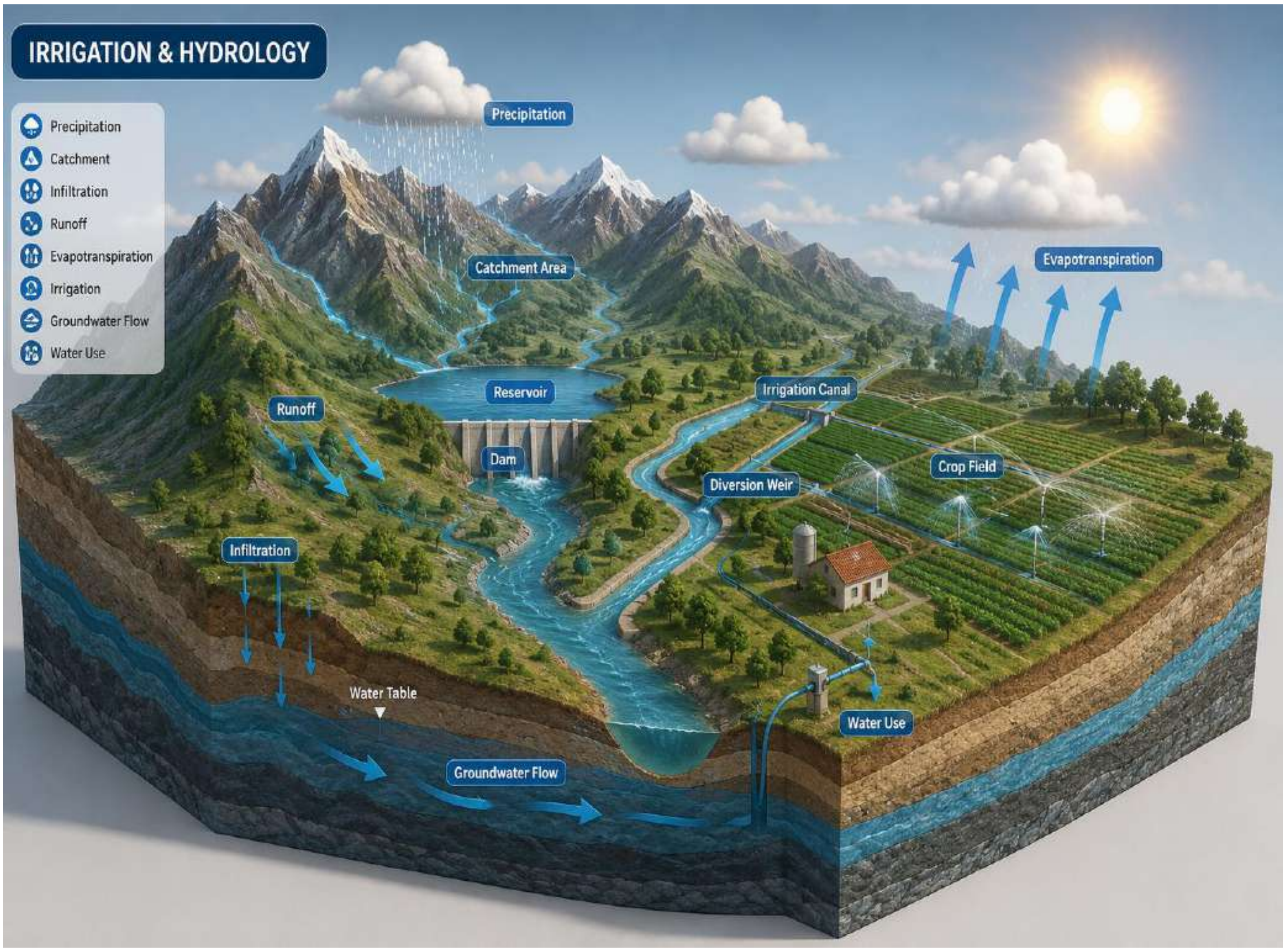
R.C.Patel College Of Engineering & Polytechnic, Shirpur
Department of Civil Engineering

Course Title- Water Resource Engineering **Course Code -** 315314
Programme Name -Civil Engineering **Semester-** Fifth

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
I	Introduction to Irrigation and Hydrology	CO1	07	04	04	04	12



Unit 1 : Introduction to Irrigation and Hydrology.

Introduction

Irrigation Engineering and Hydrology deal with the efficient use, measurement, movement and management of water for agriculture and other engineering Purposes. These helps to ensure reliable water supply, improve Crop Production and support the safe design of water resource Projects.

1.1 Irrigation

Definition Irrigation is the Process of supplying water to agricultural land through canals, wells, tubes, Pumps, or other methods to help crops grow.

(OR) Irrigation is the artificial supply of water to crops at the required time when rainfall is not enough for Proper plant growth.

- Rainfall is not always sufficient or regular. Crops need water throughout their growing Period. Therefore irrigation is necessary.

Advantages / Benefits of Irrigation

1) Increases in food Production: It helps to increase Crop production two to four times as compare to dry farming. otherway also fish production can be developed in the irrigation tank.

2) Flood control: Irrigation structures like reservoirs detain floods for some time and thus reduces destructive power and thus helps in flood Control.

3) Generation of hydroelectric power:
The project generally designed for irrigation can also be designed for power generation. Canal falls can be used for power generation.

4) Domestic water supply. - Irrigation helps to water supply of town, where water is not easily available.

5) Inland navigation - If large irrigation canals are designed then it can also be used for navigation purpose.

6) Afforestation :- As a along side or bank of canal trees may be planted which grows along the bank of canal and thus increases timber or other trees wealth of country.

7) Increase in facilities of communication :- From the inspection path provided for good roadway to villages. (for walking, cycling and thus increases facilities for communication).

Necessity of Irrigation

Rainfall in india is seasonal, uncertain & unevenly distributed. Therefore, irrigation is necessary for successful agriculture.

1) Insufficient Rainfall : Many regions receive inadequate rainfall, making irrigation essential for crop growth.

2) Uneven distribution of Rainfall : Some areas receive heavy rainfall, while others receive very little. Irrigation ensures a regular water supply.

3) Protection against Drought :- Irrigation helps protect crops during periods of drought or delayed rainfall.

4) Improvement of soil fertility:
Water dissolves nutrients presents in the soil, making them available for plant growth.

5) Economic development: Higher agricultural production increases farmers' income and contributes to the

6) Cultivation of cash crops
Cash crops such as sugarcane, cotton, banana, and vegetables require

Classification of Irrigation or Types of Irrigation

- Irrigation
  - Flow Irrigation
    - Perennial
      - Direct Irrigation
      - Storage Irrigation
    - Inundation
  - Lift Irrigation
    - Well Irrigation
    - Lift canal Irrigation

Flow Irrigation When water is available higher level and it is passes to the lower level through gravity is known as Flow Irrigation.

Lift Irrigation: Water is lifted by some mechanical or manual means as pumps etc. then it is supplied to Irrigation is called lift irrigation.

Perennial Irrigation: In this water is supplied in accordance with requirement of crop throughout the crop period. In this storage head work such as dams, weirs or barrages etc constructed to store water and it is supplied through canal distribution system.

Direct Irrigation: In this water directly taken from river by constructing a weir or barrages and thus increases level of water and diverting it to canal.

Storage irrigation In this storage irrigation, water is stored in a reservoir behind a dam during the rainy Season and supplied to field when required.

Flood Irrigation / inundation irrigation

This type of irrigation possible when occurrence of floods in a year. irrigation work is not required across the river.

Classification of Irrigation projects

Irrigation projects are classified in different ways depending on the size of the project and the method of supplying water.

classification based on cultivable Command Area (CCA)

1. Minor Irrigation Project
2. Medium Irrigation project
3. Major Irrigation Project.

1) Minor Irrigation Project

A Project that irrigates up to 2000 hectares of land is called a minor Irrigation project.

Features
- Covers a small area
- Construction Cost is low
- completed in a short time.
- Easy to operate and maintain
- suitable for villages and small farms.

Examples Open wells, Tube wells, Farm ponds, small check dams.

2. Medium Irrigation Project:

A project that irrigates more than 2,000 hectares and up to 10,000 hectares is called a Medium Irrigation project.

Features → - Covers a medium sized area
- Uses medium storage dams and canals.
- Construction cost is moderate.
- Supplies water to several villages.

Examples → Medium dams, Canal Irrigation systems.

3. Major Irrigation Project

- A project that irrigates more than 10,000 hectares is called Major Irrigation Project.

Features → - Covers a very large area
- Uses large dams and canal networks.
- High construction cost.
- Long construction period.
- Benefits many districts or regions.

Examples → - Large river valley projects
- Multipurpose dam projects.

ill Effects of Irrigation / Disadvantages of Irrigation.

1) Water logging: Maximum quantity of water collects in the soil, reducing the air available to plant roots.

Effets → a. Roots cannot breathe properly.
b. Plant growth becomes weak.
c. Crop yield decreases.

2) Soil Salinity: Excess Irrigation causes salts to collect on the soil surface after water evaporates.

Effects → a. Soil fertility decreases
b. Plants absorb less water.
c. Crop production reduces.

3) Soil Alkalinity

Excess sodium in the soil makes it alkaline and hard.

Effects - Poor soil structure
- water cannot enter the soil easily.
- Root growth becomes difficult.

4) soil Erosion Too much flowing water washes away the fertile top layer of soil.

Effects: - loss of nutrients
- Lower crop productivity.

5) Wastage of water :
Using more water than necessary wastes valuable fresh-water resources.

6) Damage to crop Roots Continuous standing water causes roots to rot and increases plant diseases.

7) Higher Farming Cost More water pumping increases electricity, fuel, & maintenance expenses.

Measures to Prevent Excess Irrigation

1) supply only the required quantity of water.
2) Use drip irrigation or sprinkler irrigation to save water.
3) Provide proper field drainage.
4) Level the land before irrigation.
5) check soil moisture before watering.
6) Maintain irrigation canals regularly to reduce water loss.

1.2 Hydrology: Definition :-

Hydrology is the brach of civil engineering and earth science that studies water, its movement, distribution and storage on the earth's surface, below the ground and in the atmosphere.

(OR) Hydrology is the study of how water moves from the sky to the earth and back to the sky.

Hydrological cycle (Water cycle)

Water changes its form and moves continuously from the earth to the atmosphere and back again.

flow chart / steps of Hydrological cycle.

* Sun heat

↓

Evaporation

↓

Water vapour

↓

Condensation (cloud formation)

↓

Precipitation (Rain, snow, Hail)

↓

Runoff / Infiltration

↓

Rivers, Lakes, Groundwater

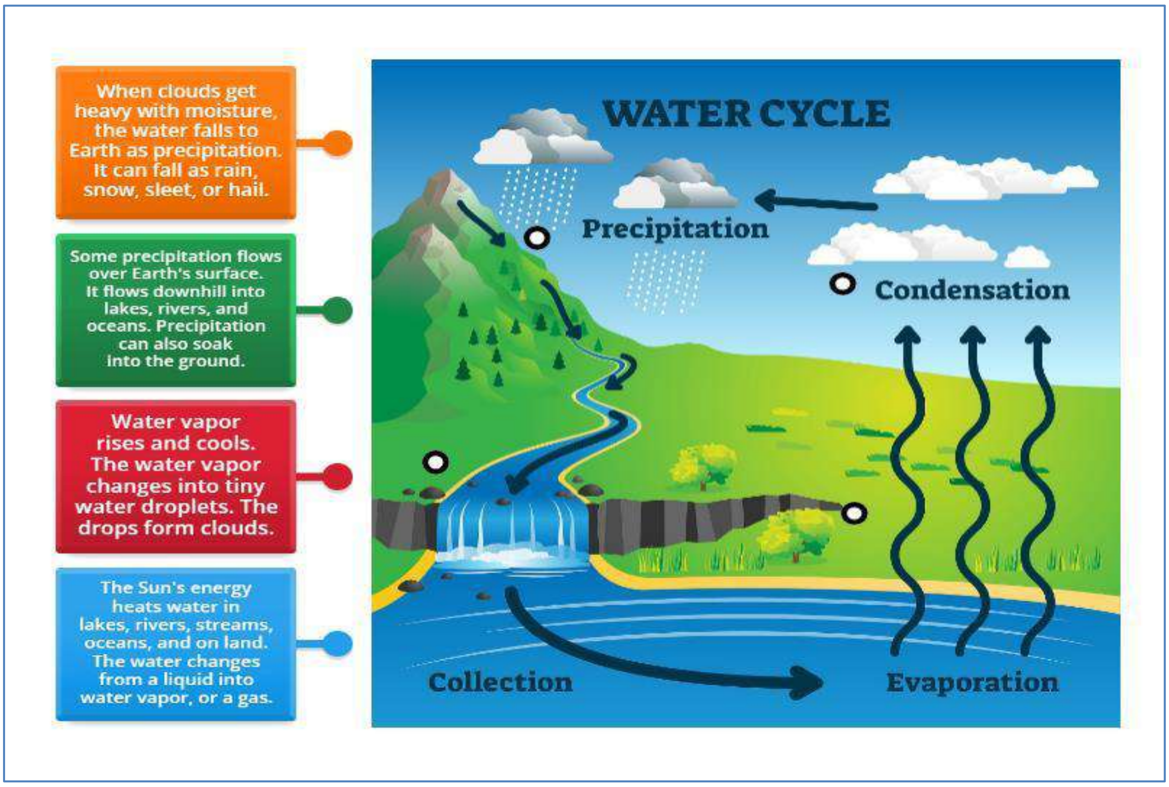
↓

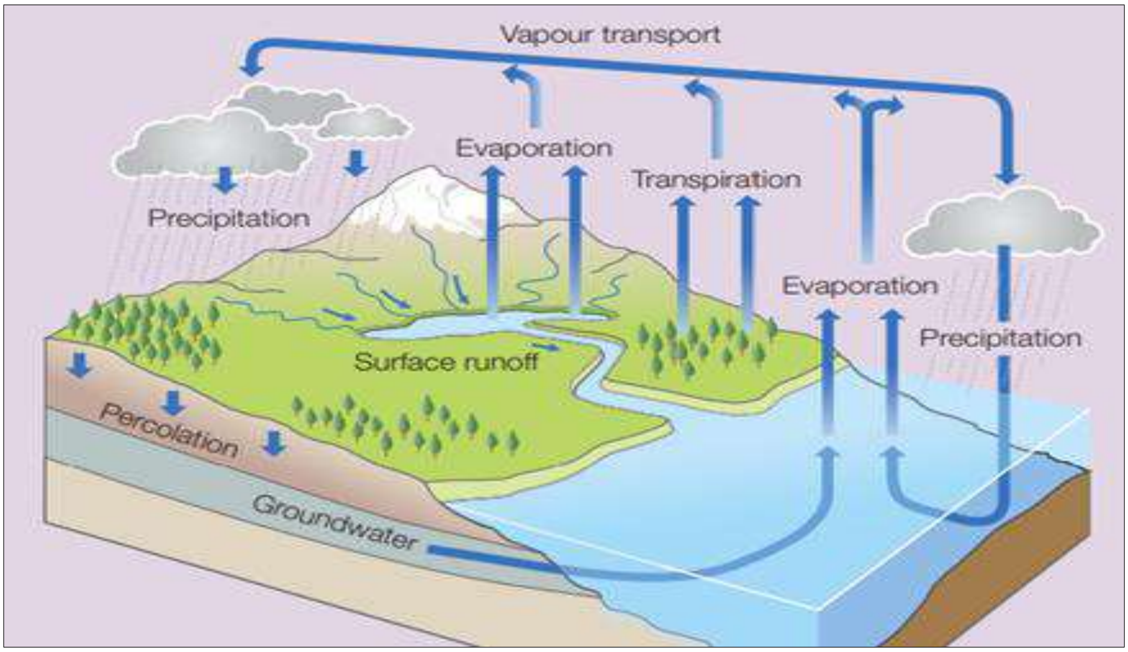
Oceans

↓

Evaporation Again

- **Hydrological Cycle**





1) Hydrological cycle starts when the sun heats water in oceans, rivers, lakes, & Ponds. This water changes into water vapour through evaporation. Plants also release water vapour through transpiration.

2) The water vapour rises to the atmosphere and cools, changing into tiny water droplets. This process is called condensation, which forms clouds.

3) As the clouds becomes heavy, water falls to the Earth as precipitation (rain, snow or hail).

4) After reaching the ground, some water flows into rivers and lakes as surface run off, while some enters the bodies, where the cycle starts again.

Rainfall

Rainfall is the process in which water droplets fall from clouds to the earth.

(OR) Rainfall is the amount of rain received at a place during a specific period.

- It is usually measured in millimetres (mm)

Factors affecting Rainfall

a) Temperature
b) Wind direction
c) Humidity
d) Mountains
e) Distance from the sea.
f) Air pressure.

Evaporation

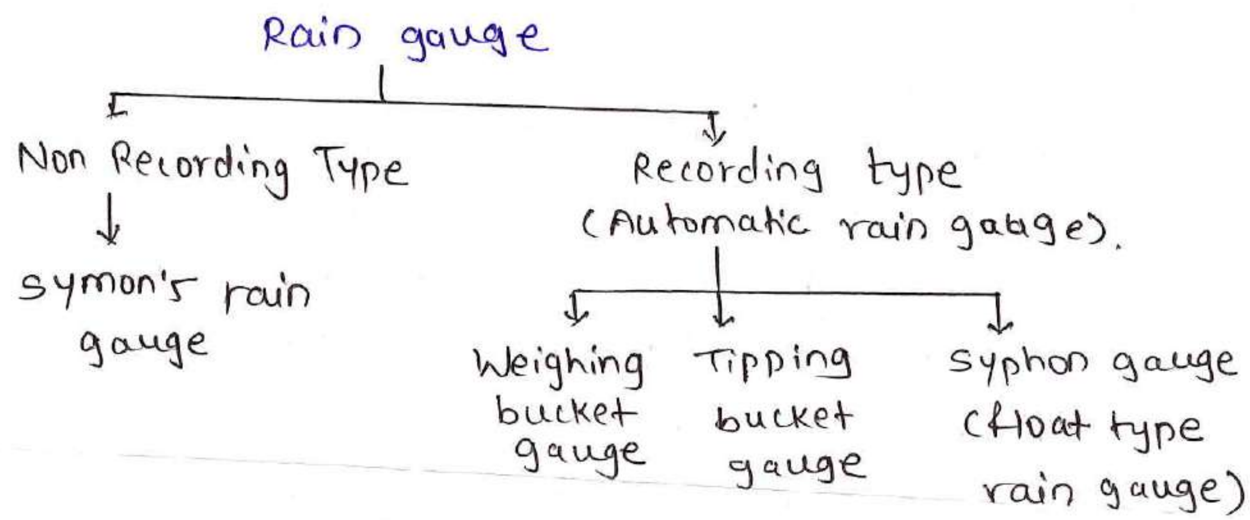
Evaporation is the conversion of water into vapour by solar heat.

It occurs from: - Rivers, Lakes, oceans, Reservoirs, Wet soil, Plant surfaces.

1.3 Rain Gauge

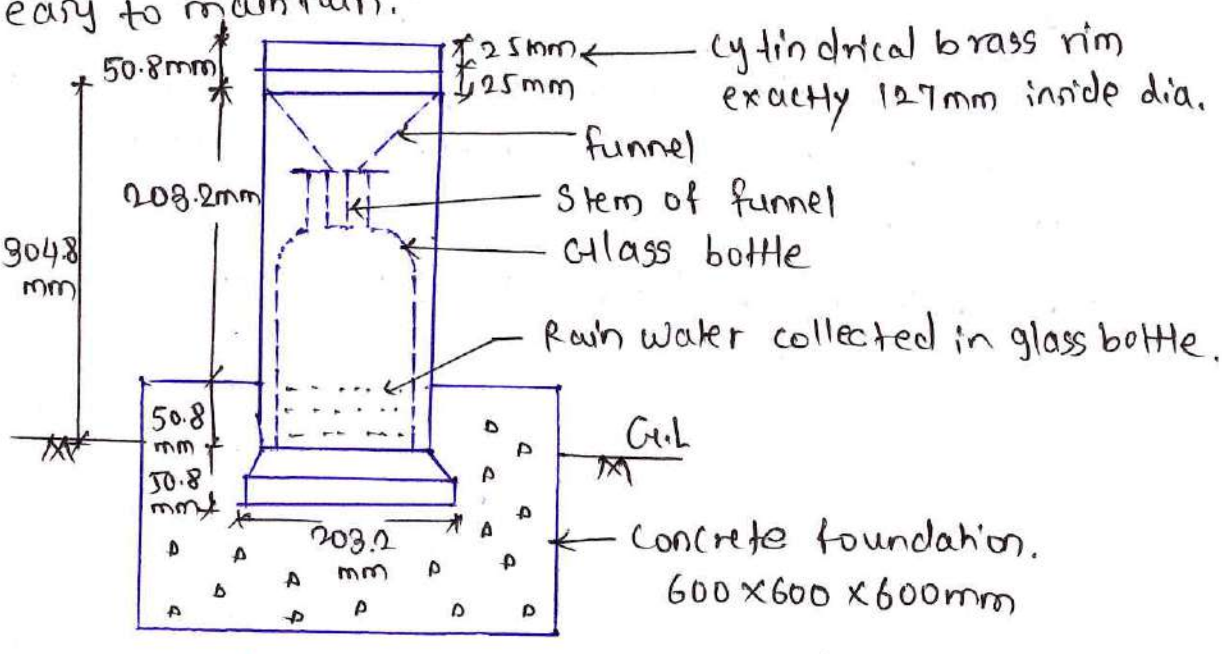
Definition → A rain gauge is an instrument used to measure the amount of rainfall received at a particular place during a specific period. The rainfall is usually measured in millimetres (mm).

Types of Rain Gauges



1) Symon's Rain Gauge

Symon's rain gauge is a non recording rain gauge used to measure the total rainfall received over a fixed period usually 24 hours, It is the most commonly used rain gauge in india because it is simple, accurate and easy to maintain.



Symon's Rain gauge

Main Parts → a) Funnel
b) Collecting bottle
c) outer container
d) Measuring cylinder
e) Base stand.

Working Principle : Symon's rain gauge works on the principle of collecting rainwater and measuring its volume.

Working Process →

construction and functioning of symon's Rain gauge:

1) It is cylindrical metal case with internal diameter of 127mm. This case is installed over the enlarged base having diameter of 203.2 mm.

2) Funnel fixed at the top of the cylindrical metal case. A brass rim of having internal diameter of 127mm is provided to the funnel.

3) cylindrical metallic case is fixed to masonry or concrete foundation having diamensions of 600 X 600 X 600mm. Foundation in such way that the funnel rim is exactly 304.8mm above ground level.

4) There is a glass bottle kept inside the metallic case. The stem of the funnel is inserted into the glass bottle.

5) The rain water enters the glass bottle the funnel and from which collected in the bottle.

6) Collected water in the bottle is then measured by means of graduated cylinders which is further gives the rainfall volume in 'cm' of water depth.

$$\frac{\text{Volume of collected water in } cm^3}{\text{Area of the aperture of the gauge in } cm^3} = \text{cm of depth of rain fallen.}$$

2. Recording Types

a) Automatic Rain Gauge:

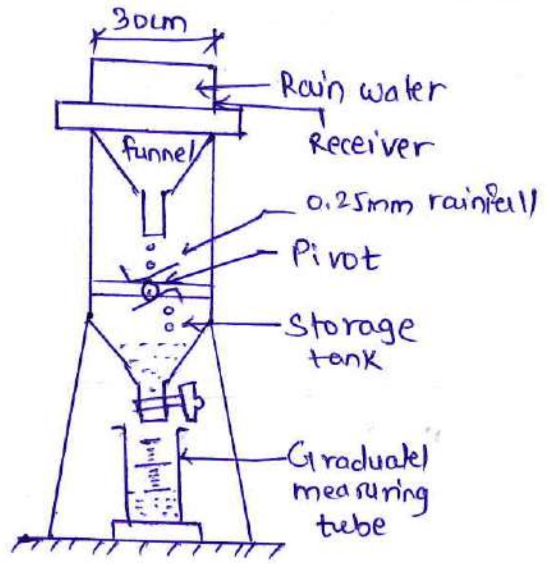
This type of Rain gauge having self recording type function. It has three types as follows:

i) Tipping bucket rain gauge

ii) Weighing type rain gauge.

iii) Float type rain gauge.

i) Tipping bucket rain gauge.



Tipping bucket rain gauge

Component parts:

1) Collector Funnel
2) Tipping Bucket Assembly
3) Pivot
4) Magnet and Reed switch
5) Recoder

Working Process

1) Rain falls into the collector funnel placed at the top of the rain gauge. The funnel directs the water into one of the two buckets.
2) The bucket gradually fills with rainwater. Each bucket has a fixed capacity. As rain continues, the bucket becomes full.
3) When the bucket reaches its fixed capacity. its weight increases and it tips about the pivot.
4) As the bucket tips, the collected rainwater is emptied through the outlet. At the same time, the second empty bucket moves under the funnel to collect the next rainwater.

5) During each tip, the magnet attached to the bucket passes the electronic sensor. The sensor sends one electrical pulse to the data logger.

6) The data logger counts every pulse. Since each tip represents a known amount of rainfall, the total rainfall is calculated automatically.

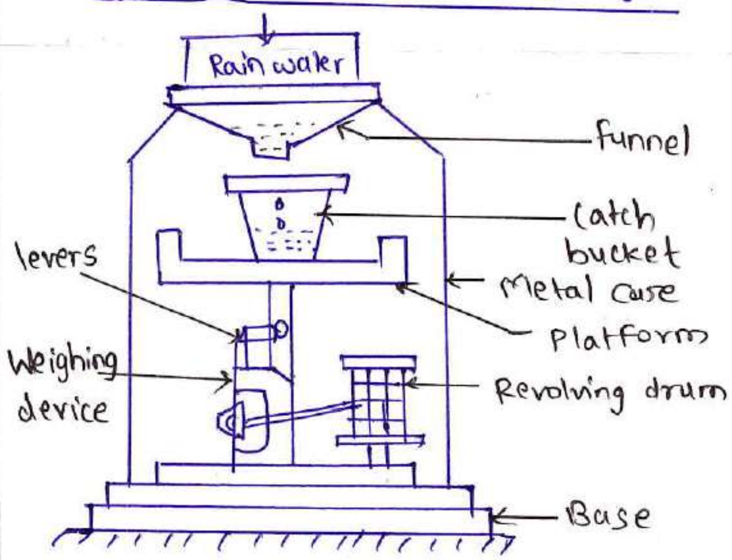
Example → 1 Tip = 0.2 mm rainfall

50 Tips = 50×0.2 = 10 mm rainfall.

7) Continuous operation. The two buckets continue tipping alternately as long as rainfall continues. This allows continuous and automatic measurement without manual observation.

8) It is suitable for hilly areas.

ii) Weighing type rain gauge



component parts:

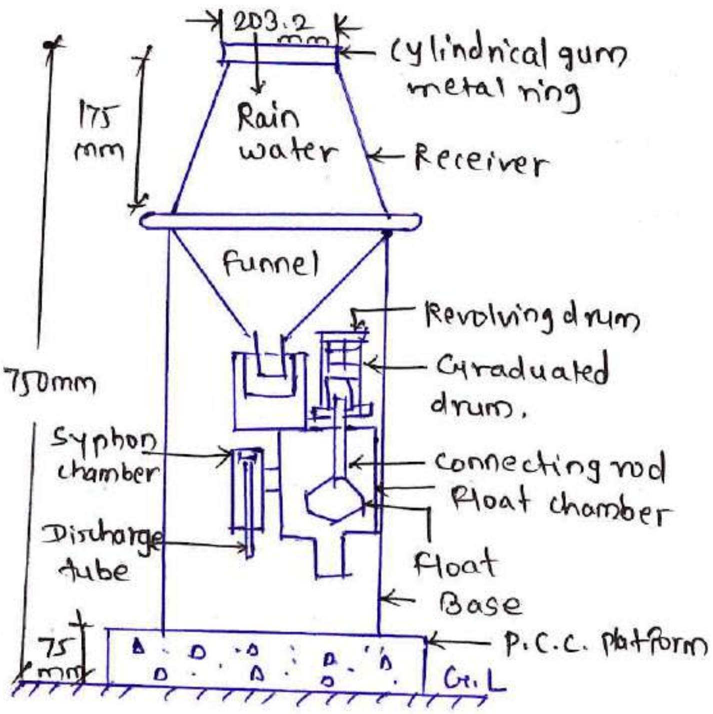
1) Funnel (Rain Receiving)
2) cylindrical metallic case
3) catch bucket
4) Platform
5) weighing device
6) Pen arm
7) Revolving drum.

Working Process →

1) When the weight of bucket is increased due to rain water then platform is moved.
2) Movement of the weighing platform is transmitted to through a system of links and levers to a pen arm or pen marker.
3) This pen arm mark the collected amounts of rainfall on a graduated graph paper wrapped round a clock driven revolving drum.

4> Thus increasing weight of the bucket helps in recording the rainfall with time by moving a pen on a revolving drum.

iii> Floating type rain gauge.



Component parts

1> Gun metal ring
2> Funnel
3> Rain water collector
4> Filter
5> Entrance tube
6> Revolving drum with recording paper or graph
7> Pen arm
8> Float chamber
9> Syphon chamber
10> Discharge tube
11> P.C.C Platform.

Working Process

1> The entry of rain water passes through funnel from to chamber that known as float chamber.
2> When water collected in float chamber increases, then float moves up. Connecting rod is fixed to the float and a pen.
3> When float moves up, then pen connected to connecting rod make a trace of collected amounts of rainfall on a graduated chart or graph paper wrapped round a clock driven revolving drum.
4> When float chamber is entirely / fulley filled with rain water, then it is automatically becomes empty that means siphon.
5> This type of rain gauge adopted by the Indian meteorological department.

1.4 Methods of calculating mean rainfall:

Mean rainfall is the average rainfall over a catchment or drainage area. Since rainfall is not uniform everywhere, different methods are used to estimate the average rainfall.

There are three common methods:

1) Arithmetic Mean Method
2) Thiessen Polygon Method
3) Isohyetal Method.

1) Arithmetic Mean Method.

The Arithmetic Mean Method is the simplest method of calculating mean rainfall. It is used when rainfall is almost uniform throughout the catchment and rain gauges are evenly distributed.

Formula →

$$\boxed{\text{Mean Rainfall} = \frac{P_1 + P_2 + P_3 + \cdots + P_n}{n}}$$

$P_1, P_2, P_3 \ldots P_n$ = Rainfall at different rain gauge stations (mm)

n = Number of rain gauge stations.

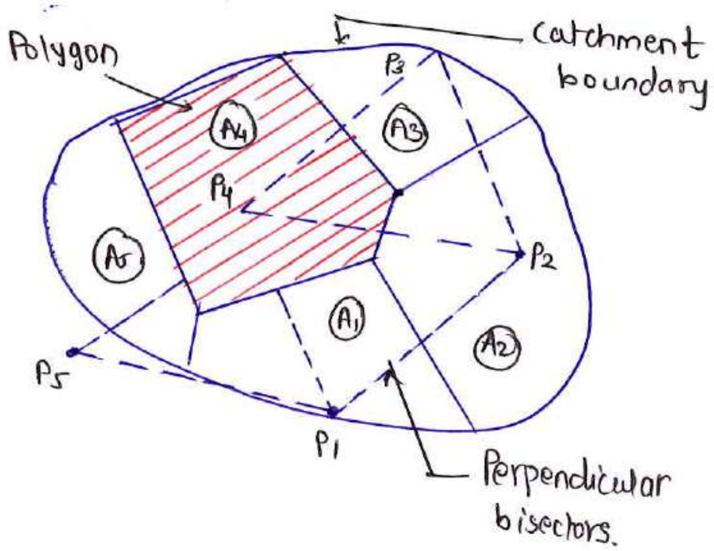
Procedure →

1) Measure rainfall at all rain gauge stations.
2) Add the rainfall values.
3) Divide the total by the Number of stations.
4) The result is the mean rainfall.

Limitations →

1) Not suitable when rainfall varies greatly.
2) Less accurate for hilly or uneven areas.

2) Thiessen's Polygon Method



- The Thiessen Polygon method calculates mean rainfall by giving different weights to each rain gauge according to the area it represents.
- Rain gauges covering larger areas receive greater weight than those covering smaller areas.

Principle →
- The catchment is divided into polygons.
- Each polygon contains one rain gauge.
- Rainfall recorded at each station represents the rainfall over its polygon area.

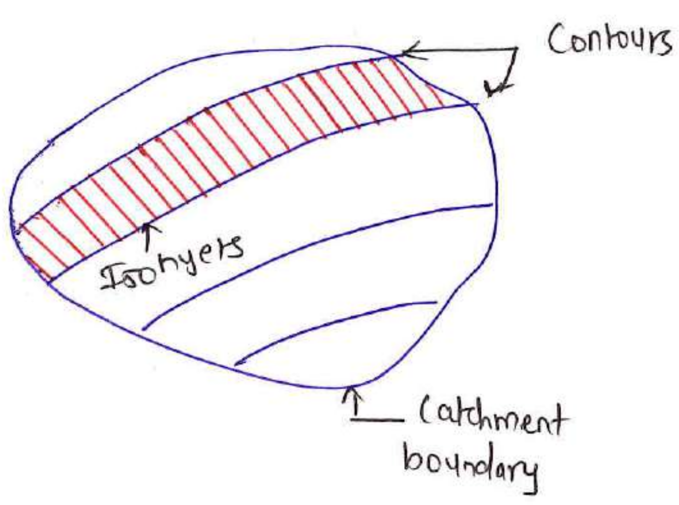
formula →

$$\boxed{\text{Mean Rainfall} = \frac{\Sigma (P_i \times A_i)}{\Sigma A_i}}$$

where, P_i = Rainfall at station i
A_i = Area represented by station i

Procedure →
1) Draw the catment boundary
2) Mark all rain gauge stations
3) Join neighbouring stations with straight lines.
4) Draw perpendicular bisectors to form Thiessen polygons
5) Measure the area of each polygon.
6) Mutiply rainfall by the corresponding polygon area.
7) Add all values
8) Divide by the total catchment area.

3> Isohyetal Method



The Isohyetal method is the most accurate method for calculating mean rainfall. It uses isohyets, which are lines joining points having the same rainfall.

Principle : The catchment is divided into zones between two successive isohyets. The average rainfall in each zone is multiplied by its area.

Formula :

$$\boxed{\text{Mean Rainfall} = \frac{\Sigma (P \times A)}{\Sigma A}}$$

where,

P = Average rainfall between two isohyets

A = Area between the isohyets.

Procedure

1> Plot rainfall data on a map.

2> Draw isohyets of equal rainfall.

3> Calculate the area between successive isohyets.

4> Find the average rainfall for each zone.

5> Muliply average rainfall by the corresponding area.

6> Add all products.

7> Divide by the total catchment area.

Limitations

1> Requires skilled interpretation.

2) More time and effort are needed.

3> Not suitable when rain gauge data are insufficient.

Numericals

Winter 2025

1) The following data shows a catchment area with average annual rainfall by using arithmetic mean method. Find out the mean rainfall over entire catchment area.

Station	A	B	C	D
Rainfall (mm)	110	103	99	89

Solution

$$\Sigma P = \frac{P_1 + P_2 + P_3 + P_4}{n} \quad \text{— (1)}$$

So, $P_1 = 110$ mm, $P_2 = 103$ mm, $P_3 = 99$ mm, $P_4 = 89$ mm

n = No of stations = 4

from (1)

$$\Sigma P = \frac{110 + 103 + 99 + 89}{4}$$

$$\boxed{\Sigma P = 100.25 \text{ mm}}$$

Winter 23

2) Compute the average rainfall by Thiessen's polygon method and arithmetic average method for C.A at dam site.

Rain gauge st. Rainfall in mm.	1400	1500	1100	1200	1300
C.A in sq. Km	20	30	24	26	25

Solution

1) Average rainfall by thiessen's polygon method.

$$P = \frac{A_1P_1 + A_2P_2 + A_3P_3 + A_4P_4 + A_5P_5}{A_1 + A_2 + A_3 + A_4 + A_5} = \frac{\Sigma A \times P}{\Sigma A}$$

$$= \frac{(20 \times 1400) + (30 \times 1500) + (24 \times 1100) + (26 \times 1200) + (25 \times 1300)}{(20 + 30 + 24 + 26 + 25)}$$

$$= \frac{28000 + 45000 + 26400 + 31200 + 32500}{125}$$

$$P_{avg} = \frac{163100}{125} = \underline{\underline{1304.8 mm}} = \underline{\underline{1.308 m}}$$

ii) Arithmetic average method:

Solution $\longrightarrow$ $P = \frac{P_1 + P_2 + P_3 + P_4 + P_5}{N} = \frac{\Sigma P}{N}$

$$P = \frac{1400 + 1500 + 1100 + 1200 + 1300}{5}$$

$$P = \frac{6500}{5} = \underline{\underline{1300}} \text{ mm}$$

iii) Runoff

Average annual rainfall $P = \frac{(1304.8 + 1300)}{2}$

$= 1302.4 mm$

$= \underline{\underline{130.24 cm}} < 200 cm.$

for Number of hot region ; Inglis formula is,

$$R (cm) = \frac{P(P - 17.74)}{254}$$

$$= \frac{130.24(130.24 - 17.74)}{254} = 57.68 cm$$

$$\boxed{R = 57.68 cm = 0.5768 m}$$

Yield = Runoff $\times$ C.A

$= 0.5768 \times 125 \times 10^6$

Yield $= 72.113 \times 10^6 mm^3$

$\left\{ \begin{array}{l} C.A = 20 + 30 + 24 + 26 + 25 \\ = 125 km \\ = 125 \times 10^6 mm \end{array} \right.$

$$\boxed{\text{Yield} = 72.113 \text{ Mm}^3}$$

1.5 Runoff

Defination: Runoff is the part of rainfall or melted snow that does not penetrate to ground or evaporate. It flows over the land surface and through small streams, rivers and drains until it reaches lakes, reservoirs or the sea.

Factors Affecting Runoff

1) Rainfall characteristics:

Rainfall is the most important factor affecting runoff.

a) Rainfall intensity: Heavy rainfall produces more runoff because the soil cannot absorb water quickly.

b) Rainfall duration: Long duration rainfall increases runoff after the soil becomes saturated.

c) Rainfall distribution: Uniform rainfall over a large area generally produces more runoff over a than rainfall occuring only in a small area.

2) Soil Type:

different soils absorb water at different rates.
- sandy soil: water enters easily, so runoff is less.
- clayey soil: water enters slowly, so runoff is more.

3) Topography:

It depends upon surface and its degree of Inclination.

4) Storage condition:

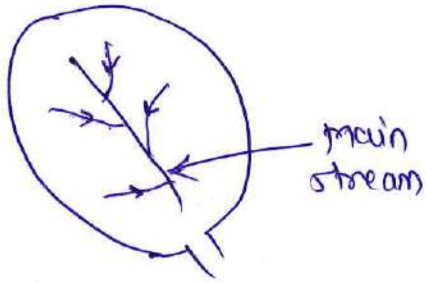
- Surface storage – Runoff is small
- Artificial storage – Due to evaporation Runoff is less.
- Ground storage – If soil pervious storage will increase but runoff will decreases.

5) Infiltration capacity:

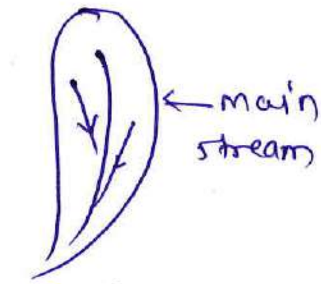
Infiltration is the process by which water enters the soil.
High infiltration → less runoff.
Low infiltration → More runoff.

6) Shape of Catchment:

- In fan shape catment as more the amount of Runoff.
- In ferm compare to less runoff.



a) fan shape



b) Fern shape.

7) Drainage system:

- Well developed drainage channels carry water quickly.
- Poor drainage may store water for some time and delay runoff.

8) Meteorological condition:

- Amount of runoff will be more if ground Saturated and frozen condition
- If temperature more then runoff is less.

9) Land Use:

- Urban areas with roads, buildings & concrete surface produce high runoff.
- Agricultural and forest areas allow more wate to enter the soil, reducing runoff.

10) Antecedent soil moisture:

- Dry soil absorb more water, runoff is less
- wet soil absorb less water, so runoff is more.

1.6 Maximum Flood discharge Measurement

Maximum flood discharge is the highest rate of flow of water passing through a river or stream during a flood. It is generally expressed in m^3/s (cumecs).

- When sufficient rainfall and streamflow data are not available, engineers estimate the maximum flood discharge using empirical methods.
- These methods are based on formulas developed from observations in different regions.

1.) Dickens formula

$$Q = CM^{3/4} \quad \text{or} \quad Q = CA^{3/4}$$

where, $C = 2$ to 40 constant.

Q = MFD in m^3/s

A = catchment area in km^2

2) Inglis formula

It is applicable to western Maharashtra and Gujrat for fan shaped catchment.

$$Q = \frac{125\,M}{\sqrt{M + 10.24}} \quad \text{OR} \quad \frac{125\,A}{\sqrt{A + 10.24}}$$

Here constant 125 may sometimes 123 or 120.

3) Ali Nawaz Jang Bahadur's formula

$$Q = 2.75\,A^{3/4}$$

4) Revy's formula

$$Q = CA^{3/4}$$

Factors Affecting Maximum value of MFD

The various factors which affect maximum value of MFD as follows:

1) High intensity of rainfall
2) Late in rainy season.
3) Uniformly spread rainfall in large extent of CA. (Catment Area)
4) Fan shaped catchment area.
5) Steep slope.
6) Rockey soil.
7) Downstream (D/S) direction of the wind.

Shri. Amarishbhai Patel
Survey No. 41/1, 41/2A,
Opposite to Pharmacy Education Complex,
Near Balaji Nagar, Karwand Road,
Shirpur- 425405 Dist: Dhule (MS)
Telephone: (02563)299299
Email: registrar@rcpcoep.ac.in

ASSIGNMENT QUESTIONS

1) Enlist the classification of Irrigation on the basis of purposes.
2) State any four benefits of Irrigation.
3) Define rainfall and explain Symon's rain gauge station.
4) The following data show a catchment area with average annual rainfall by using arithmetic mean method. Find out the mean rainfall over entire catchment area.

Station	A	B	C	D
Rainfall (mm)	110	103	99	89

5) Define Runoff and state the factors affecting runoff.
6) State any two ill effects of irrigation.
7) Enlist methods of assessment of irrigation water and explain any one.
8) Explain Hydrological cycle with the help of a neat sketch.
9) The isohyets for annual rainfall over a catchment basin were drawn. The areas of strips between isohyets are indicated below in table. Find average depth of a mud precipitation over the basin.

Isohyets (cm.)	Area (sq.km.)
75-85	580
85-95	2960
95-105	2850
105-115	1000
115-135	610
135-155	160

10) Define : i) Run-off ii) Yield
11) Define Rainfall. Draw a neat sketch of symon's rain gauge.
12) Define : i) Rainfall ii) Hydrological Cycle
13) Enlist the methods of calculating average Rainfall.
14) Explain any two surveys conducted for an irrigation project.
15) Enlist any four advantages of irrigation.
16) Explain the points in the selection of site for rain gauge station?
17) Describe Thiessen's polygon method with suitable sketch.