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Internal Assessment Test 1 – Mar. 2018

Sub:	Water Resource Engineering				Sub Code:	10CV846	Branch:	CIVIL
Date:	14/03/18	Duration:	90 min's	Max Marks: 50	Sem/Sec:	VIII/All		OBE

	Answer any for 50 marks	MARKS	CO	RBT
1 (a)	Define the term Runoff and list the various factors that affect the runoff of a given area.	[05]	CO1	L2
(b)	Explain the Thiessen polygon method with its advantages in hydrograph.	[10]	CO1	L2
2 (a)	Explain in details the different types of precipitation and atmospheric ocean circulation of water.	[06]	CO1	L2
(b)	Explain in brief: a) Unit hydrograph. b) Runoff coefficient c) -Index d) -Index.	[10]	CO1	L2
3 (a)	A catchment area of 140 km^2 received 120 cm rainfall in a year. At the outlet of the catchment the flow in the stream daily catchment has found to have an average rate of $2m^3$/sec. for 3 months, $3m^3$/sec for 6 months and $5m^3$/sec. for 3 months. Find out runoff coefficient and losses in the catchment area.	[10]	CO1	L2
4 (a)	Explain **Syphon's Rain gauge** with neat sketch diagram.	[10]	CO1	L2
5 (a)	A 6 hours storm produced rainfall intensities of 7, 18,25,12,10 and 3 mm/hour in successive one –hour intervals over a basin of $800km^2$. The resulting runoff is observed to be 2640 hactare metre. Determine the index of the basin.	[10]	CO1	L2

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IAT-1 SOLUTION

SUBJECT: WATER RESOURCE ENGINEEERING (10CV846)

Que.01 Runoff:

Runoff can be described as the part of the water cycle that flows over land as surface water instead of being absorbed into groundwater or evaporating. **Runoff** is that part of the precipitation, snow melt, or irrigation water that appears in uncontrolled surface streams, rivers, drains, or sewers.

Surface **runoff** is **water**, from rain, snowmelt, or other sources, that flows over the land surface, and is a major component of the **water** cycle. **Runoff** that occurs on surfaces before reaching a channel is also called overland flow. A land area which produces **runoff** draining to a common point is called a watershed.

Various factors affecting runoff:

Meteorological factors affecting runoff:

- Type of precipitation (rain, snow, sleet, etc.)
- Rainfall intensity.
- Rainfall amount.
- Rainfall duration.
- Distribution of rainfall over the watersheds.
- Direction of storm movement.
- Antecedent precipitation and resulting soil moisture.

Physical characteristics affecting runoff:

- Land use
- Vegetation
- Soil type
- Drainage area
- Basin shape
- Elevation
- Slope
- Topography
- Direction of orientation
- Drainage network patterns
- Ponds, lakes, reservoirs, sink, etc. in the basin, which prevent or alter runoff from continuing downstream.

Q.2 Thiessen polygon method:

The **Thiessen Polygon method** is an interpolation**method** commonly used for precipitation, but can be used on other point datasets. **Thiessen Polygons** are Voronoi Cells, a geometric means of dividing up an area given a set of known values at a relatively small number of points.

Solution: Thiessen polygons: the area influenced by a particular rain gauge Converts point precipitation data to an area .

• Locations within the watershed are assigned to the nearest rain gage

Area-weighted averages use proportional weights for precip values (i.e. the more area, the more the gage influences the average) , Arithmetic averages provide equal weights to all precip values Can be greatly different!

Creating Thiessen polygons requires four steps:

1. Plotting the rain gages on the watershed map

2. Connecting adjacent rain gages with a straight line

3. Determining the perpendicular bisectors

4. Extending the perpendicular bisectors to create polygons

• Factors to Consider: 1. All polygons should contain a rain gage 2. No polygon line should intersect another polygon line. Instead, they should all meet at polygon vertices

Consider a catchment area with say, 3 raingauge stations. Let there be 3 stations outside the catchment, but in its neighborhood.

The catchment area is drawn to scale and the position of these 6 stations are plotted on it. These 6 stations are joined so as to get a network of triangles.

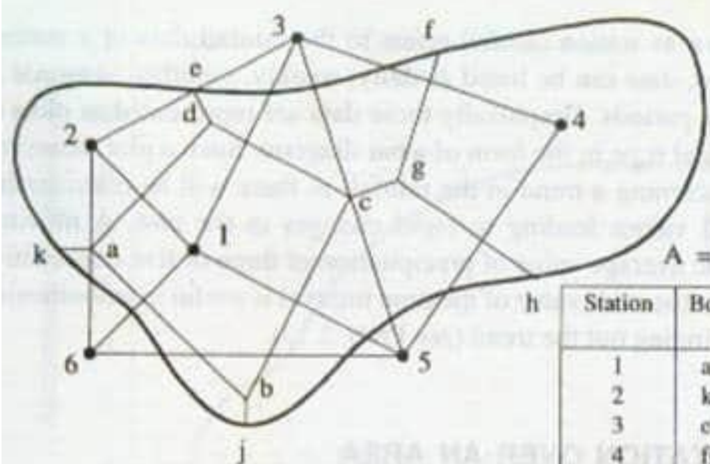
Perpendicular bisectors are drawn to each of the sides of these triangles. These bisectors form a polygon around each station.

If the boundary of the catchment cuts the bisectors, then the boundary is taken as the outer limit of the polygon. These bounding polygons are called Thiessen Polygons. The area of these polygons is measured with a planimeter or by grid overlay.

If there are n stations with rainfall values $P_1, P_2, P_3, \ldots.. P_n$ *and* $A_1, A_2, A_3, \ldots.. A_n$ *are the areas of the respective Thiessen polygons, the average rainfall over the catchment* $\bar{P}$ *is computed as*

$$\bar{P} = \frac{P_1 A_1 + P_2 A_2 + P_3 A_3 + \ldots\ldots\ldots\ldots\ldots + P_n A_n}{A_1 + A_2 + A_3 + \ldots\ldots\ldots\ldots\ldots + A_n} = \sum_{1}^{n} P_i \frac{A_i}{A}$$

$\frac{A_i}{A}$ *is called the weightage factor*



A = total catchment area

Station	Bounded by	Area	Weightage
1	abcd	A_1	A_1/A
2	kade	A_2	A_2/A
3	edcgf	A_3	A_3/A
4	fgh	A_4	A_4/A
5	hgcbj	A_5	A_5/A
6	jbak	A_6	A_6/A

Advantages:

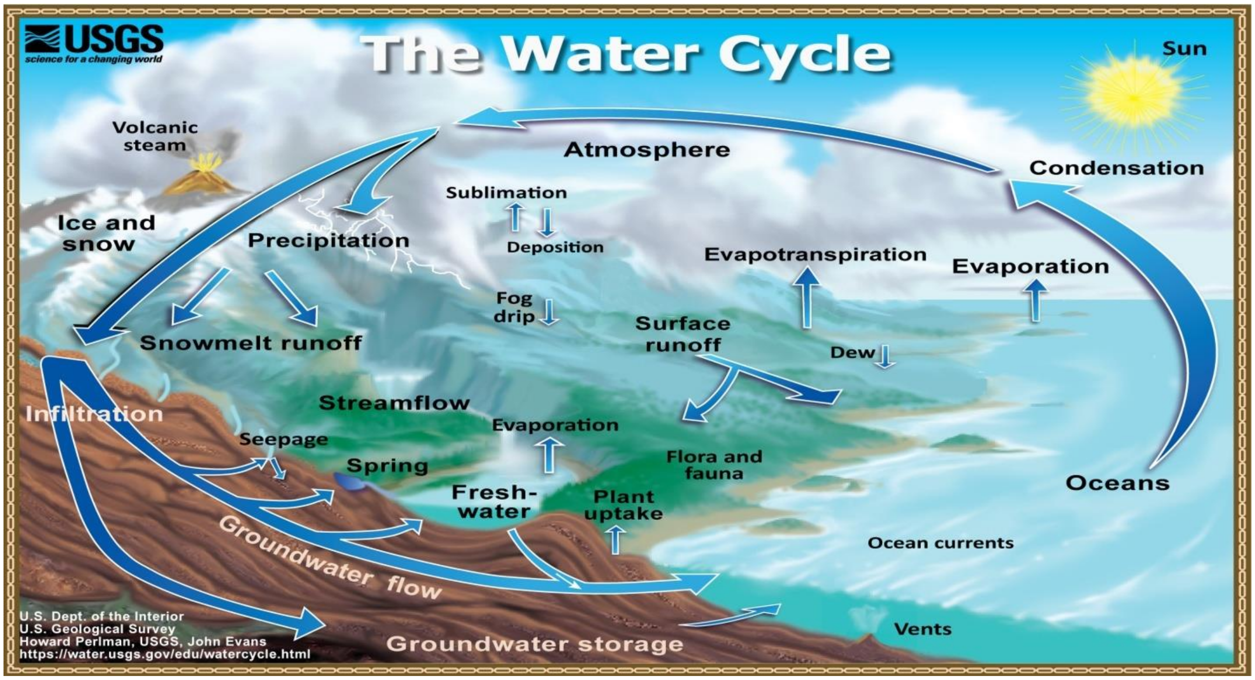
In order to achieve accurate estimation of the spatial distribution of rainfall, it is necessary to use interpolation methods, for this, the Thiessen* method is considered as the most important in engineering praxis. This method assigns weight at each gauge station in proportion to the catchment area that is closest to that gauge.

Larger area topography can be covered, most economical method.

Q.3 PRECIPITATION:

In meteorology, precipitation is any product of the condensation of atmospheric water vapor that falls under gravity. The main forms of precipitation include drizzle, rain, sleet, snow, graupel and hail. Precipitation occurs when a portion of the atmosphere becomes saturated with water vapor, so that the water condenses and "precipitates".

- The process of continuous condensation in free air helps the condensed particles to grow in size. When the resistance of the air fails to hold them against the force of gravity, they fall on to the earth’s surface. So after the condensation of water vapour, the release of moisture is known as precipitation. This may take place in liquid or solid form.
- Precipitation in the form of drops of water is called rainfall, when the drop size is more than **5 mm**.
- It is called **virage** when raindrops evaporate before reaching the earth while passing through dry air.
- **Drizzle** is light rainfall with drop size being less than 0.5 mm, and when evaporation occurs before reaching the ground, it is referred to as
- When the temperature is lower than the 0° C, precipitation takes place in the form of fine flakes of snow and is called **snowfall**. Moisture is released in the form of hexagonal crystals. These crystals form flakes of snow. Besides rain and snow, other forms of precipitation are **sleet** and **hail** (more about hail while studying thunderstorms), though the latter are limited in occurrence and are sporadic in both time and space.
- **Sleet** is frozen raindrops and refrozen melted snow-water. When a layer of air with the temperature above freezing point overlies a subfreezing layer near the ground, precipitation takes place in the form of sleet.
- Raindrops, which leave the warmer air, encounter the colder air below. As a result, they solidify and reach the ground as small pellets of ice not bigger than the raindrops from which they are formed. Sometimes, drops of rain after being released by the clouds become solidified into small rounded solid pieces of ice and which reach the surface of the earth are called **hailstones**. These are formed by the rainwater passing through the colder layers. Hailstones have several **concentric** layers of ice one over the other.
- **Rainfall:** drop size more than 0.5 mm.
- **Virage:** raindrops evaporate before reaching the earth.
- **Drizzle:** light rainfall; drop size less than 0.5 mm.
- **Mist:** evaporation occurs before reaching the ground leading to foggy weather.
- **Snowfall:** fine flakes of snow fall when the temperature is less than 0°C.
- **Sleet:** frozen raindrops and refrozen melted snow; mixture of snow and rain or merely partially melted snow.
- **Hail:** precipitation in the form of hard rounded pellets is known as hail; 5 mm and 50 mm.

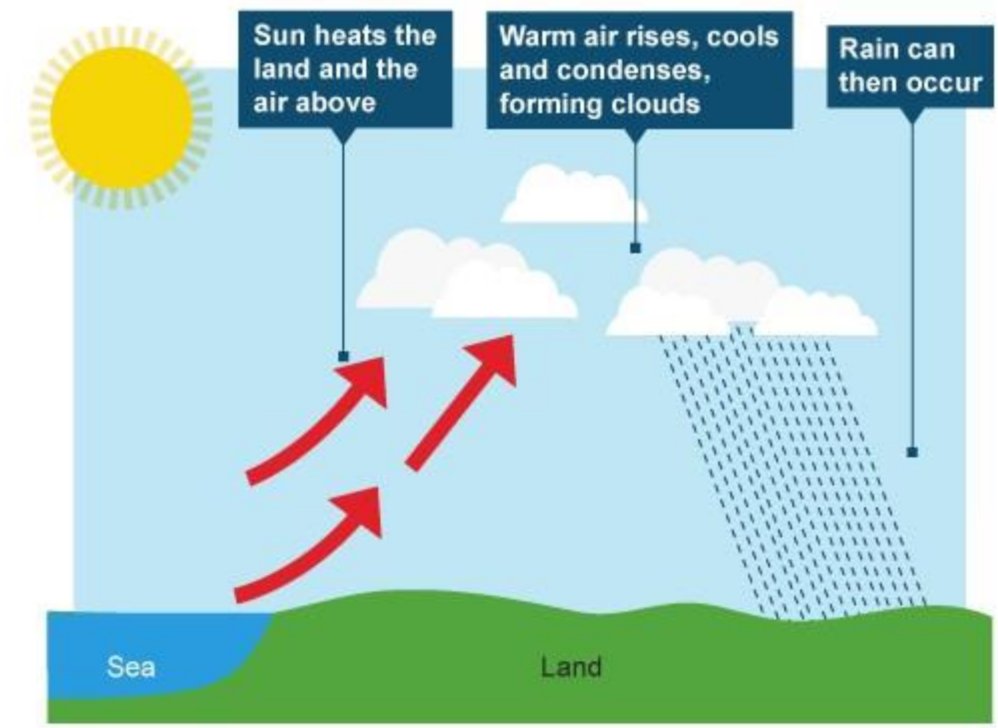


TYPES OF PRECIPITATION:

- Types of Rainfall /Precipitation
  - 2.1 Conventional Rainfall
  - 2.2 Orographic Rainfall
  - 2.3 Frontal Precipitation
  - 2.4 Cyclonic Rain
  - 2.5 Monsoonal Rainfall
- 3 World Distribution of Rainfa

Conventional Rainfall

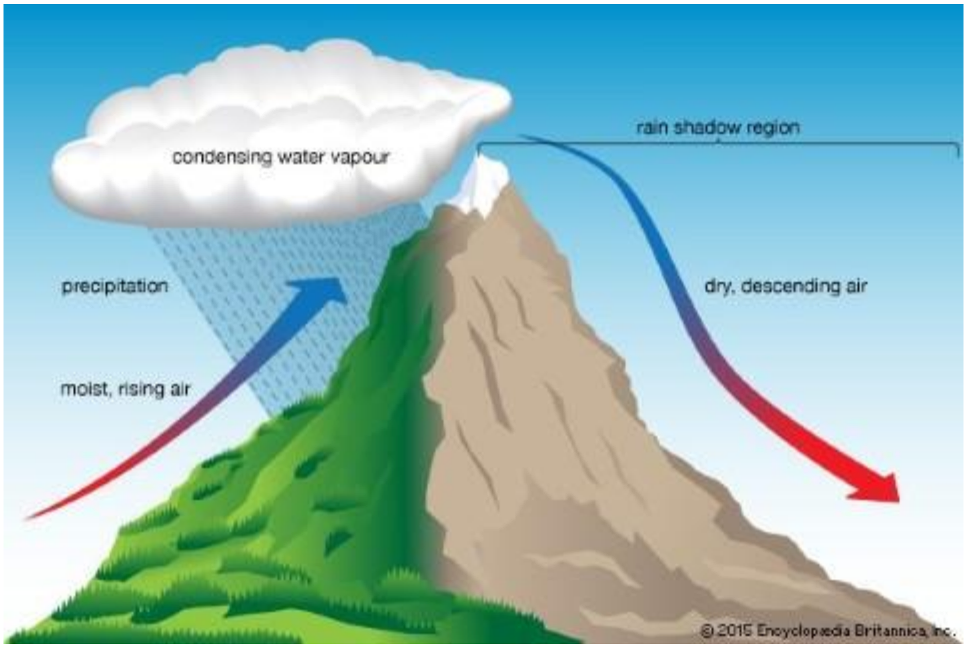
- The, air on being heated, becomes light and rises up in convection currents. As it rises, it expands and loses heat and consequently, condensation takes place and cumulous clouds are formed. This process releases **latent heat of condensation** which further heats the air and forces the air to go further up.
- Convectional precipitation is heavy but of **short duration**, **highly localised** and is associated with minimum amount of cloudiness. It occurs mainly during **summer** and is common over **equatorial doldrums** in the Congo basin, the Amazon basin and the islands of south-east Asia.



Orographic Rainfall

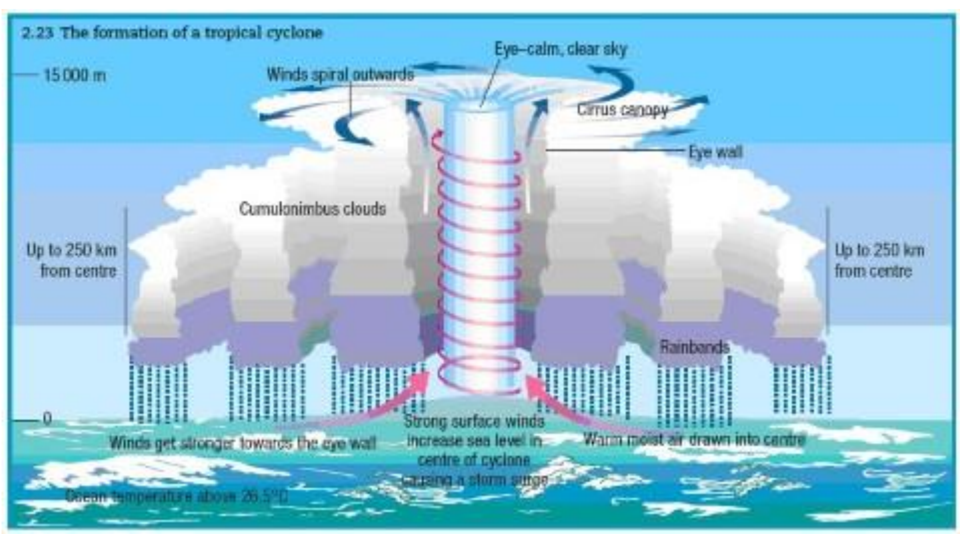
- When the saturated air mass comes across a mountain, it is forced to ascend and as it rises, it expands (because of fall in pressure); the temperature falls, and the moisture is condensed.
- This type of precipitation occurs when warm, humid air strikes an orographic barrier (a mountain range) head on. Because of the initial momentum, the air is forced to rise. As the moisture laden air gains height, condensation sets in, and soon saturation is reached. The surplus moisture falls down as orographic precipitation along the windward slopes.
- The chief characteristic of this sort of rain is that the **windward slopes** receive greater rainfall. After giving rain on the windward side, when these winds reach the other slope, they descend, and their temperature rises. Then their capacity to take in moisture increases and hence, these **leeward slopes** remain rainless and dry. The area situated on the leeward side, which gets less rainfall is known as the **rain-shadow area** (Some arid and semi-arid regions are a direct consequence of rain-shadow effect. Example: **Patagonian desert in Argentina, Eastern slopes of Western Ghats**). It is also known as the **relief rain.**
- Example: Mahabaleshwar, situated on the Western Ghats, receives more than 600 cm of rainfall, whereas Pune, lying in the rain shadow area, has only about 70 cm.

The Wind Descending on the Leeward Side is heated adiabatically and is called **Katabatic Wind.**



Cyclonic Rain

- Cyclonic Rainfall is **convectional rainfall on a large scale**. (we will see this in detail later)
- The precipitation in a tropical cyclone is of convectional type while that in a temperate cyclone is because of frontal activity.



Monsoonal Rainfall

- This type of precipitation is characterized by **seasonal reversal of winds** which carry oceanic moisture (especially the south-west monsoon) with them and cause extensive rainfall in south and southeast Asia. (More while studying Indian Monsoons).

Q. Explain in brief:

Unit hydrograph, runoff coefficient, Φ- index , ω-index

UNIT HYDROGRAPH: The unit hydrograph is the unit pulse response function of a linear hydrologic system. • First proposed by Sherman (1932), the unit hydrograph (originally named unit-graph) of a watershed is defined as a direct runoff hydrograph (DRH) resulting from 1 in (usually taken as 1 cm in SI units) of excess rainfall generated uniformly over the drainage area at a constant rate for an effective duration. • Sherman originally used the word "unit" to denote a unit of time. But since that time it has often been interpreted as a unit depth of excess rainfall.

The unit hydrograph is a simple linear model that can be used to derive the hydrograph resulting from any amount of excess rainfall. The following basic assumptions are inherent in this model;

1. Rainfall excess of equal duration are assumed to produce hydrographs with equivalent time bases regardless of the intensity of the rain

2. Direct runoff ordinates for a storm of given duration are assumed directly proportional to rainfall excess volumes.

3. The time distribution of direct runoff is assumed independent of antecedent precipitation

4. Rainfall distribution is assumed to be the same for all storms of equal duration, both spatially and temporally.

Terminologies

1. Duration of effective rainfall : the time from start to finish of effective rainfall

2. Lag time (L or tp): the time from the center of mass of rainfall excess to the peak of the hydrograph

3. Time of rise (TR): the time from the start of rainfall excess to the peak of the hydrograph

4. Time base (Tb): the total duration of the DRO hydrograph.

Rules to be observed in developing UH from gaged watersheds

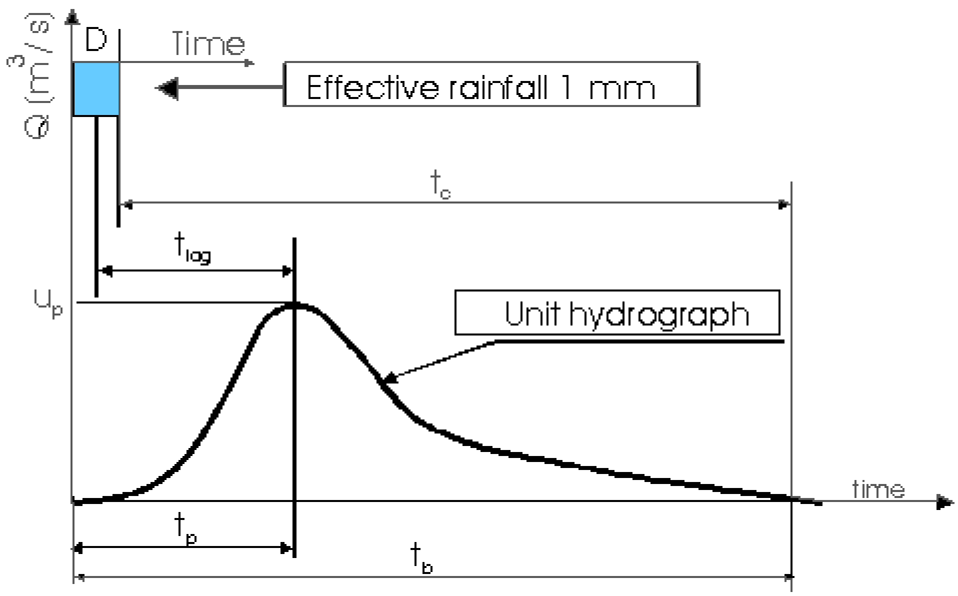
1. Storms should be selected with a simple structure with relatively uniform spatial and temporal distributions

2. Watershed sizes should generally fall between 1.0 and 100 mi2 in modern watershed analysis

3. Direct runoff should range 0.5 to 2 in.

4. Duration of rainfall excess D should be approximately 25% to 30% of lag time tp

5. A number of storms of similar duration should be analyzed to obtain an average UH for that duration
6. Step 5 should be repeated for several rainfall of different durations.



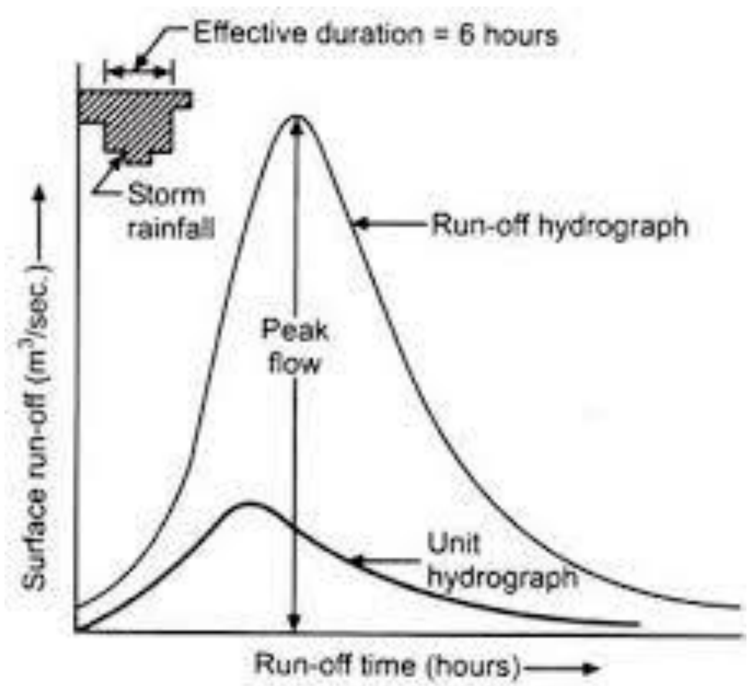


Fig. 15.16.

b. The **runoff coefficient** (C) is a dimensionless **coefficient** relating the amount of**runoff** to the amount of precipitation received. It is a larger value for areas with low infiltration and high **runoff** (pavement, steep gradient), and lower for permeable, well vegetated areas (forest, flat land).

$$K = \frac{\text{Runoff [mm]}}{\text{Rainfall [mm]}}$$

Runoff coefficient from an individual rainstorm is defined as runoff divided by the corresponding rainfall both expressed as depth over catchment area (mm):

Phi-index (Φindex)- INFILTRAION INDICES: This is defined as the rate of infiltration, in which the rainfall volume equals runoff volume.(Total rainfall depth-losses due to abstraction)/hours duration of rainfall.

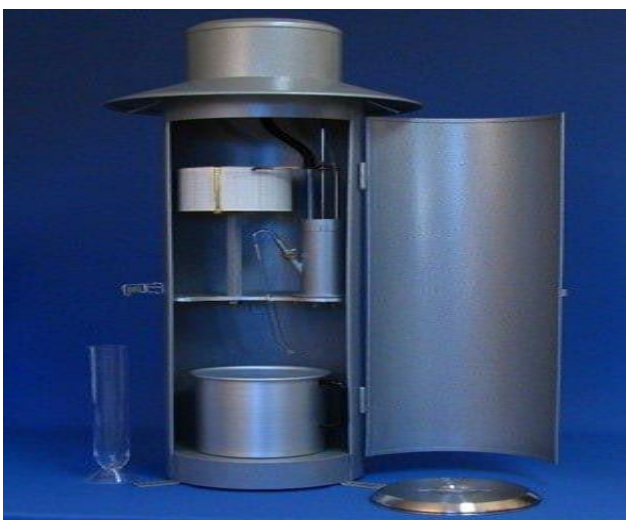
The W – index

This is the average infiltration rate during the time when the rainfall intensity exceeds the infiltration rate. Thus, W may be mathematically calculated by dividing the total infiltration (expressed as a depth of water) divided by the time during which the rainfall intensity exceeds the infiltration rate. Total infiltration may be fund out as under:

Total infiltration = Total precipitation – Surface runoff – Effective storm retention

The W – index can be derived from the observed rainfall and runoff data. It differs from the - index in that it excludes surface storage and retention. The index does not have any real physical significance when computed for a multiple complex watershed. Like the phi-index the - index, too is usually used for large watersheds.

SYPHON RAIN GAUGE_RECORDING TYPE_FLOATING



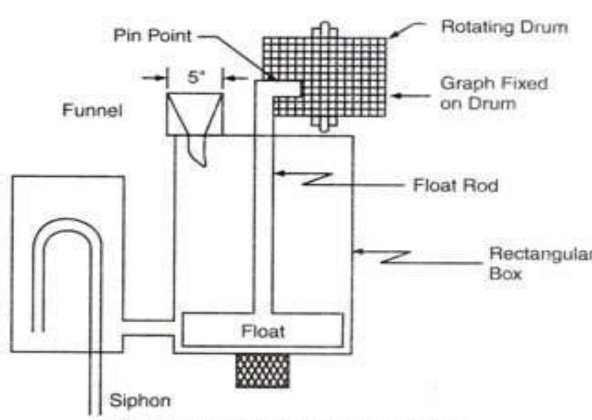
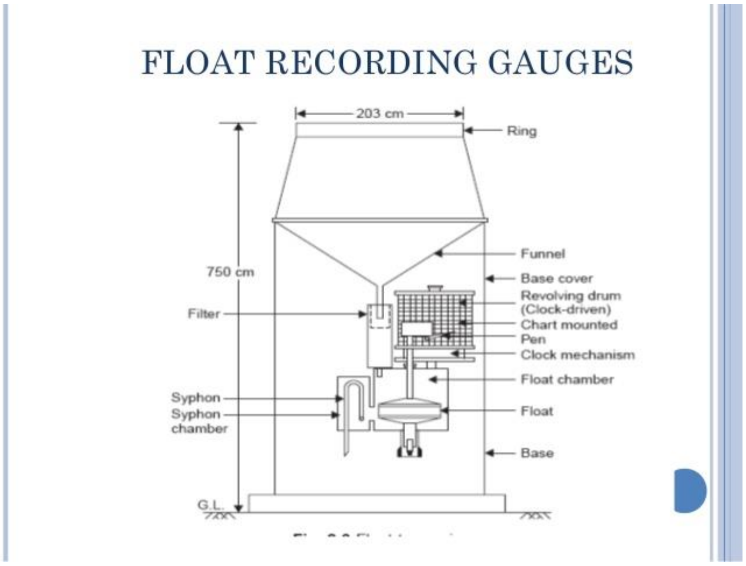


Fig. 2.5. Recording type rain-gauge

The working of this type of rain gauge is similar to weighing bucket rain gauge. A funnel receives the water which is collected in a rectangular container. A float is provided at the bottom of container, and this float raises as the water level rises in the container. Its movement being recorded by a pen moving on a recording drum actuated by a clock work.

When water rises, this float reaches to the top floating in water, then syphon comes into operation and releases the water outwards through the connecting pipe, thus all water in box is drained out. This rain gauge is adopted as the standard recording rain gauge in India and the curve drawn using this data is known as mass curve of rain fall.



TYPICAL LAYOUT

Numerical: 3a. Solution:

Numerical:5 a solution:

papergrid

Date: / /

A catchment area of 140 km² received 120 cm rainfall in a year. At outlet of the catchment the flow in the stream draining the catchment was found to have an avg. rate of 2 m³/sec for 3-months, 3 m³/sec for 6-months & 5 m³/sec for 3-months.

(i) Runoff coeff for catchment:

Total P = $140 \times 10^6 \times 1.2 = 1.68 \times 10^8 m^3/year$

R = $2 \times 3 \times 30 \times 24 \times 60 \times 60 + 3 \times 6 \times 30 \times 24 \times 60 \times 60 + 5 \times 3 \times 30 \times 24 \times 60 \times 60$

101088000

P − losses = R

R coff = ~~0.61~~ 0.6017

R — reduce to 0.5 — $\frac{R}{P} = 0.5$

Runoff = $.84 \times 10^8 m^3/year$

∴ Runoff cm = $\frac{.84 \times 10^8}{140 \times 10^6}$ = .6 m = 60 cm

Losses = 120 − 60 = 60 cm

Q. 5 (a)

time - 6 hours.

Rainfall intensities →

Total Rainfall volume

total = (7 + 18 + 25 + 12 + 10 + 3) = (75 mm)

Rainfall Depth = Rainfall volume / CATCHMENT Area

= 75 mm / 800 km² = 75 / ~~800 × 10³ m~~

(1) = 75 mm / 800 × 10¹² = 0.09375 × 10⁻¹² mm.

→ Run off = [2640 hact-metre] → metre

ϕ index = 75 mm / 6 = mm/hr

2640 hact m = 2640 × 10⁴ m². m

2640 × 10⁴ m³