship of river run-off and time
5. Always a falling curve

Codes:

	A	B	C	D
(a)	1	3	2	5
(b)	1	5	3	2
(c)	4	3	2	5
(d)	4	5	3	2

Q.17 In a watershed, four rain gauges I, II, III and IV are installed. The depths of normal annual rainfall at these stations are 60, 75, 80 and 100 cm respectively.
The rain gauge at station III went out of order during a particular year. The annual rainfall for that year recorded at the remaining three stations was 90, 60 and 70 cm. The rainfall at station III can be considered as
(a) 60 cm (b) 70 cm
(c) 80 cm (d) 120 cm

Q.18 Match List-I (Hydrological Terms) with List-II (Relationship/Nature of Curve) and select the correct answer using the codes given below the lists:

List I

A. Convective
B. Cyclonic
C. Frontal
D. Orographic

List II

1. Atmospheric disturbance
2. Mountain barrier
3. Pressure difference
4. Temperature difference
5. Warm and cold air masses

Codes:

	A	B	C	D
(a)	1	4	5	2
(b)	4	3	5	2
(c)	1	4	2	5
(d)	4	3	2	5

Q.19 The area between the two isohyets 45 cm and 55 cm is 100 km², and that between 55 cm and 65 cm is 150 km². What is the average depth of annual precipitation over the basin of 250 km²?
(a) 50 cm (b) 52 cm
(c) 56 cm (d) 60 cm

Q.20 The normal annual precipitation at stations *X*, *A*, *B* and *C* are 700 mm, 1000 mm, 900 mm and 800 mm respectively. If the storm precipitation at three station *A*, *B* and *C* were 100 mm, 90 mm and 80 mm respectively, then the storm precipitation for station X will be
(a) 70 mm (b) 80 mm
(c) 90 mm (d) 105 mm

Q.21 The maximum average depth due to one day storm over an area of 100 km² is 100 mm. Depth-Area-Duration (DAD) curves indicate that for the same area of 100 km² the maximum average depth for a 3 hour storm will be
(a) 100 mm
(b) more than 100 mm
(c) less than 100 mm
(d) none of the above

Q.22 If the coefficient of variation of rainfall value at 4 raingauge stations is 30% and permissible error in the estimation of mean rainfall is 10%, then the additional number of raingauge stations required in the catchment is
(a) 3 (b) 4
(c) 5 (d) 9

Q.23 The following rainfall data refers to stations *A* and *B* which are equidistant from station '*X*':

	Station 'A'	Station 'X'	Station 'B'
Long-term normal annual rainfall (in mm)	200	250	300
Annual rainfall (in mm) for the year 1940	140	*P*	270

The value of *P* (in mm) will be
(a) 250 (b) 220
(c) 205 (d) 200

Q.24 Match List-I with List-II and select the correct answer using the codes given below the lists:

List-I

A. Tropical cyclone
B. Front
C. Anticyclone
D. Convective precipitation

List-II

1. High pressure region with clock wise winds in northern hemisphere
2. Local phenomenon at heating and formation of circulation cell
3. Interface between two different air masses
4. Strong depression with anticlockwise winds in northern hemisphere
5. Effect of mountains in lifting air masses

Codes:

	A	B	C	D
(a)	4	5	1	2
(b)	4	3	1	2
(c)	1	3	4	2
(d)	4	2	1	3

Q.25 Match List-I (Type of rain gauge) with List-II (Characteristic) and select the correct answer using the codes given below the lists:

List-I

A. Tipping bucket type
B. Weighing bucket type
C. Symon's gauge
D. Natural siphon type gauge

List-II

1. Standard recording type rain gauge adopted in India
2. Gives intensity of the rainfall
3. Gives mass curve of rainfall
4. Non recording gauge

Codes:

	A	B	C	D
(a)	3	3	4	1
(b)	2	3	4	1
(c)	3	2	4	1
(d)	2	3	1	4

Q.26 Study the following statements:
1. Cyclonic precipitation is caused by the lifting of an air mass due to the pressure difference.
2. Convective precipitation is caused due to the upward movement of the air that is warmer than its surroundings.
3. Orographic precipitation is caused by air masses which strike some natural topographic barriers like mountains, and cannot move forward and hence rise up, causing condensation and precipitation.

The correct statements(s) is(are):
(a) only 1 (b) both 1 and 2
(c) both 1 and 2 (d) 1, 2 and 3

Q.27 The standard Symons' type raingauge has a collecting area of diameter
(a) 12.7 cm (b) 10 cm
(c) 5.08 cm (d) 25.4 cm

Q.28 The standard recording raingauge adopted in India is of
(a) weighing bucket type
(b) natural siphon type
(c) tipping bucket type
(d) telemetry type

Q.29 The variation of rainfall between two sections in Isohyetal method is assumed :
(a) Linear (b) Parabolic
(c) Elliptical (d) Non-linear

Q.30 A river basin is divided into three Thiessen polygons with areas in the ratio of 0.45, 0.30 and 0.25. A rain storm causes precipitation in these polygons as 38 mm, 55 mm and 42 mm respectively. The average depth of precipitation for the basin is
(a) 45.0 mm (b) 44.1 mm
(c) 48.5 mm (d) 46.0 mm

Q.31 Symon's rain gauge is of type:
(a) recording type
(b) non-recording type
(c) may be both (a) and (b)
(d) indicating type

Q.32 Match the items in List-I (Instruments) and List-II (Items to be measured) using the codes below:

List-I

A. Tipping bucket gauge
B. Indian Standard Pan
C. Lysimeter
D. Rainfall simulator

List-II

1. Infiltration intensity
2. Evapotranspiration
3. Rainfall
4. Evaporation

The correct code is

Codes:

	A	B	C	D
(a)	3	4	2	1
(b)	1	4	2	3
(c)	1	2	4	3
(d)	3	2	4	1

Q.33 A, B and C are three catchments each having an area of about 10,000 km² situated in an arid zone, mountainous region of a tropical zone and flat region of a tropical zone respectively. The desirable number of hydrometeorological stations for each of these three areas N_A, N_B and N_C respectively will be such that

(a) $N_B > N_C > N_A$
(b) $N_A < N_B < N_C$
(c) $N_A > N_B > N_C$
(d) $N_B = N_C$ and $N_B > N_A$

Q.34 For a given storm, the highest rainfall P_0 and the average rainfall depth $\bar{P}$, are related as $\frac{\bar{P}}{P_0} =$

(a) $K \exp(A^n)$ (b) $\exp(-KA^n)$
(c) K^{-A} (d) constant

Q.35 Thermo-hygrograph gives a continuous recording of
(a) discharge on a thermal sensitive paper
(b) temperature and pressure
(c) temperature and humidity
(d) solar radiation and wind velocity

Q.36 Instruments for measuring the intensity of incoming radiations are called
(a) pyrheliometers
(b) sunshine recorders
(c) hygrometers
(d) psychrometers

Q.37 The relationship between wind direction and pressure gradient is stated as follows:
If an observer stands with his back to the wind in the northern hemisphere, the lower pressure is
(a) on his left (b) on his right
(c) in front of him (d) to his back

Q.38 A rainfall with an intensity of 5 mm/h is classified as
(a) traces (b) light rain
(c) moderate rain (d) heavy rain

Q.39 A precipitation in the form of water droplets of size less than 0.5 mm and intensity less than 1 mm/h is known as
(a) Rain (b) Sleet
(c) Hail (d) Drizzle

Q.40 The Indian Meteorological Department has changed over from Symon's, gauge to fibre glass raingauges of two sizes. The collector areas of these gauges are:
(a) 1000 cm² and 500 cm²
(b) 400 cm² and 20 cm²
(c) 200 cm² and 100 cm²
(d) 100 cm² and 50 cm²

Q.41 In installing a raingauge network, the relevant Indian Standard recommends that
(a) the density of gauges should be more in plains than in hills
(b) in regions having an average elevations of 1000 m, at least one station per 130 km² is desired
(c) at least 50% of raingauge stations should be of recording type
(d) at least 10% of raingauge stations should be of recording type

Q.42 If 'p' is the precipitation, 'a' is the area represented by a rain gauge, and 'n' is the number of rain gauges in a catchment area, then the weighted mean rainfall is

(a) $\frac{\Sigma ap^3}{\Sigma a^2}$ (b) $\frac{\Sigma ap}{n}$

(c) $\frac{\Sigma ap}{\Sigma a}$ (d) $\frac{\Sigma ap^5}{\Sigma a^3}$

Q.43 Mean precipitation over an area is best obtained from gauged amounts by
(a) arithmetic mean method
(b) Thiessen method
(c) linearly interpolated isohyetal method
(d) orographically weighted isohyetal method

Q.44 Which one of the following defines Aridity Index (AI)?

(a) $AI = \frac{PET - AET}{PET} \times 100$

(b) $AI = \frac{PET}{AET} \times 100$

(c) $AI = \frac{AET}{PET} \times 100$

(d) $AI = \frac{AET - PET}{AET} \times 100$

(where AET = Actual Evapotranspiration and PET = Potential Evapotranspiration)

Q.45 Which one of the following is not a major type of storm precipitation?
(a) Frontal storm
(b) Air mass storm
(c) Orographic storm
(d) Continental storm

Q.46 The least accurate method of computing mean depth of rainfall is
(a) Theissen polygon method
(b) Isohyetal method
(c) Arithmetic mean method
(d) None of the above

Q.47 Isobar is a line which joins the points of equal
(a) rainfall depth
(b) temperature
(c) humidity
(d) atmospheric pressure

Q.48 Which is the odd one in the following?
(a) Snow (b) Sleet
(c) Rain (d) Hail

Q.49 Coefficient of variation is given by

(a) $\frac{\text{Standard deviation}}{\text{Mean}} \times 100$

(b) $\frac{\text{Variance}}{\text{Mean}} \times 100$

(c) $\frac{\text{Mean}}{\text{Standard deviation}} \times 100$

(d) $\frac{\text{Mean}}{\text{Variance}} \times 100$

Q.50 According to Indian Standard, the number of raingauge stations for an area of 5200 km² in plains should be
(a) 10 (b) 15
(c) 20 (d) 40

Q.51 Which of the following type of raingauge is used for measuring rains in remote, hilly inaccessible areas?
(a) Tipping bucket type
(b) Weighing type
(c) Floating type
(d) Symon's raingauge

Q.52 The normal annual rainfall at stations A, B and C situated in meteorologically homogeneous region are 175 cm, 180 cm and 150 cm respectively. In the year 2000, station B was inoperative and stations A and C recorded annual precipitations of 150 cm and 135 cm respectively. The annual rainfall at station B in that year could be estimated to be nearly
(a) 150 cm (b) 143 cm
(c) 158 cm (d) 168 cm

Q.53 An anticyclone is
(a) a low pressure system withclockwise winds in northern hemisphere
(b) a high pressure system with clockwise winds in northern hemisphere
(c) a low pressure system with anticlockwise winds in northern hemisphere
(d) a high pressure system with anticlockwise winds in northern hemisphere

Q.54 During June 1984, reservoir had an average surface area of 20 km². In that month, mean rate of inflow = 10 m³/s, outflow = 15 m³/sec, monthly rainfall = 10 cm and change in storage = 16 Mm³. Assuming seepage losses to be 1.8 cm, the evaporation in month of June is:
(a) 11.21 cm (b) 23.40 cm
(c) 20.42 cm (d) 31.20 cm

Q.55 The normal annual precipitation of five raingauge stations A, B, C, D and E are respectively 125, 102, 76, 113 and 137 cm. During particular storm, the precipitation recorded by stations A, B, C and D are 13.2, 9.2, 6.8 and 10.2 cm respectively. The instrument at station E was inoperative during that storm. The rainfall at station E during storm is:
(a) 112.20 mm (b) 118.60 mm
(c) 128.60 mm (d) 114.20 mm

Q.56 The mean of normal annual rainfall for 5 stations is 92.8 m and standard deviation is 30.7. The optimum number of raingauge stations to limit the error in the mean value of rainfall to $\beta = 10\%$ is:

(a) 8 (b) 10
(c) 9 (d) 11

Q.57 During the month of 30 days, the average loss (seepage) from the 1375 ha reservoir was 2.5 cm, total precipitation on the reservoir was 18.5 cm and total evaporation was 9.5 cm. The constant rate of withdrawal from the reservoir in 30 days during which reservoir level dropped by 0.75 m in spite of average inflow into the reservoir of 0.5 Mm^3/day is
(a) 3.291 m^3/sec (b) 5.291 m^3/sec
(c) 2.192 m^3/sec (d) 6.191 m^3/sec

Q.58 Isohyetal method gives accurate mean areal depth of rainfall in:
1. In a plain country.
2. In a gently sloping basin.
3. In an undulating country.
4. In place of known storm movement.
5. When there are optimum number of raingauge stations.
6. When the precipitation includes snowmelt.
7. In basin consisting plains and hills.

(a) 3, 4 and 7 only (b) 1, 2, 3 and 5 only
(c) 3, 4, 5 and 6 only (d) All of the above

■■■■

Answers Precipitation

1. (d)	2. (c)	3. (b)	4. (c)	5. (d)	6. (b)	7. (d)	8. (b)	9. (b)	10. (a)
11. (a)	12. (b)	13. (c)	14. (a)	15. (b)	16. (a)	17. (c)	18. (b)	19. (c)	20. (a)
21. (c)	22. (c)	23. (d)	24. (b)	25. (b)	26. (d)	27. (a)	28. (b)	29. (a)	30. (b)
31. (b)	32. (a)	33. (a)	34. (b)	35. (c)	36. (a)	37. (a)	38. (c)	39. (d)	40. (c)
41. (d)	42. (c)	43. (d)	44. (a)	45. (d)	46. (c)	47. (d)	48. (c)	49. (a)	50. (a)
51. (a)	52. (c)	53. (b)	54. (b)	55. (c)	56. (d)	57. (d)	58. (a)		

Explanations Precipitation

10. (a)

$= 1 - q^n$

$= 1-\left(1-\frac{1}{50}\right)^{30}$

$= 0.454$

11. (a)

$= 1 - q^n$

$= 1-\left(1-\frac{1}{40}\right)^{20}$

$= 0.3973$

12. (b)

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

$= 0.3071$

17. (c)

$$P_x = \frac{N_x}{3}\left[\frac{P_A}{N_A}+\frac{P_B}{N_B}+\frac{P_C}{N_C}\right]$$

$$\Rightarrow \quad P_{11} = \frac{80}{3}\left[\frac{90}{60}+\frac{60}{75}+\frac{70}{100}\right]$$

$= 80$ cm

19. (c)

$P_1 = (45 + 55)/2 = 50$ cm

$P_2 = (55 + 65)/2 = 60$ cm

∴ Average depth of annual precipitation over the basin of 250 km^2.

$$P = \frac{\Sigma A_i}{\Sigma A}$$

$$= \frac{50\times100+60\times150}{(100+150)}$$

$= 56$ cm

20. (a)

$$\frac{1}{3}\left[\frac{700}{1000}\times100+\frac{700}{900}\times90+\frac{700}{800}\times80\right] = 70 \text{ mm}$$

21. (c)

Maximum depth for a given storm decreases with the area the maximum depth increases with duration.

22. (c)

Additional number of stations

$$= \left(\frac{\text{Coefficient of variation}}{\text{Allowable percentage of error}}\right)^2 - \text{Existing number of stations}$$

$$= \left(\frac{30}{10}\right)^2 - 4 = 5$$

23. (d)

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

25. (b)

Tipping Bucket Type: Such gauges are generally installed in hilly and inaccessible area, from where they can supply their measurements directly to the control room at meteorogical station.

Weighing Type: Weighs the rain which falls into a bucket placed on the platform of a spring or lever balance. The increasing weight of the bucket helps in recording the increasing quantity of collected rain, with time, by moving a pen on a revolving drum.

Symons' Gauge: A non recording raingauge.

Natural Syphon Type: A float type gauge, provided with a self starting syphonic arrangement is most widely used in India; and is population known as Natural syphon recording rain gauge.

27. (a)

The non-recording gauge extensively used in India is the symon's gauge. It essentially consists of a circular collecting area of 12.7 cm diameter connected to a funnel.

29. (a)

The variation of rainfall between two sections in isohyetal method is assumed linear. If P_1 and P_2 are the isohytels then

$$P_{avg} = \frac{P_1+P_2}{2}$$

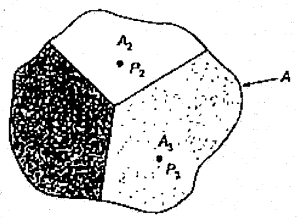
(Assuming linear variation)

30. (b)

Here, $\frac{A_1}{A} = 0.45$ and $P_1 = 38$ mm

$\frac{A_2}{A} = 0.30$ and $P_2 = 55$ m

$\frac{A_3}{A} = 0.25$ and $P_3 = 42$ mm



The average depth of precipitation for the basin is given by

$$P_{avg} = P_1\left(\frac{A_1}{A}\right)\times P_2\left(\frac{A_2}{A}\right)+P_3\left(\frac{A_3}{A}\right)$$

$P_{avg} = 38\times0.45+55\times0.30+42\times0.25$

$P_{avg} = 44.1$ mm

Hence option (b) is correct.

31. (b)

Symon's rain gauge is non-recording type rain gauge.

32. (a)

'Tipping bucket gauge' is a recording type rain gauge

'ISI standard pan' is used to measure evaporation loss

'Lysimeter' is used to measure actual evapotranspiration in the field.

'Rainfall simulator' is a device used to calculate infiltration capacity.

Hence option (a) is correct.

36. (a)

Hygrometer is an instrument used for measuring the moisture content in the atmosphere.

A psychrometer measures the relative humidity in the atmosphere.

38. (c)

On the basis of its intensity, rainfall is classified as:

Type	Intensity
1. Light rain	Trace to 2.5 mm/hr
2. Moderate rain	2.5 mm/hr to 7.5 mm/hr
3. Heavy rain	> 7.5 mm/hr

39. (d)

The rainfall is used to describe precipitations in the form of water drops of sizes larger than 0.5 mm. Sleet is frozen raindrops of transparent grain which form when rain falls through air at subfreezing temperature. Hail is a showery precipitation in the form of irregular pallets or lumps of size more than 8 mm. Drizzle is a fine sprinkle of numerous water droplets of size less than 0.5 mm and intensity less than 1 mm/h.

40. (c)

The Indian Meteorological department (IMD) has changed over to the use of fibre glass reinforced polyester raingauges, which is an improvement over the system gauge. These come in different combinations of collector and bottle. The collector in two sizes having areas of 200 and 100 cm^2 respectively.

43. (d)

Isohyets are contours of equal rainfall. The orographically weighted isohyets are prepared by tracing paper for mountainous areas and therefore they are more accurate than linearly interpolated isohyets

44. (a)

The departure of AI from its corresponding normal value is known as AI anomaly, represents moisture shortage. Based on AI anomaly, the intensity of agricultural drought is classified as follows:

AI anomaly	Severity class
1-25	Mild arid
26-50	Moderate arid
>50	Severe arid

50. (a)

In plains 1 station per 520 km^2 is recommended.

52. (c)

$$P_x = \frac{N_x}{2}\left[\frac{P_1}{N_1}+\frac{P_2}{N_2}\right]$$

$$= \frac{180}{2}\left[\frac{150}{175}+\frac{135}{150}\right]$$

$$= \frac{90}{25}\left[\frac{150}{7}+\frac{135}{6}\right]$$

$$= 5\times\frac{90}{25}\left[\frac{30}{7}+\frac{27}{6}\right]$$

$$= 18\left[\frac{180+189}{42}\right] = \frac{18\times369}{42}$$

$$= \frac{3\times369}{7} = 158.14\text{ cm} \simeq 158\text{ cm}$$

54. (b)

Inflow = $10 \times 60 \times 60 \times 24 \times 30$

$= 25.92\ Mm^3$

Outflow = $15 \times 60 \times 60 \times 24 \times 30$

$= 38.88\ Mm^3$

Rainfall volume = $\left(\frac{10}{100}\right)\times 20\times(1000)^2$

$= 2.00\ Mm^3$

Seepage = $\left(\frac{1.8}{100}\right)\times 20\times(1000)^2$

$= 0.36\ Mm^3$

Change in volume = $(25.92 + 2.00 - 38.88 - 0.36)$

$= -11.32\ Mm^3$

Actual change = $-16.0\ Mm^3$

Hence evaporation = $16.00 - 11.32 = 4.68\ Mm^3$

$$= \frac{4.68}{20\times10^6}\times10^6\times100$$

$= 23.4$ cm

55. (c)

$$P_x = \frac{N_x}{M}\left[\frac{P_1}{N_1}+\frac{P_2}{N_2}+\frac{P_3}{N_3}+\frac{P_4}{N_4}\right]$$

$$P_x = \frac{137}{4}\left[\frac{13.2}{125}+\frac{9.2}{102}+\frac{6.8}{76}+\frac{10.2}{113}\right]$$

$\Rightarrow \quad P_x = 128.60$ mm

56. (d)

We know, $N = \left(\frac{C_v}{p}\right)^2$ where

N = optimum number of raingauge stations to be established

C_v = coefficient of variation of rainfall of existing raingauge station.

p = desired degree of percentage error.

$\therefore \quad C_v = \left(\frac{\sigma}{\bar{x}}\right) = \left(\frac{30.7}{92.8}\right)\times 100$

$\Rightarrow \quad C_v = 33.1\%$

$\therefore \quad N = \left(\frac{C_v}{P}\right)^2 = \left(\frac{33.1}{10}\right)^2 = 11$

57. (d)

Period, Δt = 1 month = 30 days

Input volume = $PA + \bar{I}\Delta t$

Output volume = $\bar{O}\Delta t + (G + E + T)A$

$PA + \bar{I}\Delta t - [\bar{O}\Delta t + (G + E + T)A]$ = change in storage = ΔS

$$\Rightarrow \quad PA = \frac{18.5}{100}\times\frac{1375\times10^4}{10^6}$$

$= 2.5438\ Mm^3$

Total input volume = $17.5438\ Mm^3$

$$(G + E + T)A = (2.5 + 9.5 + 0)\times\frac{1}{100}\times\frac{1375\times10^4}{10^6}$$

$= 1.6\ Mm^3$

$$\Delta S = S_2 - S_1 = 0.75\times\frac{1375\times10^4}{10^6}$$

$= 0.1031\ Mm^3$

$\bar{O}\Delta t = [PA + \bar{I}\Delta t] - \Delta S - (G + E + T)A$

$= 17.5438 + 0.1031 - 1.60$

$= 16.047\ Mm^3$

Constant Rate of withdrawal =

$$\bar{Q} = \frac{16.047\times10^6}{30\times24\times60\times60} = 6.191\ Mm^3$$

58. (a)

Isohyetal method to determine the mean depth of rainfall is valid for undulating area and the place of storm movement.

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