Subject Name:	**19A01502 WATER RESOURCES ENGINEERING (R-19)**
Staff Name :	**V.GANGA MAHESH REDDY**
Topic:	**PART – A QUESTIONS WITH ANSWER**
UNIT-I	**INTRODUCTION TO HYDROLOGY**

1. Define hydrology.

1. Engineering hydrology is the science of water resource engineering which deals with the study of Water in
   (1) Above the earth surface.
   (2) On the earth surface.
   (3) Below the earth surface.
2. The study embraces the entire domain of water present in earth, its history along with its quantitative use on the earth.
3. A civil engineer must have the basic knowledge of hydrology to engage in the planning, designing and the construction of several
   (1) Irrigation structures,
   (2) Flood control works.

2. What are the Features of Hydrology?

1) Estimation of water resources.
2) Study the components of the hydrological cycle like precipitation, runoff, transpiration, and their interactions.
3) Study the problems of floods and droughts and preventive actions.

3. What are the Scope of Engineering Hydrology?

1. Determination of Maximum Probable Flood.
2. Determination of Water yield from a basin.
3. Study the groundwater development.
4. Determination of maximum intensity of the storm.

4. What are the Applications of Engineering Hydrology

1) Hydrology provides guidance for undergoing proper planning and management of water resources.
2) Calculates rainfall, surface runoff, and precipitation.
3) It determines the water balance for a particular region.
4) It mitigates and predicts flood, landslide and drought risk in the region.
5) It estimates the water resource potential of the river basins
6) Enables real-time flood forecasting and flood warning.
7) Hydrology analyses the variations observed in the catchments by bringing a relationship

between the surface water and groundwater resources of the catchment.

8) Hydrology studies the required reservoir capacity that is necessary for irrigation and municipal water supply purpose during drought conditions.

9) It is used in the design and operation of hydraulic structures.
10) It is used for hydropower generation.
11) Brings measures to control erosion and sediments.

5. Define hydrological cycle and what are the components of it?

The total water supply of earth is in constant circulation from earth to atmosphere and back to the earth. The earths water circulatory system is known as hydrologic cycle.

Components of hydrological cycle

1) Condensation,
2) Precipitation,
3) Evaporation,
4) Transpiration,
5) Evapotranspiration,
6) Runoff,
7) Infiltration,
8) Percolation,
9) Interception,
10) Depression Storage.

6. Define Condensation.

It is the conversion of a vapor or gas to a liquid. The water vapour evaporates from the water bodies like ocean, sea and river. These vapors after reaching a height around 20km in the sky undergo condensation and forms clouds. These later precipitate as rain, fog etc.

7. Define Precipitation and what are the types and forms of it.

It is the fall of moisture from the atmosphere to the earth's surface in any form.

Forms of precipitation

Liquid precipitation	Rainfall.
Frozen precipitation	Mist, Drizzle, Snow, Hail, Sleet, Glaze, Dew, Freezing Rain, ect.

Types of precipitation

1) Cyclonic precipitation
2) Convective precipitation
3) Orographic precipitation
4) Precipitation due to turbulent ascent.

8. Define Evaporation.

It is the conversion of natural liquids like water into gaseous form like air. Evaporation happens in the water bodies.

9. Define Transpiration.

It is the evaporation taking place from any plant or greenery. For example, a water droplet on a leaf getting evaporated into the atmosphere.

10. Define Evapotranspiration.

It is the combination of evaporation and transpiration.

11. Define Runoff.

It is the water flowing over the land making its way towards rivers, lakes, oceans, etc. as surface or subsurface flow.

12. Define Infiltration.

It is the process of filtration of water to the inner layers of soil based on its structure and nature. Pervious soils go through more infiltration than impervious. Infiltration in soils like sand, gravel and coarser material is more and for finer soil particles like clay and silt, infiltration is less.

Infiltration is inversely proportional to runoff. In soil, if infiltration is less, then the runoff is more. Similarly, more infiltration gives less runoff. Example: bitumen roads have more runoff than metallic red mud roads.

13. Define Percolation.

Percolation is the movement of water through the soil itself. Finally, as the water percolates into the deeper layers of the soil, it reaches ground water, which is water below the surface. The upper surface of this underground water is called the "water table".

14. Define Interception.

Part of precipitation required to wet the surface of soil, buildings and all pervious surfaces is called Interception.

15. Define Depression Storage.

It is the part of precipitation required to fill depression zones of land.

16. Define Cyclonic precipitation.

A cyclone is a region in the atmosphere with large low pressure having circular wind motion. The cyclonic precipitation is caused by the movement of moist air mass to this region due to the difference in pressure. Cyclones can be of two types frontal and non-frontal precipitation.

The cyclonic precipitation may be divided into two-part

1. Frontal Precipitation
2. Non-Frontal Precipitation

A. Frontal Precipitation:

A frontal is called as the hot moist air mass boundary. This precipitation is caused by the expansion of air near the frontal surface.

B. Non-Frontal Precipitation:

This is a cold moist air mass boundary that moves and results in precipitation.

17. Define Convective precipitation.

The air above the land area gets heated up by some cause. The most warmer air rises up and cools and precipitates. Convective precipitation is showery in nature. This type of precipitation happens in varying intensities. The areal extent of convective precipitation is small in the range of less than 10km in diameter.

18. Define Orographic precipitation

Moving air masses have chances to strike barriers like mountains. Once they strike, they rise up which causes condensation and precipitation. The precipitation is greater in the windward side of the barrier compared to the leeward side of the barrier.

19. Define Precipitation Due to Turbulent Ascent

1. Air mass is forced to rise up due to greater friction of the earth's surface after its travel over the ocean.
2. The air mass rises up because of increased turbulence and friction when it ultimately condenses, and precipitation occurs.
3. Winter rainfall is mainly due to this process.

20. Define the followings: Mist, Drizzle, Snow, Hail, Sleet, Glaze, Dew, Freezing Rain.

Sl.No	Form	Descriptions	Particle Size in "mm"
1	***Mist***	Tiny liquid droplets dropping from low strata	**0.1 to 0.5**
2	***Rain***	Water drops -liquid precipitation	**> 0.5**
3	***Drizzle***	Uniform sprinkle of small drops of water, also sometimes called very light rain.	**0.1 to 0.5**
4	***Snow***	Atmospheric water vapour frozen into ice crystals and falling in light white flakes or lying on the ground as a white layer.	-
5	***Hail***	Lumps of ice formed due to intense cooling, mostly during convective storm	**5 to 125**
6	***Sleet***	Grains of ice, transparent, solid, formed by freezing of raindrops near ground.	**> 0.5**
7	***Glaze***	Ice coating formed on near surface objects due to cooling of mist or drizzle.	-
8	***Dew***	Formed on cold surface during early morning hours from air moisture.	**1 to 2**

21. What are the methods available to calculate the Precipitation?

1) Arithmetic Mean Method,
2) Theissen Polygon Method, and
3) Iso-Hyetal Method.

22. What are the methods available to estimate the Missing Rainfall Data?

1) Simple Arithmetic Method
2) Normal Ratio Method
3) Modified normal ratio method
4) Inverse distance method
5) Linear programming method

23. What are the methods available for the analysis and interpret the Rainfall data?

1) Mass curve Method,
2) Hyetograph Method.

24. Using Arithmetic average method find the average rainfall over a catchment. The rainfall data is 12.6, 18.8, 14.8, 10.4, 16.2 mm.

Solution: Arithmetic Average Method:

There are 5 stations within the catchment.

$$Average\ depth\ of\ ppt. = \frac{\sum Rainfall\ value}{Number\ of\ Stations}$$

$$Average\ depth\ of\ ppt. = \frac{\sum(12.6 + 18.8 + 14.8 + 10.4 + 16.2)}{5} = \frac{72.8}{5} = 3.09\ cm$$

25. Using Thissen Polygon method find the average rainfall over a catchment.

Stations	A	B	C	D	E
Rainfall in cm	30.8	33.4	34.6	32.6	24.6
Area of polygon km^2	40	45	38	30	43

Solution: Thiessen Polygon Method:

Weighted depth of Rainfall = *(Rainfall X Area of polygon)*

Stations	**Rainfall in cm**	**Area of polygon km^2**	**Weighted depth of Rainfall**
A	30.8	40	1232
B	33.4	45	1503
C	34.6	38	1314.8
D	32.6	30	978
E	24.6	43	1057.8
	Σ	**193**	**6058.6**

$$Average\ depth\ of\ ppt. = \frac{\sum Weighted\ depth\ of\ Rainfall}{\sum Area\ of\ polygon} = \frac{6058.6}{193} = 31.53\ mm$$

26. Using Thissen Isohyet method find the average rainfall over a catchment.

Isohyets	12	13	14	15	16	17
Area b/w Isohyets km^2	22	80	110	89	70	
Rainfall in cm	12.5	13.5	14.5	15.5	16.5	

Solution: Isohyet Method:

Isohyet interval in cm	Area b/w Isohyets (km^2)	Rainfall (cm)	Volume of ppt.
12	22	12.5	275
13			
14	80	13.5	1080
15	110	14.5	1595
16	89	15.5	1379.5
17	70	16.5	1155
Total	**371**		**5484.5**

$$Average\ depth\ of\ precipitation\ = [\frac{Volume\ of\ ppt.}{Area\ of\ catchment}] = [\frac{5484.5}{371}] = 14.78\ cm$$

27. During a month a rain gauge went out of order while the other three gauges in the basin reported rainfalls of **107, 89 and 120 mm.** if the annual normal rainfalls for these three gauges are **1120, 935, 1200 mm** respectively and the normal annual rainfall of the broken gauge is **978 mm.** Estimate the missing monthly rainfall at the broken gauge? **(REFER BOO P.NO-78) (DEC- 2018 – R 15)**

Solution:

Precipitations, $P_1 = 107\ mm$, $P_2 = 89\ mm$, $P_3 = 120\ mm$.
Annual normal rainfalls, $N_1 = 1120$, $N_2 = 935$, $N_3 = 1200$.
Annual normal rainfall of broken gauge, $N_x = 978$.

Therefore, 10% of $N_x = 97.8$
$(N_x - N_1)$= (978 – 1120) = -142 < 97.8
$(N_x - N_2)$= (978 – 935) = 43 < 97.8
$(N_x - N_3)$= (978 – 1200) = -222 < 97.8

Here, the difference of $N_1, N_2\ N_3$, are less than **10% of N_x**. hence, **Simple average method** can be used to fine missing rainfall.

$$P = \frac{P_1 + R_2 + P_3}{3}$$

$$P = \frac{107 + 89 + 120}{3} = 105.33\ mm$$

The missing monthly rainfall of broken gauge is **P = 105.33 mm**

28. During a month a rain gauge went out of order while the other three gauges in the basin reported rainfalls of **107, 89 and 120 mm.** if the annual normal rainfalls for these three gauges are **1110, 800, 1100 mm** respectively and the normal annual rainfall of the broken gauge is **978 mm.** Estimate the missing monthly rainfall at the broken gauge? **(REFER BOO P.NO-78) (DEC- 2018 – R 15)**

Solution:

Precipitations, $P_1 = 107\ mm$, $P_2 = 89\ mm$, $P_3 = 120\ mm$.
Annual normal rainfalls, $N_1 = 1110$, $N_2 = 800$, $N_3 = 1100$.
Annual normal rainfall of broken gauge, $N_x = 978$.

Therefore, 10% of $N_x = 97.8$
$(N_x - N_1)$= (978 – 1110) = -132 < 97.8
$(N_x - N_2)$= (978 – 800) = 178 > 97.8
$(N_x - N_3)$= (978 – 1100) = -122 < 97.8

Here, the difference of N_1, N_3, are less than **10% of N_x**. but, N_2 difference is more than **10% of N_x**. hence, **Simple average method** cannot be used to fine missing rainfall. So, we use **Normal ratio method**

$$P_x = \frac{N_x}{m}\left(\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} + \cdots + \frac{P_m}{N_m}\right)$$

$$P_x = \frac{978}{3}\left(\frac{107}{1110} + \frac{89}{800} + \frac{120}{1100}\right)$$

$$P = 74.768\ mm$$

The missing monthly rainfall of broken gauge is **P = 74.768 mm**

29. The normal annual rainfall at stations A, B, C and D in a basin **are 80.97, 67.59, 76.28, and 92.01 cm,** respectively. In the year 1975, the station D was inoperative and the stations A, B, and C recorded annual rainfall of 91.11, 72.23, and 79.89 cm, respectively. Estimate the rainfall at station D in that year.

Solution:

As the normal rainfall values vary by more than 10%, the **Ration method is adopted**.

$$P_x = \frac{N_x}{m}\left(\frac{P_1}{N_1} + \frac{P_2}{N_2} + \frac{P_3}{N_3} + \cdots + \frac{P_m}{N_m}\right)$$

$$P_x = \frac{92.01}{3}\left(\frac{92.11}{80.71} + \frac{72.23}{67.59} + \frac{79.89}{76.28}\right)$$

$$P = 99.41\ cm$$

30. How to measure the Precipitation?

It can be measured by the rain gauge. The rain gauge may be

a) Recording type rain gauge
b) Non-Recording type rain gauge.

31. What is Rain Gauges?

a) Rain-gauges is the instrument used to measure the rainfall.
b) Rain gauges are also known as **Odometer, Pluviometer** and **Ombrometer.**

Types of Rain Gauges

Sl.No	Recording Rain Gauges	Non Recording Rain Gauge
1	Weighing bucket type	Simon's rain-gauge.
2	Tipping bucket type	
3	Floating *or* Natural Symon's rain gauge.	

32. What are the demerits of Non-recording type rain gauge?

It does not give information regarding

a) Beginning of the rainfall
b) End of the rain
c) Intensity of rainfall.

33. Enlist the three types of recording type rain gauge?

a) Tipping bucket
b) Weighing bucket
c) Floating bucket.

34. Write short notes on rain gauge density?

It is the number of rain gauge is to erected in an given area.

Rain gauge density = No of rain gauges / Area.

35. Enumerate the methods used to estimate the amount of evaporation from a water surface?

a) Evaporimeters
b) Analytical methods
c) Empirical formulae.

36. Write short notes on Evaporimeters?

a) Class A evaporation pan
b) ISI Standard pan
c) Colorado sunken pan
d) US geological survey floating pan.

37. Define pan co efficient?

Pan co efficient = lake evaporation/pan evaporation.

38. Define infiltrometers and mention its type?

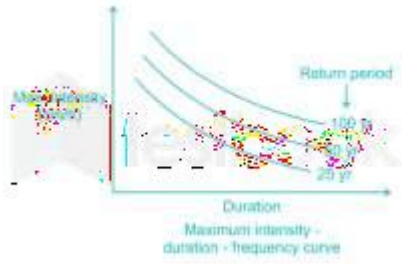
Infiltrometers are the devices used to measure infiltration. There are two kinds of infiltrometer.

a) Flooding type infiltrometer
b) Rainfall simulator.

39. Define IDF Curve.

a) Intensity-Duration-Frequency (IDF) curves describe the relationship between rainfall intensity, rainfall duration, and return period (or its inverse, probability of exceedance).
b) IDF curves are commonly used in the design of hydrologic, hydraulic, and water resource systems.

c) IDF curves are obtained through frequency analysis of rainfall observations.

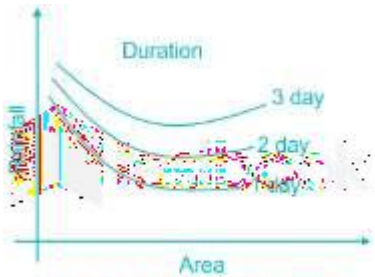


Maximum intensity - duration - frequency curve

40. Define DAD Curve.

a) Depth-Area-Duration relationships indicate the areal distribution characteristic of a storm of a given duration.

b) The maximum depth area curve for a given duration D is prepared by **assuming the area distribution of rainfall for smaller duration to be similar to** the total storm.



Depth Area Duration Curves

41. Define Probable Maximum Precipitation (PMP)

Probable Maximum Precipitation (PMP) is '**the greatest depth of precipitation for a given duration meteorologically possible for a design watershed** or a given storm area at a particular location at a particular time of year, with no allowance made for long-term climatic trends.

42. Define Design Storm.

Design storm means **a hypothetical depth of rainfall that would occur for the stated return frequency** (i.e. once every 2 years or 10 years), duration (i.e. 24-hours) and timing of distribution (i.e. type II). All values are based on the historical rainfall records for the area.

43. Define frequency of rainfall.

The number of times, during a specified period of years, that precipitation of a certain magnitude or greater occurs or will occur at a station; numerically, the reciprocal of the frequency is usually given.

44. Define consistency of rainfall data.

If the curve comes out to be straight line then the rainfall data of the station under consideration is consistent. This is based on the principle that **the mean accumulated precipitation of a number of stations which are meteorologically similar is not materially affected**.

45. What are the Hydrological Datas ?

1) Catchment Flood Management plans
2) Climate Records

3) Flood maps
4) Gauged flow records
5) Groundwater vulnerability maps
6) Hydrological summaries
7) MORECS
8) Groundwater level records
9) Water quality
10) Water resources data.

Subject Name	**19A01502 WATER RESOURCES ENGINEERING (R-19)**
Staff Name :	**V.GANGA MAHESH REDDY**
Topic:	**PART – A QUESTIONS WITH ANSWER**
UNIT-II	**COMPONENTS OF PRECIPITATION**

1. What is Evaporation and What are the types of evaporation?

Evaporation is **a type of vaporization that occurs on the surface of a liquid as it changes into the gas phase**. The surrounding gas must not be saturated with the evaporating substance. When the molecules of the liquid collide, they transfer energy to each other based on how they collide with each other.

Types of Evaporations

a) Surface Evaporation
b) Water Surface Evaporation
c) Evaporation From Plants and Leaves
d) Atmosphere Evaporation.

2. What are the factors depended by Rate of evaporation?

(1) Vapour pressures at the water surface and the air above.
(2) Wind speed - Incident solar radiation.
(3) Atmospheric pressure - Quality of water.
(4) Air and water temperatures.
(5) Size of the water body.

3. What are the Factors affecting Evaporation?

(1) Water Surface Area,
(2) Temperature,
(2) Solar Radiation and Sunshine Duration,
(3) Rh,
(4) Wind Speed,
(5) Vapor Pressure Difference (Gradient),
(6) Atmospheric Pressure,
(7) Water Quality, and
(8) Water Depth And Soil Type.

4. What are the methods available to Reduce Evaporation?

(1) Wind breakers.
(2) Covering the water surface.
(3) Reduction of exposed water surface

(4) Underground storage of water
(5) Integrated operation of reservoirs
(6) Treatment with chemical water evapo retardants (wer).

5. What are the methods available to measurement of Evaporation?

1. Using Evaporimeters.
    a) USWB Class A Evaporation Pan
    b) ISI Standard Pan
    c) Colorado Sunken Pan
    d) USGS Floating Pan

2. Using Empirical equations.
    a) Dalton's equation
    b) Meyer's Formula
    c) Rohwer's Formula.

3. By Analytical methods
    a) Water Budget Method
    b) Energy Budget Method
    c) Mass Transfer Method

6. What is Evaporimeter ?

These are pans containing water which are exposed to the atmosphere. Loss of water by evaporation from these pans are measured at regular intervals (daily). Meteorological data such as humidity, wind velocity, air and water temperatures, and precipitation are also measured and noted along with evaporation.

7. Define Evapotranspiration.

Evapotranspiration is **the sum of evaporation from the land surface plus transpiration from plants**. The typical plant, including any found in a landscape, absorbs water from the soil through its roots. ... In general, evapotranspiration is the sum of evaporation and transpiration.

Evapotranspiration = Evaporation + Transpiration

8. What are the Factors affecting Evapotranspiration?

Climate factors:

1. Temperature
2. Humidity
3. Wind speed
4. Duration & intensity of light
5. Atmospheric vapor pressure.

Soil factors:

1. Texture
2. Structure
3. Moisture content
4. Hydraulic conductivity.

Plant factors:

1. Efficiency of root systems in moisture absorption

2. The leaf are
3. Leaf arrangement and structure
4. Stomatal behaviour.

9. How to measure Evapotranspiration?

1. Lysimeter or Tank experiments
    a) Non-weighing constant water table type
    b) Non-weighing percolation type
    c) Weighing type.
2. Soil Moisture Depletion Studies.
3. Field experimental plots
4. Water balance method

10. How to determine of Evapotranspiration?

1. Blaney-Criddle Method
2. Thorn Thwaite Method
3. Hargreaves' Method.

11. Define Infiltration.

Infiltration is **the process by which water on the ground surface enters the soil**. ... Infiltration rate in soil science is a measure of the rate at which a particular soil is able to absorb rainfall or irrigation. It is measured in inches per hour or millimetres per hour. The rate decreases as the soil becomes saturated.

12. What are the Factors affecting Infiltration?

1. Initial moisture content
2. Condition of the soil surface
3. Hydraulic conductivity of the soil profile
4. Texture
5. Porosity
6. Degree of swelling of soil colloids
7. Organic matter
8. Vegetative cover
9. Duration of irrigation or Rainfall
10. Viscosity of water
11. Soil moisture content
12. Organic materials in soils
13. Land cover
14. Slope.

13. Define Infiltration Indices.

Various infiltration indices give rates of infiltration in different ways to help assessment of the water lost by way of infiltration.

The important among them are the following:

(i) Infiltration Capacity:
(ii) ϕ Index:
(iii) W Index:

14. Define Infiltration capacity.

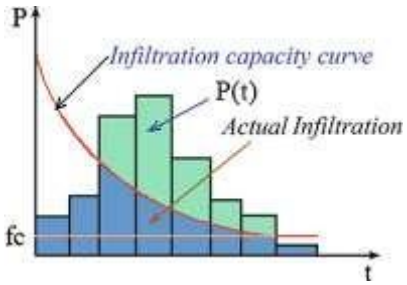
The infiltration capacity is defined as **the maximum rate of infiltration**. It is most often measured in meters per day but can also be measured in other units of distance over time if necessary. The infiltration capacity decreases as the soil moisture content of soils surface layers increases.

Horton gave the following mathematical expression to find out the value of infiltration capacity at any time:

$$f_p = f_c + (f_o - f_c)e^{-kt}$$

Where,

$f_p = Infiltration\ capacity$
$f_o = Infiltration\ rate\ at\ the\ beginning\ of\ storm$
$f_c = constant\ infiltration\ rate$
$e = base\ of\ natural\ logarithms\ (Napierian\ base)$
$t = time\ from\ beginning\ of\ rainfall\ and\ K\ is\ a\ constant$



15. Define ϕ Index:

1) It is the rate of remaining average rainfall after the surface runoff.
2) It is lost by the processes of Infiltration, Interception, Depression storage.
3) The index can be calculated from a hyetograph *(time versus intensity of rainfall graph)*

$$(\emptyset\ index) = V_{W\ Lost} = (V_{Total\ Rainfall} - V_{Total\ Runoff})$$

16. Define W Index:

W – index 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 occurs.

The W index can be obtained from the following equation:

$$W_{index} = \left(\frac{P - Q - S}{t}\right)$$

Where

$W = Average\ rate\ of\ infiltration$
$P = Total\ storm\ rainfall\ corresponds\ to\ t$
$Q = Total\ storm\ run - off$
$t = time\ during\ which\ rainfall\ intensity\ is\ more\ than\ W$
$S = effective\ surface\ retention$
$W = \phi$ average rate of retention.

17. Define Hyetograph:

a) The Graph drawn between Time versus Intensity of rainfall.

b) It is used to find **ϕ Index.**

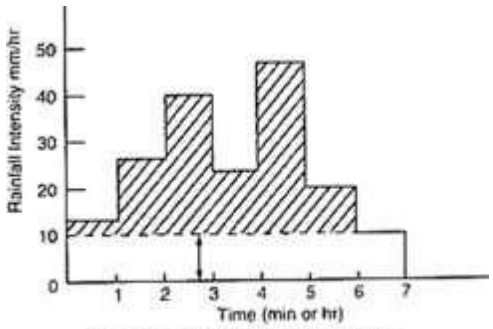


Fig. 3.2. ϕ index from hyetograph

Anantha Lakshmi

Institute of Technology & Sciences

Approved by AICTE & Affiliated to JNTUA, Ananthapuramu,
An ISO (9001-2008) Certified Institute, Near S.K.U, Itikalapalli, Ananthapuramu Dist. A

DEPARTMENT OF CIVIL ENGINEERING

Subject Name:	**19A01502 WATER RESOURCES ENGINEERING (R-19)**
Staff Name :	**V.GANGA MAHESH REDDY**
Topic:	**PART – A QUESTIONS WITH ANSWER**
UNIT-III	**RUNOFF AND HYDROGRAPH**

1. Define Runoff.

1) Surface Runoff is the water that flows across the land surface after a storm event. As rain falls over land, part of that gets infiltrated the surface as overland flow. As the flow bears down, it notches out rills and gullies which combine to form channels. These combine further to form streams and rivers.

2) The geographical area which contributes to the flow of a water is called **River** or **Watershed**. The following are the major river basins of our country

Indus -Ganges -Brahmaputra -Krishna -Godavari -Mahanandi -Sabarmati -Tapti-Brahmani-Baitarani -Narmada -Pennar -Mahi.

1. What are the types runoff?

a) Surface Runoff
b) Inter Flow Runoff
c) Ground Water Flow Runoff.

2. Define surface runoff.

Water flows over the land and is first to reach the streams and rivers which ultimately discharge the water to the sea.

3. Define inter flow runoff.

A portion of precipitation infiltrates into surface soil and depending upon the geology of the basins run as sub surface runoff and reaches the streams and rivers.

4. Define ground water flow.

It is that portion of precipitation which after infiltration percolates down and joins the ground water reservoir which is ultimately connected to the ocean.

2. What are the Factors affecting Run-off ?

Meteorological factors affecting runoff:

1) Type of **precipitation** (rain, snow, sleet, etc.)
2) Rainfall intensity

3) Rainfall amount
4) Rainfall duration
5) Distribution of rainfall over the **drainage basin**

6) Direction of storm movement
7) Precipitation that occurred earlier and resulting soil moisture
8) Other meteorological and climatic conditions that affect evapotranspiration, such as temperature, wind, relative humidity, and season.

Physical characteristics affecting runoff:

1) Land use
2) Vegetation
3) Soil type
4) Drainage area
5) Basin shape
6) Elevation
7) Topography, especially the slope of the land
8) Drainage network patterns
9) Ponds, lakes, **reservoirs**, sinks, etc. in the basin, which prevent or delay runoff from continuing downstream.
10) Human activities can affect runoff
11) Urban development and flooding.

3. How to classify the runoff based on delay between the precipitation and the runoff?

Based on the time delay between the precipitation and the runoff, the runoff is classified into two categories; as

(a) Direct runoff
(b) Base flow.

a) Direct runoff

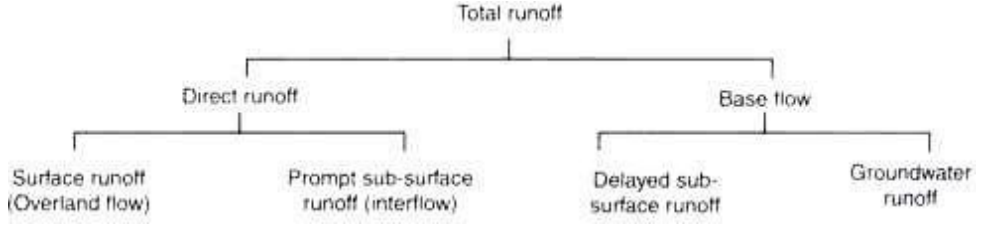
It is the part of runoff which enters the stream immediately after the rainfall. It includes surface runoff, prompt interflow and rainfall on the surface of the stream. In the case of snow-melt, the resulting flow entering the stream is also a direct runoff. Direct storm runoff and storm runoff are also used to designate direct runoff.

b) Base flow

The delayed flow that reaches a stream essentially as groundwater flow is called base flow.

4. What are the Components of Runoff?

Depending upon the source from where the portion of total flow gets contributed the components of total runoff can be recognised as shown below schematically:



5. What are the method used to estimate the runoff?

Some of the important empirical runoff estimation formulae used in various parts of India are given below:

1) Binnie's Percentages
2) Barlow's Tables
3) Strange's Tables
4) Inglis and Desouza Formula
5) Khosla's Formula
6) Rational Method
7) Cook's Method
8) SCS Curve Number Method.

6. What are the method used to estimate the runoff?

1) Non-recording Stream Gauges

a) Staff Gages
b) Wire Gages

2) Crest-stage Gauges

3) Recording Stream Gauges

a) Float type and
b) Bubble gauge or Manometer-servo water-level sensor.

7. A catchment has an area of 150 ha and a runoff/rainfall ratio of 0.40. If due to a 10 cm rainfall over the catchment a stream flow at the catchment outlet lasts for 10 hours. What is the average stream flow during the above period?

$$Average\ Stream\ Flow = \left(\frac{10\ X\ 10^{-2}\ X\ 0.4\ X\ 150\ X\ 10^{4}}{10\ X\ 60}\right)\ m^3/min$$

$$Average\ Stream\ Flow = 100\ m^3/min$$

1. Define Hydrograph Analysis and What is the Uses of Hydrograph?

1) A **hydrograph** is a graph showing the rate of flow (discharge) versus time past a specific point in a river, channel, or conduit carrying flow. The rate of flow is typically expressed in cubic meters or cubic feet per second (cms or cfs).
2) It can also refer to a graph showing the volume of water reaching a particular outfall, or location in a sewerage network.

Uses of Hydrograph

1) Design of irrigation Structures.
2) Design of Reservoirs.
3) Design of sewerage,
4) Design of surface water sewerage systems
5) Design of combined sewers. Ect….

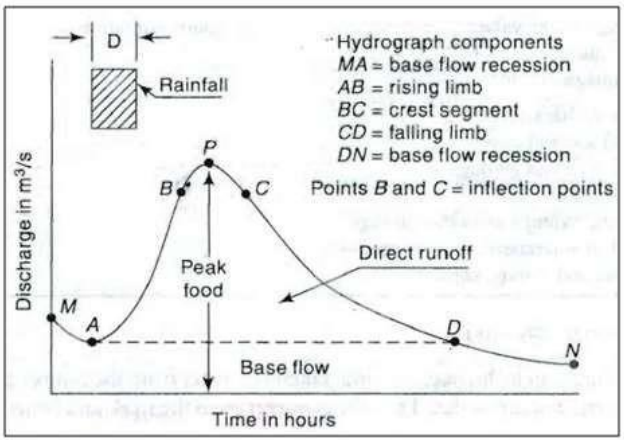


Fig.1. Elements of a hydrograph.

2. Define Unit Hydrograph and What is the Uses of Unit Hydrograph?

1) It is a hydrograph of **Surface runoff** resulting from **One unit depth of excess rainfall** occurring uniformly over Specified time.

2) This method was first suggested by **Sherman** in 1932.

3)

Uses of Unit Hydrograph

1) Development of flood hydrograph for extreme rainfall magnitudes. (For design of hydraulic structures).
2) Extension of flood-flow records based on rainfall records.
3) Development of flood forecasting and warning systems based on rainfall.

3. Define S- hydrograph.

S-curve Hydrograph: ... S curve represents the **maximum rate at which an effective rainfall intensity of 1 cm/hr in D-hours duration can drain out from a catchment** of area A km2 (SA).

Uses of Synthetic Hydrograph

To obtain a unit hydrograph of shorter duration from longer duration or vice versa.

4. Define Flood Hydrograph?

Flood hydrographs are **graphs that show how a drainage basin responds to a period of rainfall**. They are used to plan for flood situations and times of drought. They show the river discharge that occurs as a result of precipitation from an earlier storm.

5. What are the types of Hydrograph.

1) Storm hydrographs
2) Flood hydrographs
3) Annual hydrographs a.k.a. regimes
4) Direct Runoff Hydrograph
5) Effective Runoff Hydrograph
6) Raster Hydrograph
7) Storage opportunities in the drainage network (e.g., lakes, reservoirs, wetlands, channel and bank storage capacity)

6. Explain the Time characteristics of hydrograph.

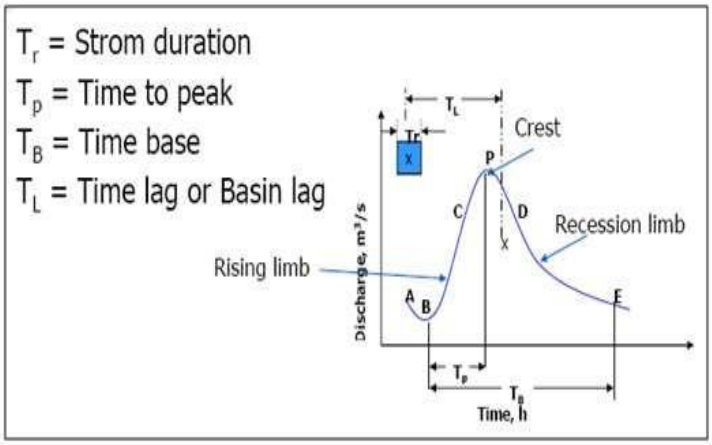


Fig. Hydrograph time characteristics.

a) Time Base of Hydrograph (T_B)

It is the time from the beginning to the end of the direct runoff.

b) Lag Time (T_L)

It is the difference in time between the center of mass of net rainfall and center of mass runoff.

c) Time to Peak (T_P)

It is the time difference between the beginnings of direct runoff (point B in Fig) to peak.

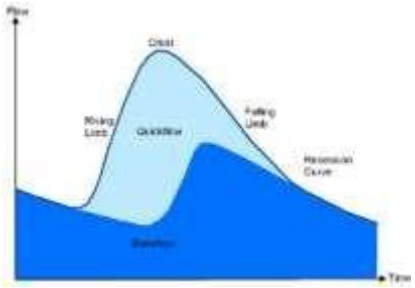
d) Rainfall Duration (T_r)

It is the effective rainfall duration, which causes direct runoff. Curve between point M and A represents recession from previous storm.

7. What are the factors affecting hydrograph?

Physiographic factors	Climatic factors
1. Basin characteristics (a) Shape (b) Size (c) Slope (d) Nature of the valley (e) Elevation (f) Drainage density 2. Infiltration characteristics (a) Land use and cover (b) Soil type and geological conditions (c) Lakes, swamps and other storage 3. Channel characteristics: cross-section, roughness and storage capacity	1. Storm characteristics: precipitation, intensity, duration, magnitude and movement of storm 2. Initial loss 3. Evapotranspiration

8. Define Baseflow.



1) Baseflow is **the portion of the streamflow that is sustained between precipitation events, fed to streams by delayed pathways**.
2) It should not be confused with Groundwater flow.
3) It is also called
    i. Drought flow,
    ii. Groundwater recession flow,
    iii. Low flow,
    iv. Low-water flow,
    v. Low-water discharge and
    vi. Sustained weather runoff or
    vii. Fair-weather runoff.

9. Define Baseflow separation.

1) Baseflow is the slowly varying portion of streamflow, and it is essential for sustaining river flows.
2) Several methods have been developed for separating baseflow from streamflow.
3) Eckhardt digital **filter** method is recommended for baseflow separation across the contiguous United States.

10. Define Maximum Probable Flood.

The Probable Maximum Flood (PMF) is **the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in a particular drainage area**.

11. Define Design Flood.

Design flood is the value of the instantaneous peak discharge adopted for the design of a particular project or any of its structures. ... The term “design flood” is used to denote the maximum flood flow that could be passed without damage or serious threat to the stability of engineering structures.

1)

Subject Name:	**19A01502 WATER RESOURCES ENGINEERING (R-19)**
Staff Name :	**V.GANGA MAHESH REDDY**
Topic:	**PART – A QUESTIONS WITH ANSWER**
UNIT-IV	**GROUND WATER**

1. Define Aquifer.

An aquifer is an underground geological formation which contains water and sufficient amount of water can be extracted economically using water wells ***(more Yield).*** Aquifers comprise generally layers of Sand and Gravel and Fracture bedrock.

2. Define Aquiclude.

It is an underground geological formation which is Porous and Impervious which contains water but water cannot be extracted using water wells ***(No Yield).*** Aquiclude comprises generally layers of Clay.

3. Define Aquifuge.

It is an underground geological formation which is an impervious formation. Thus it is incapable to (*absorb or transmit*) water through it ***(No Yield).*** Aquifuge comprises generally layers of Hard rock without fissure (Cracks).

4. Define Aquitard.

An aquitard is an underground geological formation which contains water but significant amount of water cannot be extracted using water wells ***(Lesser Yield).*** Aquitard comprises generally layers of Sandy - Clay soil with low hydraulic conductivity.

5. What are the different types of Aquifers?

1) Confined aquifer.
2) Leaky confined aquifer
3) Unconfined aquifer
4) Leaky unconfined aquifer.

6. Define Confined Aquifuge.

An aquifer which is bounded by two impervious layers at top and bottom of the aquifer is called Confined aquifer. The confined aquifer is also known as Pressure aquifer and Artesian aquifer.

7. Define Leaky Confined Aquifer.

Top and bottom layer of a confined aquifer is generally impervious. However, sometimes

these layers may be semi pervious in nature. In such a situation, the water may gain or lose through these semi pervious layers. The aquifer is then called Leaky confined aquifer.

8. Define Unconfined Aquifuge.

When water table serves as the upper boundary of the aquifer, the aquifer is known as Unconfined aquifer. The unconfined aquifer is also known as Water table aquifer and Phreatic aquifer and Gravity Aquifer.

9. Define Leaky Unconfined Aquifer.

An impervious layer is generally served as the bottom boundary of an unconfined aquifer. Sometime, the bottom of an unconfined aquifer may be semi pervious and water may gain and lose through the semi pervious bottom layer. The aquifer is then known as Leaky unconfined aquifer.

10. What are the properties of aquifer?

Sl.No	Aquifer Properties	Symbols	Units
1	Coefficient of Permeability	K	*m/sec*
2	Coefficient of Intrinsic Permeability	K_o	cm^2 / *Darcy*
3	Coefficient of Transmissibility	T	m^2/sec
4	Specific Yield	S_y	%
5	Specific Retention (Field Capacity)	S_r	%
6	Porosity	n	%
7	Specific storage (Storage coefficient) (Storativity)	S	*Unitless*
8	Specific Capacity of well (Specific Yield of well)	C'	m^3/hr
9	Well Efficiency	η_{well}	%

11. Define Porosity.

Porosity is defined as the ratio of volume of voids to the total volume of the soil matrix. The porosity is expressed as,

$$\textbf{Porosity}, \quad \mathbf{n} = \left(\frac{\mathbf{V_v}}{\mathbf{V}}\right) \mathbf{X\ 100} \quad (Percent)$$

12. Define Coefficient of Permeability (K)

The ability of un-consolidated sediments (Aquifer) to permit the water through itself with unit CS Area and Unit Hydraulic gradient at **20℃** ***temperature***.

13. Define Coefficient of Transmissibility (T)

Transmissibility defines the same meaning of Permeability. But for Unit width **"b = 1"** and full depth **"d"** of soil. (**Introduced by Mr. Theiss)**

14. What is the relation between K and T?

$$\mathbf{T = K.d}$$

15. Define Specific Yield of well.

$$S_y = \left(\frac{V_{Gw}\ extracted\ by\ gravity\ drainage\ (Yield)}{V\ dewatered}\right) X\ 100$$

16. Define Specific Retention of well (Field Capacity).

$$S_r = \left(\frac{V_{Gw}\ held\ against\ gravity\ drainage}{V\ dewatered}\right) X\ 100$$

17. Define Porosity.

Porosity = (Specific Yield + Specific Retention (Field Capacity)

$$n = (S_y + S_r)$$

18. Define Specific storage of well (Storage coefficient) (Storativity).

Volume of water that an aquifer (***releases or stores***) per unit surface area per unit (***decline or rise***) of water table.

$$S = \frac{V_w}{A\ X\ h}$$

$fro\ Unconfined\ Aquifer,\quad \boldsymbol{S = S_y}$

$fro\ Confined\ Aquifer,\quad \boldsymbol{S = {}_wH\ [a + n\mathrm{Q}]}$

Where

${}_w = unit\ wt\ of\ water = (\rho_w . g)\ \boldsymbol{\frac{kN}{m^3}}$

$\boldsymbol{S} = Storage\ coefficient\ \ (\boldsymbol{Unitless})$

$\boldsymbol{H} = Confined\ Aquifer\ thicness\ in\ m.$

$\boldsymbol{n} = Porosity\ of\ Aquifer\ \boldsymbol{in}\ \%$

$a = Compressibility\ of\ Aquifer\ material\ in\ \boldsymbol{m^2/kN}$

$\mathrm{Q} = Compressibility\ of\ water\ in\ \boldsymbol{m^2/kN}$

19. Define Specific Capacity of well.

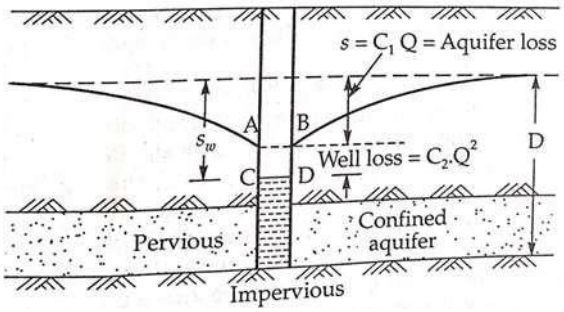
$$\text{Sp. Capacty} \left(\frac{\text{Yield of the well}}{\text{Total Drawdown}}\right) = \left(\frac{\text{Yield of the well}}{\text{Aquifer Loss+Well Loss}}\right)$$

$$Sp.Capacty = \left(\frac{Q}{S_w}\right)$$

$$Sp.Capacty = \left(\frac{Q}{C_1Q + C_2Q^2}\right)$$

$$Sp.Capacty = \left(\frac{1}{C_1 + C_2Q}\right)$$

- Sp. Capacity of Well is not Constant. But decrease as the Discharge increases.
- Sp. Capacity is a measure of the productivity of a well.
- The larger the Specific capacity, the better the well.



$\mathbf{C_1Q = S} = Aquifer\ loss$ or $Formation\ loss$

$$Discharge, \quad Q = \frac{2\pi HKS}{\ln\left(\frac{R}{r_w}\right)} \quad (Dupit's\ Confined\ Aquifer)$$

$$\mathbf{S = C_1Q}$$

$$S = \left[\frac{\ln\left(\frac{R}{r_w}\right)}{2\pi HK}\right] . Q$$

$\mathbf{C_2Q^2} = Well\ loss$

$$Total\ Drawdown,\ S_w = (Aquifer\ loss + \text{Well loss})$$

$$Total\ Drawdown,\ S_w = (C_1Q + C_2Q^2)$$

20. Define Well Efficiency.

$$\boldsymbol{Well\ Efficiency} = \left(\frac{\text{Aquifer Loss}}{\text{Total Drawdown}}\right) X\ 100$$

$$Well\ Efficiency = \left(\frac{\boldsymbol{S}}{S_w}\right) X\ 100$$

$$Well\ Efficiency = \left(\frac{C_1Q}{S_w}\right) X\ 100$$

Well efficiency of 70% or more is usually considered acceptable, with being accepted as the Minimum efficiency - 65%.

21. If specific yield of an aquifer is 17.4% and its specific retention is 15.4%. What would be its porosity?

Solution:

Porosity = (Specific yield + Specific retention)

$n = S_y + S_r$

$n = 17.4 + 15.4$

$\boldsymbol{n = 32.8\ \%}$

22. How to find the yield of aquifers?

Yield of an aquifer is measured by different ways such as

1) On the basis of velocity of ground water
2) Pumping test.
3) Recuperation test.

23. Find out the velocity of the ground water flow with the following data. Using Slitcher's and Hazen's constant as 400 and 800 respectively.
Viscosity coefficient of water at 10 degree C temperature = 1
Effective size of particle in the aquifer = 0.1 mm
Hydraulic gradient = 1 in 80

Solution:

Slitcher's formula

$$v_a = \frac{K' i D_1^2}{\mu}$$

$$v_a = \frac{400 \; X \; (\frac{1}{80}) \; X \; (0.1)^2}{1}$$

$$v_a = 0.05 \; mm/day$$

Hazen's formula

$$v_a = \frac{K'' i D_1^2}{60} \; X \; (1.8 \; T + 42)$$

$$v_a = \frac{800 \quad \frac{1}{80} \; (\quad)(X \quad)^2}{60} X \; (1.8 \; X \; 10 + 42)$$

$$v_a = 0.1 \; m/day$$

24. Define interference among wells.

1) If two or more wells are located so close to each other their drawdown curves intersects.
2) Interference of wells decreases the discharge of each individual well, though the total discharge from the wells is increased.
3) **Mr. Muskat** has propped formula for discharge of interfering wells.

25. Define identical well.

Identical wells - Wells with

Same diameter,
Same drawdown,
Same discharge,
Same time period.

26. A well 3 m in diameter has its normal water level 3 m below the ground level. By pumping, water level in well depressed to 10 metres below ground level. In a time of 4 hours the water rises by 5 m. Calculate specific yield of the well.

Given data:

$Well\ dia, \quad d = 3\ m$
$Initial\ Drawdown, \quad S_1 = (10 - 3) = 7\ \text{m}$
$Final\ Drwdown, \quad S_2 = (7 - 5) = 2\ m$
$Time, \quad T = 4\ hrs$

Solution:

$$\frac{C'}{A} = \frac{2.3}{T}\ log\ \frac{S_1}{S_2}$$

$$Area\ of\ well, \quad A = \left(\frac{3.14\ X\ 3^2}{4}\right) = 7.065\ m^2$$

$$\frac{C'}{7.065} = \frac{2.3}{4}\ log\ \frac{7}{2}$$

$$\boldsymbol{Specific\ Yield}, \quad \boldsymbol{C' = 2.213\ m^3/hr}$$

27.

Subject Name:	**19A01502 WATER RESOURCES ENGINEERING (R-19)**
Staff Name :	**V.GANGA MAHESH REDDY**
Topic:	**PART – A QUESTIONS WITH ANSWER**
UNIT-V	**IRRIGATION ENGINEERING**

1. **Define Commanded area (CA):**

   The Area irrigated by a canal system is called Commanded area.

2. **Define Gross command area (GCA):**

   Total area irrigated by a canal system is called Gross Commanded area. *GCA includes inhibited areas, roads, ponds, Uncultivable areas etc, even which would not be irrigated.*

3. **Define Cultivable command area (CCA):**

   Actually irrigated area within the GCA is termed as CCA. During any crop season, only a part of the CCA is put under cultivation and this area is termed as **Cultivable Cultivated Area**. The remaining area which is not cultivated during a crop season is conversely termed as **Cultivable Uncultivated Area**.

4. **Define Intensity of irrigation**

   Usually the areas irrigated during each crop season (Rabi, Kharif, etc) are expressed as a **Percentage of CCA** which represents the intensity of irrigation for the crop season. By adding the intensities of irrigation for all crop seasons the **yearly intensity of irrigation** to be obtained.

5. **Define Crop-ratio:**

   The ratio of the areas under the two crop seasons is called crop-ratio.

6. **Define Base period: (watering period)**

   The time between the *First watering of a crop at the time of its sowing* and its *Last watering before harvesting* is called the Base or Base period of crop.

7. **Define Crop period(C):**

   The time between the instant of *sowing to harvesting* of crop is called crop period.

8. **Define Efficiency of Irrigation and mention its types.**

   Irrigation efficiency **is** defined as the ratio between the amount of water used for consumptive use and salt balance of crop in root zone to the total volume of water supplied.

$$\eta = \left(\frac{Output}{Input}\right) X\ 100$$

$$\eta = ($$

$$\left(\frac{\text{Amount of water used for consumptive use}}{\text{Total volume of water supplied}}\right) X\ 100$$

Types of Irrigation Efficiency

1. Water-conveyance efficiency
2. Water -application efficiency (Farm efficiency)
3. Water -storage efficiency
4. Water -use efficiency
5. Water-distribution Efficiency *or* Uniformity Coefficient

9. Define Water-conveyance efficiency

It is the ratio of the water delivered into the fields from the outlet point of the channel, to the water supplied into the channel at its starting point. It takes the conveyance or transit losses into consideration.

$$\eta_c = \left(\frac{Water\ delivered\ to\ the\ fields\ from\ channel}{Water\ supplied\ to\ the\ Channel\ from\ starting\ point}\right) X\ 100$$

10. Define Water -application efficiency (Farm efficiency)

It is ratio of water stored in root zone to the water delivered to the field. It also called as Farm efficiency.

$$\eta_a = \left(\frac{Water\ stored\ in\ the\ root\ zone}{ater\ delivered\ to\ the\ field}\right) X\ 100$$

11. Define Water Storage Efficiency.

It is the ratio of the water stored in the root zone during irrigation to the water needed in the root zone prior to irrigation (i.e. field capacity- existing moisture content).

$$\eta_s = \left(\frac{Water\ stored\ in\ the\ root\ zone}{Water\ needed\ in\ the\ root\ zone}\right) X\ 100$$

12. Define Water -use efficiency

It is the ratio of the water beneficially used, including leaching water, to the Quantity of water delivered. It may be represented by qu.

$$\eta_u = \left(\frac{Beneficially\ used\ water}{Suppied\ quantity\ of\ water}\right) X\ 100$$

13. Define Water-distribution Efficiency *or* **Uniformity Coefficient**

Water distribution efficiency represents uniform depth of water penetration in the field. If the water penetration is uniform through the field the deviation become Zero *(d =0)* and hence

water distribution efficiency become unity $(\eta_d = 1)$

$$\eta_d = (1 - \frac{d}{D})$$

Where,

$\boldsymbol{D} = Mean\ depth\ of\ water\ in\ the\ field$

$\boldsymbol{d} = Deviation\ depth\ of\ water\ from\ Mean\ depth$

14. Define Frequency of Irrigation

The interval between two successive irrigations is known as frequency of irrigation.

$$Irrigation\ Interval = \left(\frac{Allowable\ soil\ moisture\ depletion}{Daily\ water\ use}\right)$$

15. Define Paleo irrigation.

Sometimes, in the initial stages before the crop is sown, the land is very dry. This particularly happens at the time of sowing of Rabi crops because of hot September, when the soil may be too dry to be sown easily. In such a case, the soil is moisture with water, so as to help in sowing of the crops. This is known as Paleo irrigation.

16. Define Kor watering

The first watering is done when the crop has grown to about three centimetres. This watering is known as Kor watering.

17. Define Kor Period

The period during which kor watering is done is known as kor Period.

18. Define Kor depth

The depth of water applied for the kor watering is called Kor depth.

19. What are the Classification of Soil in India ?

The first scientific classification of soil was done by Vasily Dokuchaev.
In India, the Indian Council of Agricultural Research (ICAR) has classified soils into 8 categories.

Types of Soil in India

1) Alluvial Soil,
2) Black Cotton Soil,
3) Red Soil,
4) Laterite Soil,
5) Mountainous or Forest Soils,
6) Arid or Desert Soil,
7) Saline and Alkaline Soil,
8) Peaty, and Marshy Soil.

20. What is Soil Fertility?

Soil fertility is a ability of soil to sustain agricultural plant growth.

Fertile soil has the following properties:

a) Supply essential plant nutrients,
b) Provide plant habitat,

c) Consistent yields with high quality
d) Proportions for plant growth,
e) Reproduction,

Absence of toxic substances which may inhibit plant growth.

21. Define Irrigation and what are the Types and Techniques of irrigation.

Irrigation is an artificial application of water to the soil. It is usually used to assist the growing of crops in dry areas and during periods of inadequate rainfall.

Types of Irrigation

1. Surface irrigation.
    a) Flow irrigation
        i. Perennial irrigation
        ii. Flood irrigation
    b) Lift irrigation

2. Sub-surface irrigation.
    a) Natural Sub-surface irrigation
    b) Artificial Sub-surface irrigation

Techniques of irrigation

1) Free flooding,
2) Check flooding,
3) Border flooding,
4) Basin flooding,
5) Furrow irrigation method,
6) Drip irrigation method,
7) Sprinkler irrigation method.

22. Define Surface Irrigation.

Surface irrigation is where water is distributed **across the land by gravity**. In this system, no irrigation pump is involved. It is most common form of irrigation throughout the world.

23. Define Subsurface irrigation.

Subsurface irrigation means an irrigation device with a delivery line and water emitters installed below the soil surface that slowly and frequently emit small amounts of water into the soil to irrigate plant roots.

24. Define Flow irrigation.

The irrigation in which the water flows under gravity from the source to the field is known as gravity **flow irrigation**. Due to gravity water flows from higher areas to the lower areas. After which it is distributed in the fields. Silt in the canal water has a fertilizing agent.

25. Define Lift irrigation.

Lift irrigation is a **method of irrigation in which water is not transported by natural flow**, (as in gravity-fed canal) but is lifted with pumps or surge pools etc.

26. Define Perennial Irrigation.

This **irrigation** system guarantees continuous and constant water supply to the crops throughout the crop period as per the requirement of the crop. This system supply water to the crops through a canal distribution system that takes off from a weir or a reservoir.

27. Define Flood irrigation.

Flood irrigation is an **irrigation technique in which a field is essentially flooded with water which is allowed to soak into the soil to irrigate the plants**. This type of irrigation is one of the oldest techniques known to man, and can be seen in use in some developing nations and in regions where water supplies are ample.

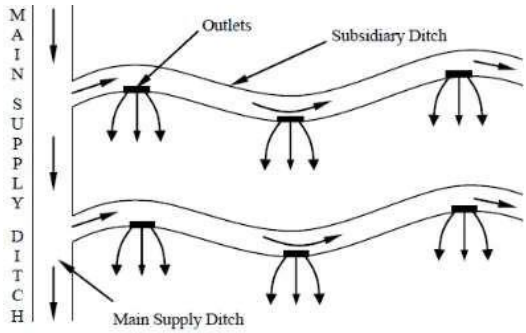
28. Define Natural sub surface irrigation.

Natural sub surface irrigation is possible where an **impervious layer exists below the root zone**. Water is allowed in to series of ditches dug up to the impervious layer, which then moves laterally and wets root zone.

29. Define Artificial subsurface irrigation.

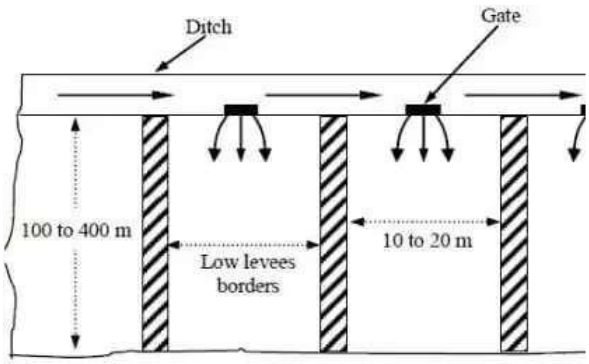
In this method, **water is applied beneath the land surface through a network of buried perforated or open jointed pipes**. As water is passed under pressure in these pipes, it comes out through open joints.

30. Define Free Flooding Irrigation



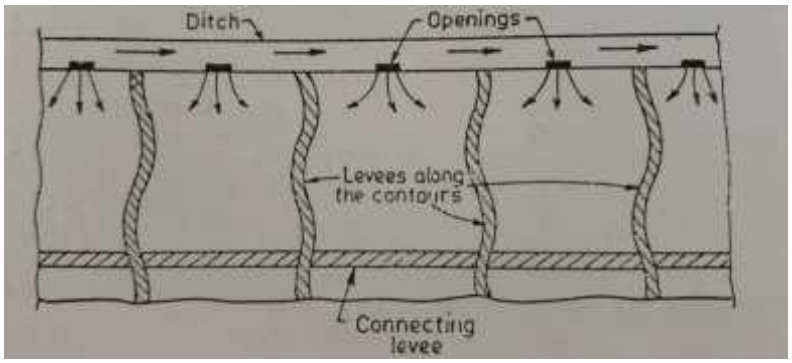
1. The free flooding technique is performed by excavating ditches in the irrigation land. As shown in the figure, from the main supply ditch, water is collected in the subsidiary or lateral or contour ditches. These subsidiary ditches are excavated either along the contour or above or below the slope of the area. The water from the lateral ditches is allowed to flow freely without any sort of control and hence it is also called **wild flooding.**
2. The wild flooding technique is best suitable for crops that are cultivated closely.
3. The contour ditches excavated in free flooding techniques are mostly spaced at a distance of **20 to 30m.** This merely depends on the type of soil, type of crop, soil texture, etc.
4. It performs well when employed on a sloped land or an irregular land.
5. This method is not preferred where checks, basins, border or furrows are feasible.
6. The initial cost of land preparation of free flooding is very less. But it demands high labour requirements and possesses less efficiency.

31. Define Border Flooding Irrigation



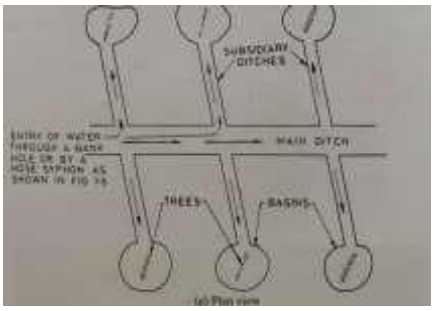
1. Border flooding method involves dividing the irrigation land into several strips of width around 10 to 20 m and length of 100 to 400m.
2. Each strip is separated by a border or levees.
3. The ridges constructed between the borders must have sufficient height to prevent overtopping during the irrigation.
4. In this method the water is allowed to flow from the supply ditch to each strip.
5. So to prevent water to concentrate in one area, the surface must be leveled in the direction perpendicular to the flow of water.
6. As the water flows through the strip, it infiltrates at the lower end. At this point, the supply is closed.
7. High efficiency is gained when the strips are short and narrow.

32. Define Check Flooding



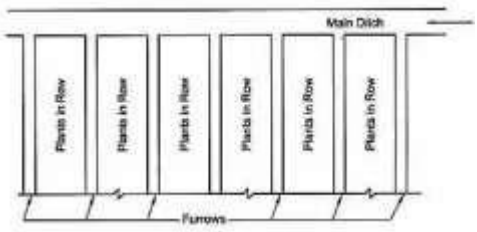
1. Check flooding is a method similar to flooding where the water is controlled by the surrounding **check area** that is formed by the construction of levees.
2. These levees can be short or long which are constructed along the contour.
3. Most of the check area has a measure varying from 0.2 to 0.8 hectares.
4. In check flooding, the water from the supply ditch is allowed to move to the check area and is held for a period until desirable infiltration takes place.
5. Check flooding is suitable for both permeable and less permeable soil.
6. If applied for permeable soils, the water is quickly spread to the soil. While in case of less permeable soil, the water is allowed to stay for longer period to ensure adequate penetration.

33. Define Basin Flooding



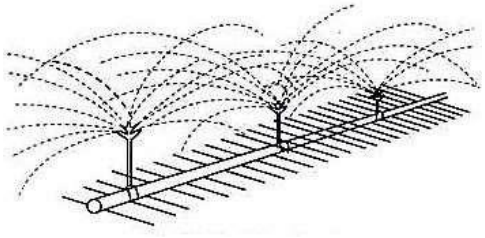
Basin flooding is a special type of check flooding. Here, the subsidiary ditches receive water from the mains supply ditch. Each subsidiary ditch is connected to a basin that occupies one or more trees. This method is especially followed for orchard trees.

34. Define Furrow Irrigation Method



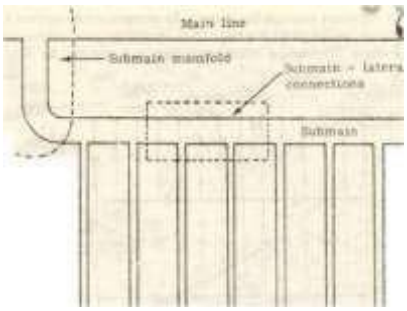
1) In this method, furrows are made between rows of plants.
2) Furrows are narrow field ditches that carry water with a length of 400 meters and a depth of 8 to 30cm.
3) The spacing of crops decides the spacing of the furrows.
4) These are employed for row crops.
5) Furrows can be made in corrugations for land areas with irregular topography. Excessive length of furrows must be avoided because long furrows may result in high water on one end and less water on the other end.
6) The water from the furrows is diverted to the row crops by means of plastic tube syphons or border takeout or spiles or lathe box.

35. Define Sprinkler Irrigation System



1) The sprinkler irrigation system is a farm-water application that applies water in the form of spray. This spraying is performed by a series of pipes and pumps.
2) It is a kind of artificial rainfall and hence nourish the crops with the required amount of water.
3) The method is very costly and involves great technicalities. For examples, debris and silts must not enter these pipe system as it will affect the smooth operation of the sprinkler. Debris results in the choking of the nozzles while silt results in huge wear in the impellers, bearings and the nozzles.

36. Define Drip Irrigation Method



1) The drip irrigation method is also called trickle irrigation.
2) In this system, the water is applied directly to the roots by an arrangement made underground.
3) This hence results in the prevention of loss of water due to evaporation and percolation.
4) This is a modern irrigation water distribution technique employed in areas where there is a scarcity of water and the presence of salts in the available water.
5) The drip irrigation system consists of a head, mains, sub-mains, laterals and drop nozzles.

37. What are the necessity of irrigation?

1) India is basically an agricultural country, and all its resources depend on the agricultural.
2) Water is evidently the most vital element in the plant life.
3) Water is normally supplied to the plants by nature through rains.
4) However, the total rainfall in a particular area may be either insufficient, or ill-timed.
5) In order to get the maximum yield, it is essential to supply the optimum quantity of water.

38. What are the Purposes of irrigation?

1) Providing insurance against short duration droughts
2) Reducing the hazard of frost (increase the temperature of the plant)
3) Reducing the temperature during hot spells
4) Washing or diluting salts in the soil softening tillage pans and clods
5) Delaying bud formation by evaporative cooling
6) Promoting the function of some micro-organisms.

39. What are the Importance of irrigation engineering?

1) Irrigation helps to increase productivity of agriculture even in low rainfall.
2) Droughts and famines are avoided by irrigation.
3) The productivity on irrigated land is higher as compared to the un-irrigated land.
4) Irrigation facility supports for cultivation throughout the year.
5) Irrigation facilities makes multiple cropping possible to grow more than one crop in most of the areas of the country.
6) Irrigation has helped to bring most of the **fallow land** under cultivation.
7) Irrigation has stabilized the output and yield levels.
8) Irrigation increases the availability of water supply, which in turn increases the income of the farmers.

40. What are the Objectives of irrigation?

1) To supply water partially or totally for crop need
2) To cool both the soil and the plant
3) To leach excess salts
4) To improve groundwater storage
5) To facilitate continuous cropping
6) To enhance fertilizer application

25. What are the Benefits of irrigation?

1) Increase in crop yield
2) Protection from famine
3) Cultivation of superior crops
4) Elimination of mixed cropping:
5) Economic development
6) Hydro power generation
7) Domestic and industrial water supply

41. What are the Advantages of irrigation?

1) Increase in food production
2) Optimum utilization of water for optimum benefits
3) General development of the country
4) Elimination of mixed cropping
5) Generation of hydroelectric power
6) Afforestation
7) Domestic water supply
8) Inland navigation.

42. What are the Disadvantages of irrigation?

1) Pollution of underground water
2) Water – logging of the area
3) Creating unhealthy conditions in colder and damp places
4) Irrigation water may cause breading places of mosquitoes
5) Irrigation increases the expenditure of government
6) Gives rise to disease like malaria
7) Excessive seepage causes water-logging and
8) The climate becomes cooler and makes the locality damp resulting ill-health of the public.

43. Define Delta:

Depth of water required for any crop in the base period is called as delta.

Sl.No	Crop	Delta in "cm"
1.	Rise	120
2.	Sugarcane	120
3.	Tobacco	75
4.	Garden fruits	60
5.	Cotton	50
6.	Vegetables	45
7.	Wheat	40
8.	Barley	30
9.	Maize	25

10.	Fodder	22.5
11.	Peas	15

44. Define Duty:

Duty represents the irrigating capacity *(irrigation power)* of water. It gives the relation between area of irrigated crop and quantity of irrigation water required during the entire period of the growth of that crop *(Base period).*

$$Duty = \left(\frac{Area\ of\ Irrigated\ crop}{Discharge\ of\ irrigated\ water}\right)$$

Duty is expressed in terms of $\left(\frac{Hectar}{Cumec}\right)$

Sl.No	Crop	Duty in $\left(\frac{Hectar}{Cumec}\right)$
1.	Rise	775
2.	Sugarcane	730
3.	Kharif crops	1500
4.	Rabi crops	1800
5.	Perennials	1100
6.	Fodder	2000

45. State relationship between duty and delta and base period.

$$\Delta = \mathbf{8.64}\ \left(\frac{B}{D}\right)\ \text{in } \mathbf{m}$$

$$\Delta = \mathbf{864}\ \left(\frac{B}{D}\right)\ \text{in } \mathbf{cm}$$

Where,

Δ is in **cm** or in **m**

B is in **days**

D is duty in **Hectares/cumec.**

46. What are the Factors Affecting Duty of Crop

1) Type of soil
2) Temperature and wind
3) Rainfall and wind.
4) Crop
5) Method of cultivation.
6) Water management.
7) Climate and season

47. How to improving duty?

Duty of water can be improved if water is used carefully. The following efforts can be made to improve duty:

1) The water losses can be reduced by having the irrigated area nearer to the head of the canal.
2) Evaporation losses can be minimized by using the water as quickly as possible.
3) Water losses can be minimized by lining the canals.
4) The cultivators should be trained to use water economically without wasting.
5) The soil properties should be studied by establishing research stations in villages.

48. If rice requires about **10 cm depth** of water at an average interval of **about 10 days,** and the crop period for rice is **120 days**, ***Find out the value of delta for rice.***

Given Data:

Depth of water = 10 cm
Watering interval = 10 days
Crop period = 120 days.

Solution:

$$\boldsymbol{No.of\ watering\ for\ crop} = (\frac{\boldsymbol{Crop\ period}}{\boldsymbol{Watering\ interval}})$$

$$No.of\ watering\ for\ crop = (\frac{120}{10})$$

$$No.of\ watering\ for\ crop = 12$$

and each time, 10cm depth of water is required. Therefore, the total depth of water

$$\boldsymbol{Dlta = (Depth\ of\ water\ X\ No.of\ watring)}$$

$$Dlta\ for\ Rise, \qquad \Delta = (10\ X\ 12) = 120\ cm$$

49. If wheat requires about **7.5 cm depth** of water after every **28 days,** and base period of wheat is **140 days**, ***Find out the value of delta for wheat..***

Given Data:

Depth of water = 7.5 cm
Watering interval = 28 days
Crop period = 140 days

Solution:

$$\boldsymbol{No.of\ watering\ for\ crop} = (\frac{\boldsymbol{Crop\ period}}{\boldsymbol{Watering\ interval}})$$

$$No.of\ watering\ for\ crop = (\frac{140}{28})$$

$$No.of\ watering\ for\ crop = 5$$

and each time, 10cm depth of water is required. Therefore, the total depth of water

$$\boldsymbol{Dlta = (Depth\ of\ water\ X\ No.of\ watring)}$$

$$Dlta\ for\ Rise, \qquad \Delta = (7.5\ X\ 5) = 37.5\ cm$$

50. If water flowing at rate of **100 m^3 /sec**, runs continuously to the base period, and matures **1500 hectare** land of crops, then **What is the duty of water** for that particular cop.

Solution:

$$Duty = (\frac{Area\ of\ Irrigated\ crop}{Discharge\ of\ irrigated\ water})$$

$$D = (\frac{1500}{100})$$

$$\boldsymbol{D = 15\ hectare/cumec}$$

51. Find the delta for a crop when its duty is **864 Hectares /cumec** on the field, the base period of this crop is **120 days.**

Given Data:

B = 120 days

D = 864 hectares/cumec

Solution:

$$\Delta = 864 \left(\frac{B}{D}\right) \text{ in } cm$$

$$\Delta = 864 \left(\frac{120}{864}\right)$$

Δ = **120 cm**

52.* Define Consumptive use of water *(Evapotranspiration)

The total quantity of water required by crops in irrigation area.

Evapotranspiration = *Evaporation* + *Transpiration*

53. What are the factor affecting consumptive uses of water?

Climate factors:

1) Temperature
2) Humidity
3) Wind speed
4) Duration & intensity of light
5) Atmospheric vapor pressure.

Soil factors:

1) Texture
2) Structure
3) Moisture content
4) Hydraulic conductivity.

Plant factors:

1) Efficiency of root systems in moisture absorption
2) The leaf are
3) Leaf arrangement and structure
4) Stomatal behaviour.

54. What are the methods available for direct measurement of consumptive use.

1) Lysimeter or Tank experiments
    a) Non-weighing constant water table type
    b) Non-weighing percolation type
    c) Weighing type.
2) Soil Moisture Depletion Studies.
3) Field experimental plots
4) Water balance method.

55. Define soil moisture with classification and forms.

The water is held in the pores of the soil mass is termed as Soil water or Soil moisture. It is expressed as ***mm.***

Classification of Soil water

1) Gravitational water *(Superfluous water)*
2) Capillary water *(Available water)*
3) Hygroscopic water *(Un-available water).*

Forms of Soil –Water

1) Saturation capacity :
2) Field capacity :
3) Permanent wilting point:
4) Available moisture :
5) Soil – moisture deficiency or Field moisture deficiency
6) Soil moisture tension or Capillary potential or Capillary tension or Force of suction

56. Define Saturation capacity *(Maximum moisture holding capacity)*

The amount of water required to fill all the pore spaces between the soil particles by replacing all the air held in the pore spaces.

57. Define Field capacity.

The **remaining moisture content of the soil** after the free drainage of gravity water.

58. Define Permanent wilting point.

1. Permanent wilting point is the water content at which plants can no longer extract sufficient water from the soil for its growth.
2. PWP is at the lower end of the ***available moisture range***. If the plant does not get sufficient water to meet its needs, it will wilt permanently.

$$\mathbf{PWP} = \left(\frac{\text{Wt. of water retained in certain vol. of soil}}{\text{Wt. of the same vol. of dry soil in Wilting}}\right) \text{X } 100$$

3. Permanent wilting points differ widely for different soils but have approximately the same values for different plants grown on the same soil.
4. The value of permanent wilting percentage may be as low as ***2% for light sandy soils*** and it may be as high as ***30% for heavy clay soils***.

59. Define Available moisture .

1) The difference between the ***Field capacity water*** and the ***Permanent wilting point water*** is called available moisture.

$$\boldsymbol{Available\ moisture = (Field\ capacity - Permanet\ wilting)}$$

2) It refers to the **Capillary water** which is used by the plants for their growth.

60. Define Soil – moisture deficiency or Field moisture deficiency.

Required Water for ***field capacity*** *is known as Soil-Moisture deficiency.*

61. Define Soil moisture tension or Capillary potential or Capillary tension or Force of

suction.

1) Force per unit area of soil is known as soil moisture tension.
2) It is expressed in terms of ***atmosphere (atm).***
3) Soil moisture tension is inversely proportional to its moisture content.
4) Soil moisture tension is in the range of ***7 to 32 atmospheres*** for all soils, and hence it cannot be extracted by the roots of the plants.