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Internal Assessment Test 1 – April 2023

Sub:	Hydrology and Irrigation Engineering					SubCode:	18CV63	Branch:	CV
Date:	25.4.2023	Duration:	90 mins	Max Marks:	50	Sem/Sec:	VI		OBE

Answer any five questions.
Provide neat sketches wherever necessary

		MARKS	CO	RBT
1	Discuss various processes involved in 'Hydrologic Cycle' using Horton's Engineering representation.	[10]	CO1	L1
2	Explain Convective, Orographic and Cyclonic type of precipitation.	[10]	CO1	L2
3	a) The average normal rainfall of five rain gauges in the base stations are: 89,54,45,41 and 55cm. If the error in the estimation of rainfall should not exceed 10%. How many additional rain gauges may be required? b) What are the different forms of precipitation? Explain.	[10]	CO1, 2	L2,3
4	Explain a) Tipping bucket raingauge b) Natural Syphon raingauge	[10]	CO1	L2
5	Briefly explain with neat sketch a) Mass curve b) Double Mass curve c) Rainfall Hyetograph d) Moving Average method	[10]	CO2	L1
6	What is Evapouration? List and Explain the factors affecting it.	[10]	CO2	L1
7	Explain: a) Arithmetic Mean Method b) Isohyetal Method c) Normal Ratio method	[10]	CO1	L2

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IAT 1

Scheme

Ques 1.

Soln Various processes in Hydrological cycle — 5 × 2 = (10)

Ques 2

Convective
Orographic
Cyclonic
} — 3.5 × 2 + 3 = (10)

Ques 3

(a) $N = \left(\frac{Cv}{C}\right)^2 = 11.13$

Addⁿ no required = 12 − 5 = 17

— (5)

(b) forms of precipitation.
- Snow
- Rain
- Hail
- Glaze
- Sleet

— × (5)

Qy

(a) Tipping bucket
- diagram.
- Size
- method of rainfall collection

— × (5)

(b) Natural Syphon raingauge.
- diagram
- Size
- Method of rainfall collection

— (5)

Total = (10 marks)

Q5 (a) Mass curve — (2.5)
- plot
- Importance

(b) Double mass curve. — (2.5)

(c) Rainfall hyeto graph — (2.5)

(d) moving average — (2.5)

Q6 Evaporation — (4)

factors Affecting — (6)
- wind velocity
- Size & shape of C.A.
- Temperature.
- Humidity.
-

Q7 (a) Arithmetic mean method — (3)
- Importance
- formula used

(b) Isohyetal method — (4)
- Importance
- formula used

(c) normal ratio method — (3)
- Importance
- formula used.

Ans 1

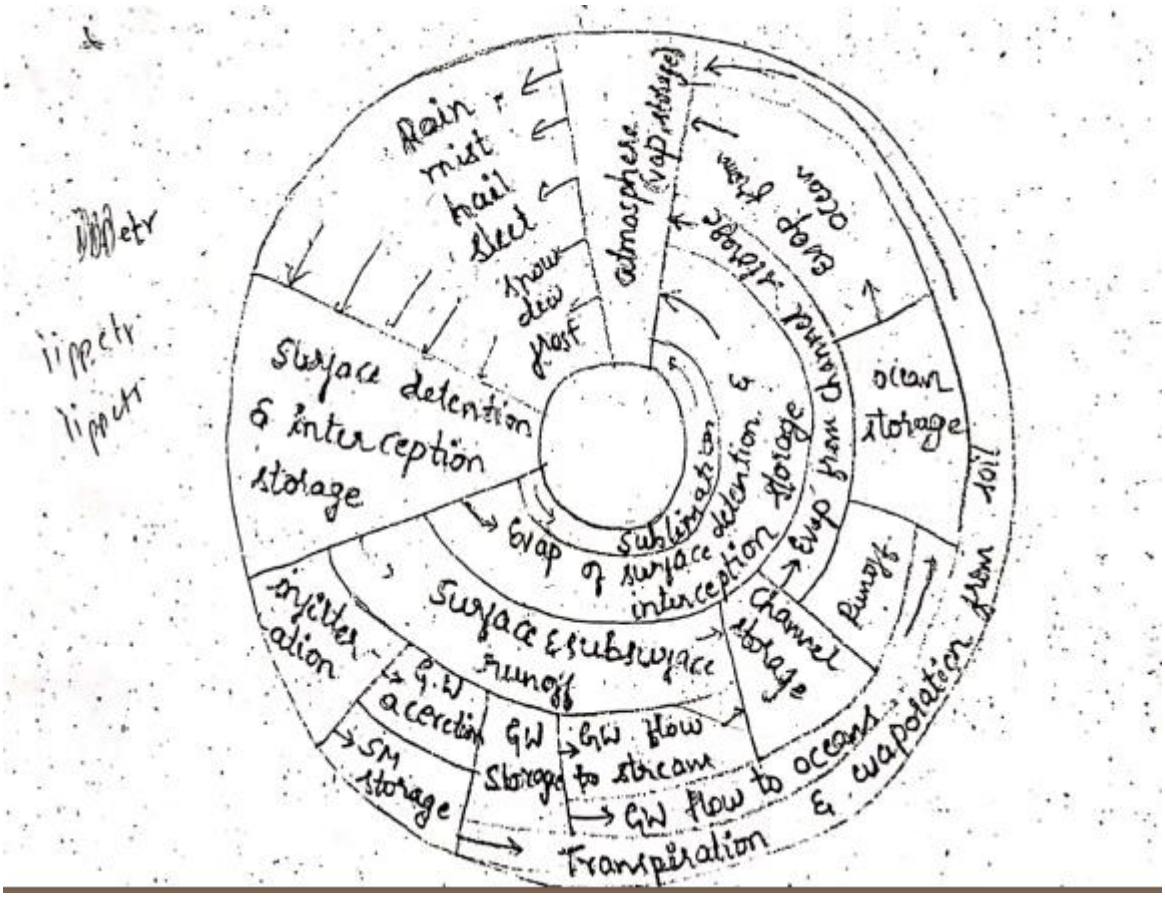
Hydrological Cycle :-

The group of numerous arcs which represents the different paths through which the water in nature circulates & is transformed is what is known as hydrologic cycle.

The hydrologic cycle has no beginning or end as the water in nature is continuously kept in cyclic motion. However, for the purpose of description the cycle may be visualised to commence with the precipitation from the atmosphere. Precipitation may takes place in liquid form as rain & also in solid form as

atmosphere. Precipitation may takes place in liquid form as rain & also in solid form as hail, snow, dew, frost etc.. While ppt is taking place, a part of it may evaporate & reach back the atmosphere. Some more ppt is intercepted by the trees & vegetation & the rest of it only would reach the ground. The intercepted ppt eventually evaporates into the atmosphere. The ppt reaching the ground surface is

The infiltered water may be distributed in different ways. First, it supplies moisture to the vegetation & after utilizing it for the sustenance of their life, the vegetation sends this moisture back into the atmosphere through the leaves by a process known as transpiration. Secondly, the infiltered water may percolate deep & become ground water supply to surface streams known as ground water runoff, or it may become ground water supply to oceans. The ground water runoff is sometimes referred to as the baseflow or


rain
mist
hail
sleet
snow
dew
frost
atmosphere (vapour storage)
evap from ocean
ocean storage
Channel flow
Surface detention & interception storage
Sublimation
evap of surface detention interception storage
evap from soil
Pumps
Channel storage
Surface & subsurface runoff
GW storage
GW flow to stream
GW flow to ocean
Transpiration & evaporation from soil

Ans 2

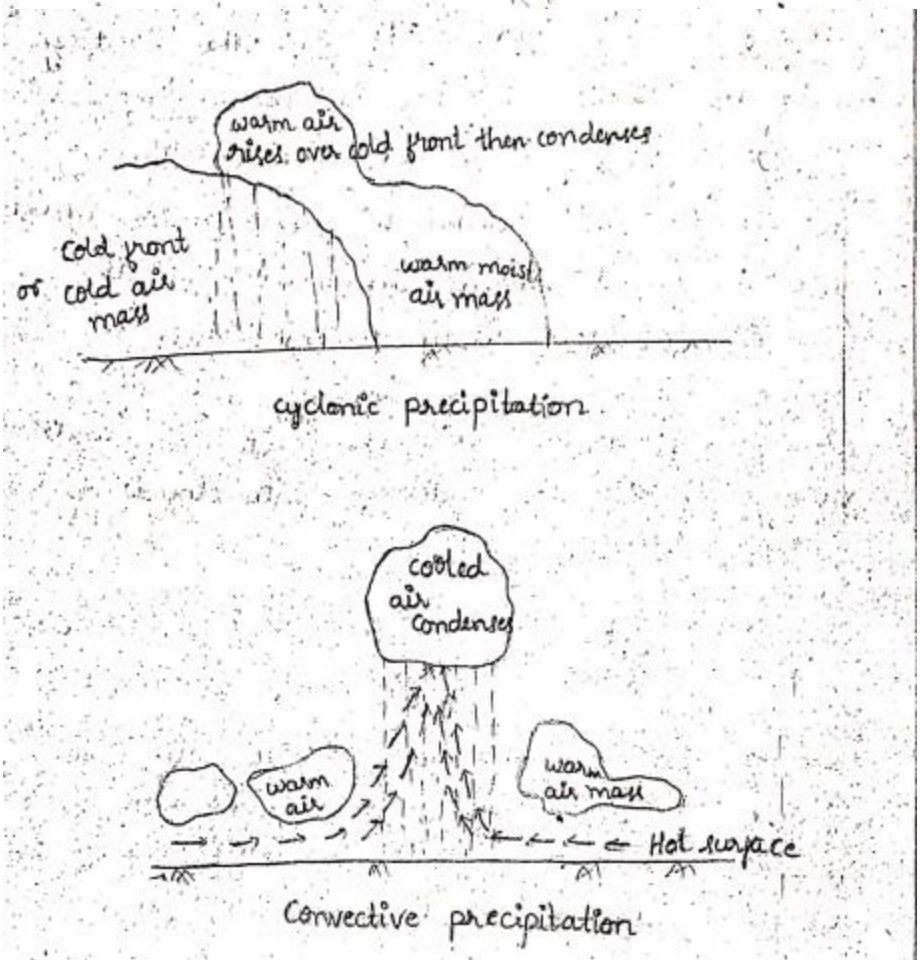
Types of precipitation :-

1) Cyclonic or frontal precipitation :-

When the moist air or warm airmass meets cool air mass. The molecules in the cold air are more tightly packed together (more dense) & thus the cold air is heavier than warm air, the warmer air mass is forced up over the cool air. As it rises, the warm air cools, the water vapour in the air condenenses & forms the clouds & results in ppt.

Convective ppt :- It results from the heating up of the earth's surface. The warm ground heats the air over it. As the air warms, the air molecules begin to move further apart with increased distance molecules, ∴ the molecules are less denly packed. Thus the air becomes lighter & rises rapidly into the atmosphere. As the air rises, it cools, water vapour in the air condenses into clouds & precipitation occurs.

Orographic ppt :- It results when warm moist air moving across the ocean is forced to rise by large mountains. As the air rises, it cools. Cold air cannot hold as much moisture as warm air. As air cools, the water vapour in the air condenses & water droplets forms.



Ans 3

A)

Sol: The mean rainfall is obtained as:

$$P_m = \frac{89+54+45+41+55}{5} = 56.8 \text{ m}$$

Now,

$$\sigma^2 = \frac{(89-56.8)^2+(54-56.8)^2+(45-56.8)^2+(41-56.8)^2+(55-56.8)^2}{5-1}$$

or $\sigma^2 = 359.2$

$\therefore \sigma = 19.95$

The coefficient of variation is calculated as:

$$\therefore C_V = \frac{19.95}{56.8} = 0.33367$$

$$\therefore N = \left(\frac{C_V}{0.10}\right)^{10} = \left(\frac{0.33367}{0.1}\right)^2 = 11.13$$

$\equiv 12$

Thus additional no. required = (12 – 5) = 7.

B

Forms of precipitation :-

Drizzle :- It is fine sprinkle of very small & rather uniform water drops with diameters b/w 0.1 & 0.5 mm. The drops are so small that they seem to float in air. To qualify as drizzle (also called mist) the drops must not only be small but they must also be very numerous. The intensity of drizzle rarely exceeds 1 mm/hr.

Rain :- It is ppt of liquid water in which the drops are generally larger than 0.5mm in

Glaze :- The ice coating formed when rain or drizzle freezes as it comes in contact with cold objects at the ground is called glaze.

Sleet :- When rain drops are frozen while falling through a layer of subfreezing air (below 0°C) near the earth's surface or refreezing of largly melted ice crystals occurs, transparent globular grains of ice known as or ice pellets are formed. The pellets are generally b/w 1mm & 4mm in diameter.

Snow :- PPt in the form of ice crystals is called snow. When ice crystals fuse together, it is called snowflake.

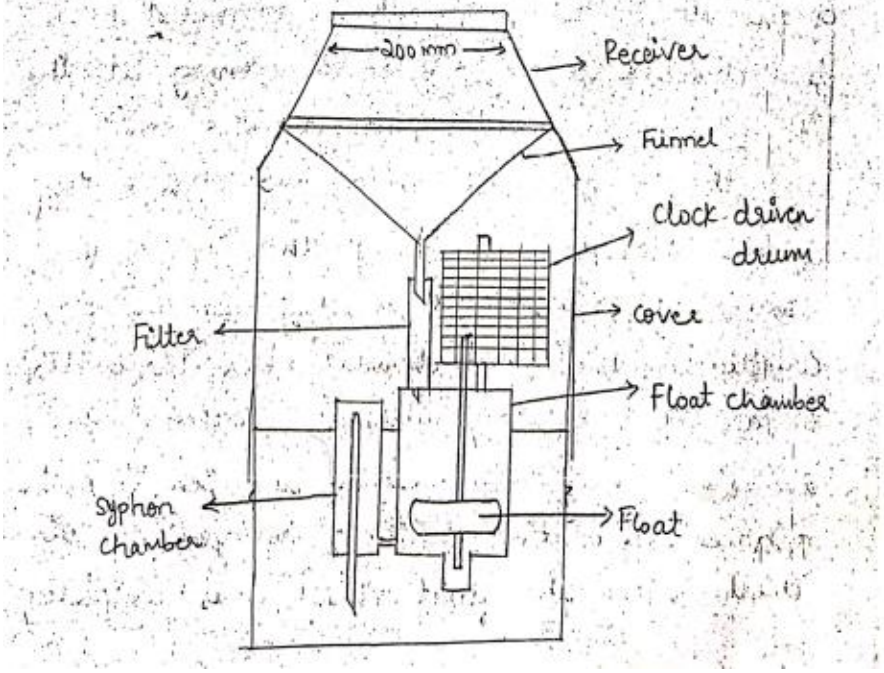
Hail :- PPt in the form of balls of or irregular lumps of ice over 5mm in dia is called hail. It occurs almost exclusively in violent or prolonged thunderstorms.

Dew :- Dew forms directly by condensation on the ground mainly during the night when the surface has been cooled by the outgoing radiation.

Ans 4
a)

Syphon gauge :-

Here the siphon mechanism is used to empty the rainwater collected in the float chamber.



Rain water entering the gauge at the top is led into the float chamber through a funnel & filter. The purpose of the filter is to prevent dust & other particles from entering the float chamber which may hinder the siphon mechanism.

The float chamber consists of a float with a vertical stem protruding outside, to the top of which a pen is mounted. This pen rests on a chart secured around the clock driven drum. The drum may be made to revolve once a day, once a week or once in any other desired period.

There is a small compartment by the side of the float chamber which is connected to the float chamber through a small opening at the bottom. This is called siphon chamber which houses a small V^le pipe with bottom end open & the top end almost ~~se~~ touching the top of the chamber. During the storm the rain water collected in the float chamber rises the water ~~sleyace~~ surface in it & along with the water surface the float also rises enabling the pen to make a trace cumulative depth of rainfall on the chart. When the float chamber is completely filled with water, the pen reaches the top of the chart. At this instant the siphoning occurs automatically through the pipe in the siphon chamber, the float chamber is emptied & the pen is brought to zero on the chart again. The complete siphoning should be over in less than 15 sec of time. This gauge cannot record ppt in the form of other than rain. The float may be damaged if the rainfall catch freezes.

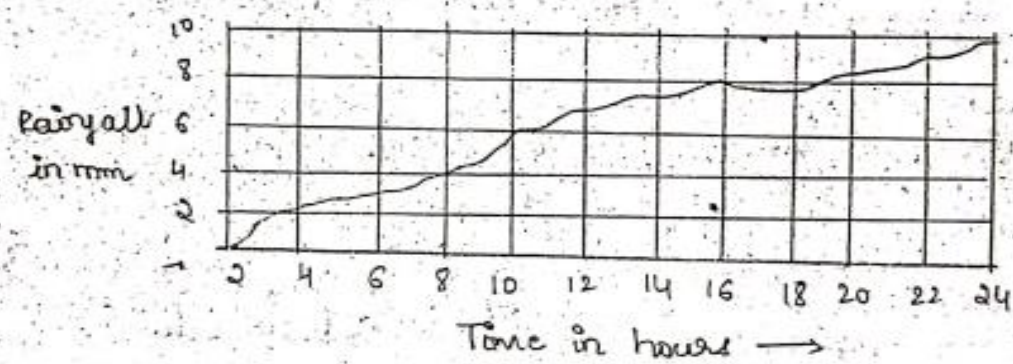
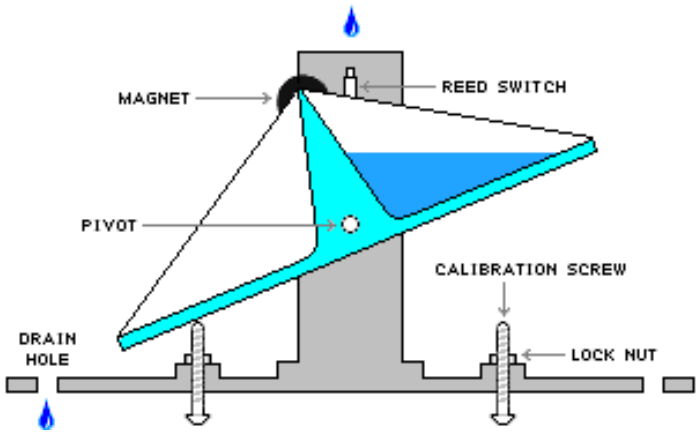


Fig :- Rainfall chart from float type RG.

Tipping–Bucket Type

The catch from the funnel falls onto one of a pair of small buckets. These buckets are so balanced that when 0.25 mm of rainfall collects in one bucket, it tips and brings the other one in position. The tipping actuates an electrically driven pen to trace a record on clockwork-driven chart. The record from tipping bucket gives data on the **intensity of rainfall**. The main advantage of this type of instrument is that it gives an electronic pulse output that can be recorded at a distance from the raingauge.

b)



Ans 5

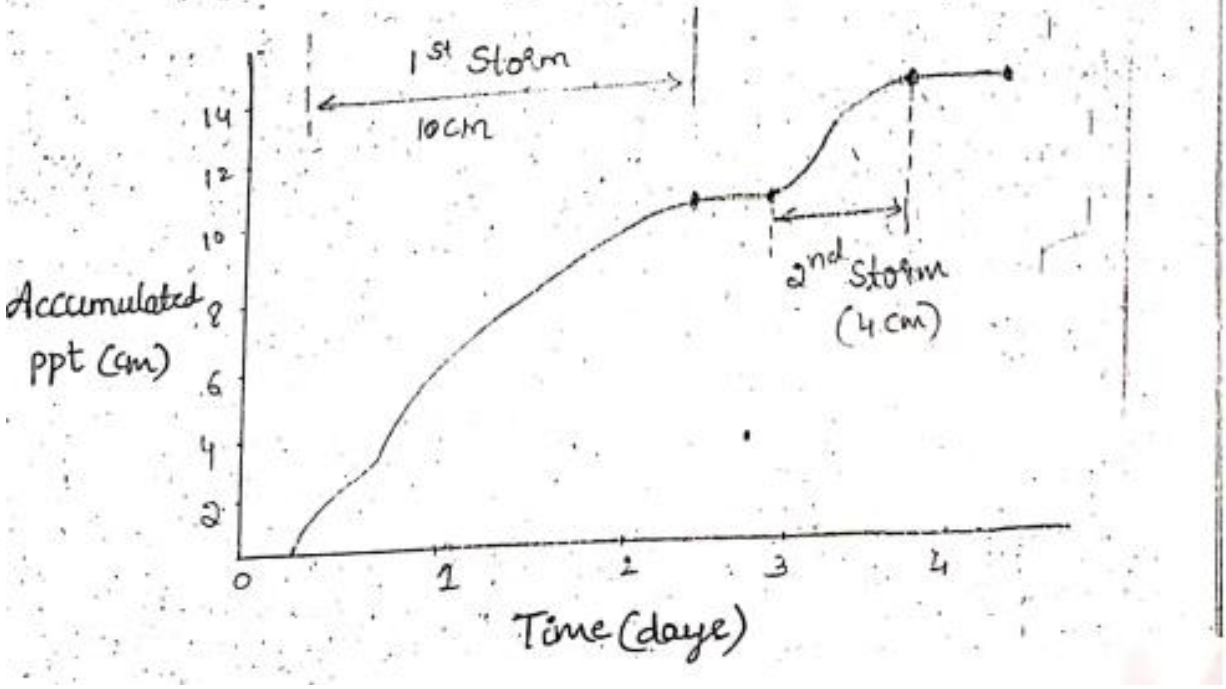
a)

Mass curve of rainfall :-

It is plot of the accumulated ppt against time, plotted in chronological order. Records of float type & weighing bucket type gauges are of this form.

Mass curves of rainfall are very useful in extracting the information on the duration & magnitude of a storm. Also, intensities at various time intervals in a storm can be obtained by the slope of the curve.

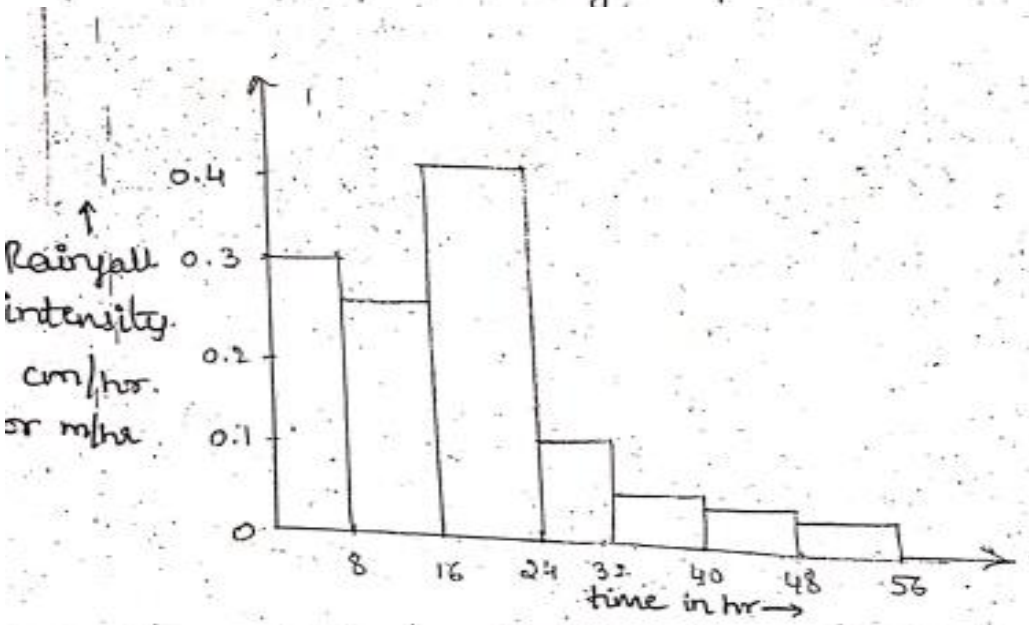
For non-recording raingauge, ... prepared from a knowledge of approximate begining & end of a storm & by using the mass curves of adjacent recording gauge stations as a guide.



B

Hyetograph :-

A hyetograph is a plot of the intensity of rainfall against the time interval. It is derived from the mass curve & is usually represented as a bar chart. It is very convenient way of representing the characteristics of a storm & is particularly imp in the development



Hyetograph of storm.

C

Double Mass curve :-

This technique is used to test the consistency of rainfall record at any raingauge station which is suspected to contain certain discrepancies.

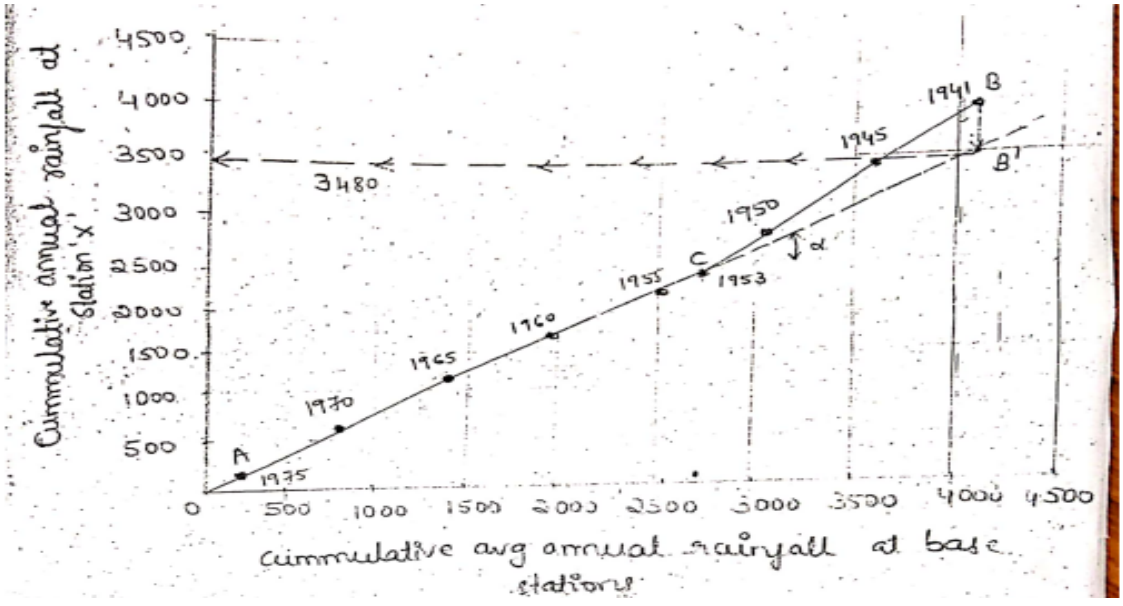
The inconsistances in the rainfall data of a station may be ~~rasi~~ due to various reasons.

- The raingauge might have been installed at different sites in the past - i.e though there is a long & continuous rainfall record, the entire data is not homogeneous with

respect to the present location of gauge.

- The exposure conditions of the gauge may have undergone a significant change due to the growth of trees or the construction of tall buildings in the proximity of gauge site.
- There may have been a change in the instrument, say from 125 mm to 200 mm raingauge
- The raingauge may have been faulty for a part of period of record or the method & accuracy of measurement may have been suspected.

A graph is plotted b/w the cummulative rainfall of the base stations as abscissa & " " of station x as ordinated. The resulting plot is called <u>double mass curve</u>.

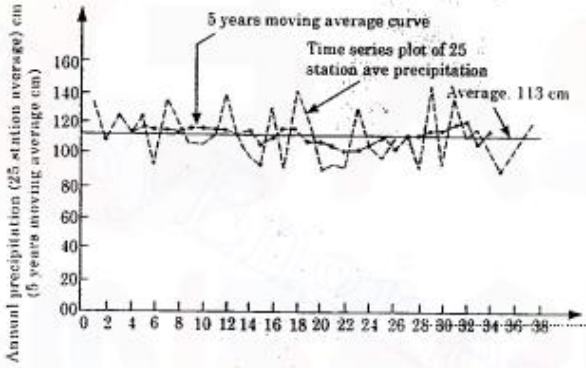


Moving Average

If we plot point rainfall (rainfall collected at raingauge station) with time in chronological order the fluctuations will be large in the time series of rainfall. From this it will be difficult to determine the trend of the rainfall. Thus a moving average plot is made which smoothens out the fluctations in time series and **help in determining the trend of rainfall**.

To find out moving average, for say 3 yrs., average of rainfall of 1st, 2nd and 3rd yrs is plotted against 2nd yrs. average of 2nd, 3rd and 4th yr is plotted against 3rd yr. and so on.

Similarly for 5 yr moving average, av. of rainfall of 1st, 2nd, 3rd, 4th and 5th yr is plotted against 3rd yr, av. of 2nd, 3rd, 4th, 5th and 6th yr is plotted against 4th yr and so on.



Ans 6

Evaporation

- The process of transformation of liquid water into gaseous form is called evaporation.
- The rate of evaporation is dependent on (i) the vapour pressures at the water surface and air above, (ii) air and water temperatures, (iii) wind speed, (iv) atmospheric pressure. (v) quality of water, (vi) depth of water body and (vii) shape and size of water body.

Factors affecting evaporation:

Vapour Pressure

The rate of evaporation is proportional to the difference between the saturation vapour pressure (e_w) at the existing water temperature, and the existing actual vapour pressure in the air, e_a.

The relationship is given by:

$$E_L = C(e_w - e_a) \qquad \text{Dalton's law}$$

where, E_L = rate of evaporation (mm/day), C = a constant; and e_w and e_a are in mm of mercury. Evaporation continues till $e_w = e_a$; and if $e_w < e_a$, condensation takes place.

Temperature

The other factor remaining same, the rate of evaporation increases with an increase in the water temperature.

Wind

- Wind aids in removing the evaporated water vapour from the zone of evaporation hence increase in wind speed increases the scope of evaporation.

Atmospheric Pressure

Other factors like heat input remaining same, a decrease in the barometric pressure, as in high altitudes, increases evaporation.

Water Quality

The rate of evaporation from water surfaces exposed to identical climatic conditions may vary according to the quality of water. For example, evaporation decreases by about 1 per cent for every 1 per cent increase in salinity, so that evaporation from sea water with an average salinity of about 3.5 per cent is some 2 to 3 per cent less than evaporation from fresh water at the same temperature.

Depth of Water Body

- For shallow water body seasonal temperature of water matches with that of air above. This means that maximum rates of evaporation from a shallow water body will be experienced during the summer months.

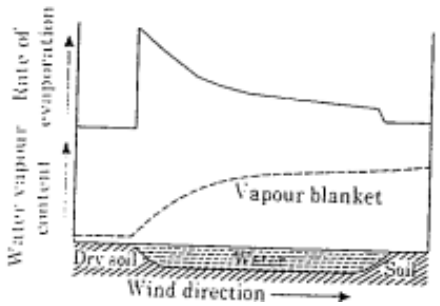
  In the case of a large deep water body, however, water temperatures commonly lag behind the temperatures of the overlying air.

- During the spring and early summer months considerable depths of water are slowly and gradually warmed up by a part of the incoming solar energy which would otherwise be available for evaporation. Subsequently the slow release of this stored heat, by the deep water body during the autumn and winter months, means that a supply of heat energy in excess of that received directly from the sun is made available for evaporation at that time of the year.

- Hence highest rates of evaporation from deep water bodies occurs during the winter. Furthermore, during winters, water vapour-laden air will be rapidly lifted away from the underlying water surface as a result of convectional activity, encouraged by the temperature gradient, whereas during the summer, the colder water will tend to cool and stabilize the air immediately above it and so inhibit the removal of vapour laden air.

Size and Shape of Water Surface

Air moving across a large lake has a low water vapour content at the upwind edge and evaporation from the lake surface will gradually increase the water vapour content. Thus a vapour blanket is created over the lake, the thickness of which increases in windward direction. There will be decrease in the rate of evaporation as the vapour blanket in contact with water surface increases in thickness. Thus, the larger the lake, the greater will be the total reduction in evaporation.



Ans 7

b)

ii) Normal ratio method :-

If the normal annual rainfall at the surrounding gauges differ from the normal annual rainfall of the station in question by more than 10%, the normal ratio method is preferred. In this method the rainfall values at the surrounding station are weighed by the ratio of normal annual rainfall. i.e

$$P_x = \frac{1}{m}\left[\frac{N_x}{N_1}P_1 + \frac{N_x}{N_2}P_2 + \ldots + \frac{N_x}{N_m}P_m\right] \text{ (or)}$$

$$P_x = \frac{N_x}{m}\left[\frac{P_1}{N_1} + \frac{P_2}{N_2} + \ldots + \frac{P_m}{N_m}\right]$$

a)

i) Arithmetic average method :-

If the normal annual ppt at the adjacent stations are within 10% of the normal rainfall of the station under consideration. Then the missing rainfall data may be estimated as a simple arithemetic average of the rainfalls at the adjacent gauges. Thus if the missing ppt at station x is P_x & $P_1, P_2 \ldots P_m$ are the rainfalls at m surrounding raingauges.

$$P_x = \frac{1}{m}(P_1 + P_2 + \ldots + P_m)$$

where; N_x → Normal annual rainfall at st x.
$N_1, N_2 \ldots N_m$ are normal " " at m surrou-
-nding gauges resp.
$P_1, P_2 \ldots P_m$ → storm produced rainfalls.
A minimum of 3 surrounding stations are gene-
-ally used in this method.

C

iii) Isohyetal method :-

The most accurate method of computing the avg depth of rainfall is the isohyetal method. An isohyet may be defined as the line joining points of equal rainfall. In other words all the places along an isohyet experience the same amount of rainfall.

The rainfall amounts recorded by each station are indicated at the station locations. The isohyets are then drawn on the same map.

First the points of a required isohyets are then drawn on the same map. located by linear interpolation b/w the adjacent gauges. Then b/w the points thus located, the isohyets are joined by eye to produce smooth curves giving reasonable consideration to the evidence of nearby gauges not involved in the interpo-
-lation.

New isohyets have to be made for each rainfall event.

$P_m = (\Sigma P_{ij} A_{ij})/A$

P_m is the average rainfall in the catchment

$P_{ij} = (P_i + P_j)/2$

A_{ij} is the area between two successive isohytes P_i and P_j

A is the total area of the catchment.