CBCS SCHEME

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18CV63

Sixth Semester B.E. Degree Examination, July/August 2022
Hydrology and Irrigation Engineering

Time: 3 hrs. Max. Marks: 100

Note: *Answer any FIVE full questions, choosing ONE full question from each module.*

Module-1

1 a. Discuss the various processes involved in 'Hydrologic Cycle' using Horton's Engineering representation. (10 Marks)

b. List the importance of hydrology with emphasis on global water availability. (10 Marks)

OR

2 a. Define Rain gauge. Describe with a neat sketch, the principle of working of Symon's non - recording gauge and its demerits. (06 Marks)

b. What is Precipitation? Distinguish between Convection and Orographic precipitation. (07 Marks)

c. Determine the optimum number of raingauges in a catchment area using the following data :
i) Number of existing rain gauges = 08.
ii) Mean annual rainfall at the gauges : 1000, 950 , 900 , 850 , 800 , 700 , 600 and 400mm.
iii) Permissible error = 6%. (07 Marks)

Module-2

3 a. What is meant by 'Evaporation Losses'? Discuss the factors affecting evaporation. (08 Marks)

b. Define 'Evapotranspiration'. Explain in brief the 'Lysimeter method' of estimating the same in the field. (06 Marks)

c. What is the Evaporation, if 4.80 litres of water is removed from an evaporation pan of diameter 1.22m and the simultaneous rainfall measurement is 9 0mm? (06 Marks)

OR

4 a. Discuss the factors that affect infiltration. Explain with a neat sketch, measurement of infiltration using double ring infiltrometer. (10 Marks)

b. A 6 hour storm produced rainfall intensities of 7, 18, 25, 12, 10 and 3mm hour is successive one hour intervals over a basin of 800km^2. The resulting run - off is observed to be 264×10^5 m^3. Determine ϕ - index for the basin. (10 Marks)

Module-3

5 a. Define the following :
i) Basin recharge ii) Direct run off iii) Drainage density iv) Form factor
v) Overland flow. (10 Marks)

b. What is Runoff? List and explain factors affecting it. (10 Marks)

OR

6 a. How the hydrograph is affected by the following :
i) Shape of the basin ii) Non – uniform aerial distribution of rainfall. (06 Marks)

b. Define 'Unit hydrograph'. With the help of neat sketch, explain the various components of a flood hydrograph. (06 Marks)

c. Given the ordinates of a 4 – hour unit hydrograph. Derive the ordinates of 12 – hour unit hydrograph for the same catchment. What is the peak value of discharge and the corresponding time interval observed in 4-h and 12-h unit hydrograph. **(08 Marks)**

Time (Hours)	0	4	8	12	16	20	24	28	32	36	40	44
Ordinates of 4-h UH cm^3/sec	0	20	80	130	150	130	90	52	27	15	05	0

Module-4

7 a. Define Irrigation. Discuss in brief the benefits and ill – effects of irrigation. **(08 Marks)**

b. Distinguish between : Direct Irrigation and Storage Irrigation. **(06 Marks)**

c. What is Bhandara Irrigation? List its advantages and disadvantages. **(06 Marks)**

OR

8 a. Define Duty and Delta. Derive the relation between them. **(06 Marks)**

b. Define the following :

i) Permanent wilting point ii) Field capacity. **(06 Marks)**

c. After how many days water supply is required to ensure good yield, if :
Field capacity of soil = 30% ; Permanent wilting point = 12% ;
Density of soil = 1.4g/cc ; Effective depth of root zone = 80cm ;
Daily consumptive use = 15mm. Readily available moisture is 85% of available moisture.
(08 Marks)

Module-5

9 a. Write an explanatory note on Canal classification on the basis of its alignment. **(06 Marks)**

b. Enumerate the basic differences between Lacey's and Kennedy's theory. **(06 Marks)**

c. A channel section is to be designed for the following data :
Discharge Q = 5 cumecs ; Silt factor = 1.0 ; Side slope = 0.5H = 1V.
Also determine bed slope of the channel. Use Lacey's theory. **(08 Marks)**

OR

10 a. With a neat sketch, explain different zones of a storage reservoir. **(10 Marks)**

b. With a neat sketch, explain step – by – step procedure of determining reservoir capacity for a specific yield using the mass – inflow curve. **(10 Marks)**

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:- Hydrology and Irrigation Engineering :-

July/ August 2022 18CV63

Q. No. 1) a) Discuss the various processes involved in the Hydrologic Cycle using Horton's Engineering representation. (10 M)

Ans :-

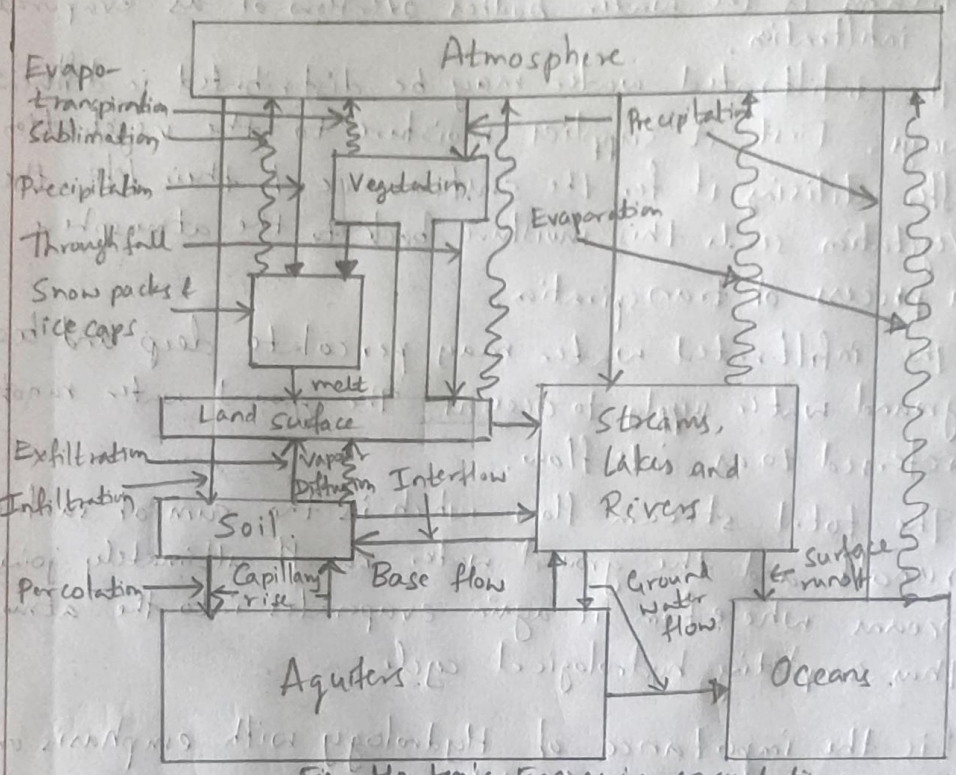


Fig. Horton's Engineering representation

→ The hydrological cycle consists of various complicated processes such as precipitation, interception, evaporation, transpiration & infiltration.

→ The hydrological cycle has no beginning or end as the water is kept in cyclic motion.

→ The precipitation may take place in liquid form as rain and also in solid form as hail, snow, dew, frost etc

→ While precipitation is taking place, a part of it may evaporate and reach back the atmosphere. Some more precipitation is intercepted by the trees and vegetation and the rest of it only would reach the ground. The intercepted precipitation eventually evaporates into the atmosphere.

→ The precipitation gets infiltrated into ground and that in excess of infiltration would be detained temporarily on the ground before it becomes overland flow and subsequently surface runoff.

→ The precipitation falling on the water bodies like ponds and lakes may be disposed of either as surface runoff to streams if the water bodies overflow or as evaporation or as infiltration.

→ The infiltrated water may be distributed in different ways. First, it supplies moisture to the vegetation and after utilising it for the sustenance of their life, the vegetation sends this moisture back to the atmosphere by a process of transpiration.

→ The infiltrated water may percolate deep and become ground water supply to oceans. The ground water runoff is referred to as interflow.

→ The total stream flow which is the sum of surface runoff and the ground water runoff ultimately joins the oceans wherefrom it again evaporates into the atmosphere thus completing hydrological cycle.

Q.1) b) Lis the importance of Hydrology with emphasis on global water availability (10 M)

Ans :-

Distribution of World's water (availability)

Location	Water volume in km^3	% of total water
Fresh water lakes	125000	0.009
Saline lakes.	104200	0.008
Stream channels	1200	0.0001
Ground water (<0.8 km deep)	4168200	0.31
Ground water (>0.8 km deep)	4168200	0.31
Soil moisture	66700	0.005
Ice caps and glaciers.	29177300	2.15
Atmosphere	12900	0.001
Oceans	1321310000	97.2
Total (Approximate)	13.6×10^8	100

→ Water is the most important natural resource on the earth. The most precious resource is sometimes scarce sometimes abundant and is always very unevenly distributed, both interms of space and time.

→ Europe and Asia together have only 27 % of world's fresh water though they accommodate about 76 % of world's population.

→ The oceans cover 71 % of surface area of earth and which have an avg. depth of 3.8 km hold as large as 97 % of the earth's water and 2 % is frozen in ice caps

→ The deep ground water accounts for 0.31 %. This 99.31 % of water is of no use to man.

→ The remaining 0.69 % which is of the order of 4.374 $\times 10^6$ km^3. represents the fresh water and atmosphere holds only 0.3 % of fresh water.

→ The global annual precipitation and evaporation are estimated to be equal and each being of the order 100 cm. Therefore the global avg. annual precipitation volume works out 510000 km^3.

→ The avg. moisture available in the atmosphere at any time is only 12900 km^3.

Q. 2) a) Define raingauge. Describe with a neat sketch, the principle of working of Symon's non-recording gauge & its demerits. (06M)

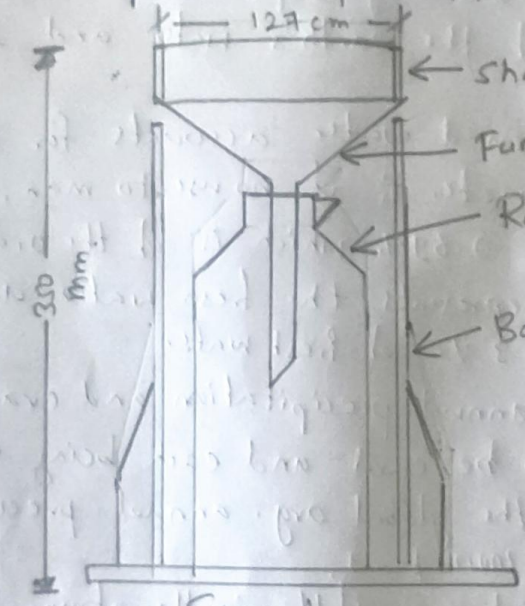
Ans :- Rainfall is measured on the basis of the vertical depth of water accumulated on a level surface during an interval of time. The instrument used for measurement of rainfall is called "Raingauge"

Symon's non-recording Type raingauge :-

Working Principle :-

→ The water is collected in the receiving bottle is measured by a graduated measuring jar with an accuracy of 0.1ml

→ The rainfall is measured every day at 8:30 am IST. and hence this rain gauge gives only depth of rainfall for previous 24 hours.



Symon's raingauge

Demerits of Symon's Rain gauge :-

→ It gives only the depth (total) of rainfall for previous 24 hours.

→ It doesn't provide intensity and rainfall duration of the rainfall during different time interval of the day.

Q. No. 2) b). What is precipitation? Distinguish between Convection and Orographic precipitation.

Ans :- Precipitation is that part of atmospheric moisture that reaches the earth's surface in the form of rain, snow, hail, sleet and ice.

Convective precipitation	Orographic precipitation
1) Lifting of unstable air that is warmer than surrounding air due to uneven surface heating which results in thunder storms and precipitation is spotty and highly variable in intensity.	1). It is the most important precipitation and is responsible for most of heavy rains in India. It is caused by air masses which strike some natural topographic barrier like mountains.
2). This type of precipitation occurs in the tropics. where on a hot day, the ground surface gets heated unequally causing the warmer air to lift up and precipitation occurs in the form of high intensity and short duration.	2) The greatest amount of precipitation falls on the windward side and leeward side has very little precipitation. Medium to high intensity rainfall continuing for longer duration.

2) c) Determine the optimum number of raingauges in a catchment area using the following data.

i) Number of existing rain gauge = 08.

ii). Mean annual rainfall at the gauges :- 1000, 950, 900, 850, 800, 700, 600 and 400 mm.

iii) Permissible error = 6 %.

Sol:- Number of existing raingauges $\Rightarrow m = 08$

Mean annual arg rainfall = $\bar{P} = \underline{775 \text{ mm}}$

P_i	1000	950	900	850	700	600	400
$(P_i - \bar{P})$	225	175	125	75	-75	-175	-375
$(P_i - \bar{P})^2$	50625	30625	15625	5625	5625	30625	140625

$$\Sigma (P_i - \bar{P})^2 = 279375$$

$$\sigma_{m-1} = \sqrt{\frac{\Sigma (P_i - \bar{P})^2}{(m-1)}}$$

$$= 199.7766 \text{ mm}$$

$$Cv = \frac{100 \times \sigma_{m-1}}{\bar{P}}$$

$$C_v = \frac{100 \times 199.77}{775}$$

$$= \underline{25.78}$$

Number of optimum rainganges –

$$N = \left(\frac{C_v}{\epsilon}\right)^2 = \left(\frac{25.78}{6}\right)^2 = 18.45 \simeq 19$$

Additional rainganges = 19 – 08

$$= \underline{11}$$

Module – II

3) a) What is meant by "Evaporation Losses"? Discuss the factors affecting evaporation. (08 M)

Ans :- Evaporation is a process by which water from liquid or solid state passes into the vapour state and is diffused to atmosphere.

Factors affecting Evaporation are :-

i) Vapour pressure. ii) Temperature iii) Wind.
iv) Atmospheric pressure. v) Quality of water vi) Depth and size of water surface. vii) Humidity viii) Radiation.

i) Vapour pressure :- High vapour pressure increases the rate of evaporation. Rate of evaporation is directly proportional to difference b/w the saturation vapour pressure and actual vapour pressure.

ii) Temperature :- The rate of emission of molecules from water body is a function of its temperature. The rate of evaporation increases with increase in water temperature.

iii) Wind :- The rate of evaporation increases with increase in wind velocity. The 10 % increase in wind velocity

increases by 2-3 % of evaporation.

iv) Atmospheric Pressure :- Evaporation decreases with increase in atmospheric pressure as the rate of diffusion from water body into the air is suppressed. At higher altitudes the atmospheric pressure is usually lesses and there by increasing evaporation.

v) Quality of water :- The rate of evaporation of fresh water is greater than saline water. The saline water has lower vapour pressure compared to fresh water. Evaporation from fresh water is 3 to 4 % more than sea water.

vi) Depth and size of water surface :- Evaporation from shallow water bodies is greater than deep water bodies. Also, the depth of evaporation from larger surface areas is less compared to evaporation from ~~shallower~~ smaller surface reservirs.

vii) Humidity :- Humidity of the atmosphere is more the evaporation will be less.

viii) Radiation :- Evaporation increases with increase in radiation.

Q.No:-3) b) Define 'Evapotranspiration'. Explain in brief 'Lysimeter method' of the estimating the same in field? (06M)

Ans:- Transpiration is the process by which water vapour escapes from the living plant, principally through the leaves and enters the atmosphere. Evapotranspiration is the sum of water used by plants in an given area in transpiration and water evaporated from the adjacent soil in the area in any specified time.

'Lysimeter method' of the ~~existing~~ estimating the same in field:-

→ It consists of a circular tank about 60 to 90 cm in diameter and 180 cm deep.

→ The lysimeter is filled with soil and individual crops or natural vegetation, for which the evapotranspiration is required are grown.

→ For better results the lysimeter may be surrounded by the guard area of at least 4 hectares of the same crop with similar conditions.

→ The limitation of lysimeter method is that differences may exist between the lysimeter and natural conditions of soil profiles, soil moisture regime, plant rooting characteristics, methods of water application, water table, temperature and the net energy exchange.

Q. No:- 3) c) What is evaporation, if 4.50 litres of water is removed from an evaporation pan of diameter 1.22 m and the simultaneous rainfall measurement is 9.0 mm? (04 M)

Sol?:- Area of Pan $= \left(\frac{\pi}{4}\right) \times (122)^2 = 11689.87\ cm^2$

Volume of water removed = 4.50 litres.

$= 4500\ cm^3$

∴ Depth of water removed $= \frac{4500}{11689.87}$

$= 0.41\ cm$

$= 4.1\ mm.$

∴ Evaporation = Rainfall − Depth of water removed

$= 9.0 - 4.1$

$= 4.9\ mm$

Q. No:- 4) a) Discuss the factors that affect infiltration. Explain with a neat sketch, measurement of infiltration using double ring infiltrometer. (10 M)

Ans:- Factors that affect infiltration are —

i) Depth of surface detention and thickness of saturated soil

ii) Soil moisture. iii) Compaction iv) Surface cover conditions.
v) Temperature. vi) others.

i) Depth of surface retention and thickness of saturated layer :-

Infiltration takes place due to combined influences of gravity and capillary forces. At any instant of time the resistance to flow is proportional to the thickness of the saturated layer of soil upto wet front, while the driving head is proportional to $(L+d)$, 'd' being depth of detention.

ii) Soil moisture :- The infiltration increases with increase in moisture content of soil.

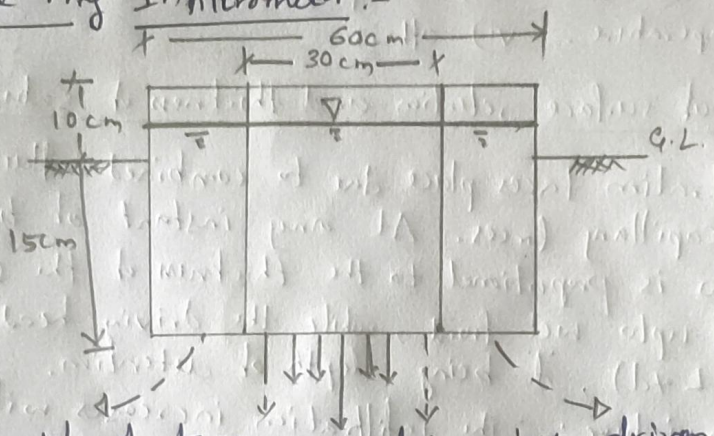
iii) Compaction :- The clay surfaced soils are compacted even by the impact of raindrops, which reduces infiltration. This compaction not only reduces porosity but also pore sizes. The infiltration is less on the surface of soil which is compacted.

iv) Surface cover conditions :- The nature of surface cover has also an important influence on the infiltration. The presence of dense vegetation on the surface increases infiltration. The vegetative covers retard the movement of overland flow and causes high detention depths. The surfaces covered with snow and paved urban area will obviously have lower infiltration.

v) Temperature :- The effect of temp. on infiltration is explained through viscosity. At high temp. viscosity of water is low, high infiltration is expected. During winter, the temperature is less and infiltration is less.

vi) Others :- Entrapped air in the pores, quality of water and freezing are other factors. The presence of entrapped air increases the resistance to flow, therefore reduces infiltration.

Double-ring Infiltrometer :-



It consists of two concentric rings driven into the soil to a depth of about 15 cm uniformly without tilt and disturbing the soil to the least. The diameters of rings may vary b/w 25 to 60 cm. Water is then applied in both the inner and outer rings then applied in both the inner and outer rings to maintain a constant depth of about 5 cm. The water depths in the both rings are maintained constant during the observation period. The measurement of water volume added into the inner ring is only noted.

Q.No:- 4) b) A 6 hour storm produced rainfall intensities of 7, 18, 25, 12, 10 and 3 mm/hour in successive one hour intervals over a basin of 800 km^2. The resulting runoff is observed to be 264×10^5 m^3. Determine ϕ-index for the basin. (10M)

Soln:-

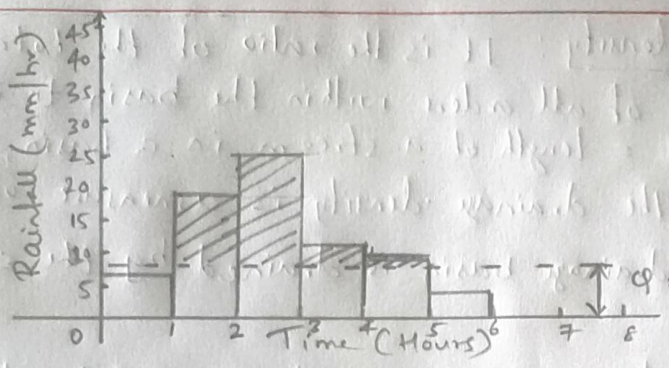
Total volume of runoff = 264×10^5 m^3

Area of the basin = 800 km^2

= 800×10^6 m^2.

$\therefore$ Depth of runoff = $\frac{V}{A} = \frac{264 \times 10^5}{800 \times 10^6} = 0.033$ m

= 33 mm



Trial :- 1) $\phi = 7$ mm/hr.

Runoff = $(7-7) + (18-7) + (25-7) + (12-7) + (10-7) + (3-7)$

$33 \neq 37$

Trial :- 2) $\phi = 8$ mm/hr

Runoff = $(7-8) + (18-8) + (25-8) + (12-8) + (10-8) + (3-8)$

$33 = 33$

$\therefore \phi = 8$ mm/hr.

Module 3

Q.No:-5). Define the following :- i) Basin recharge. ii) Direct runoff iii) Drainage density iv) form factor v) Overland flow (10M)

Ans :- i) **Basin recharge** :- The method through which the water enters aquifer in the Basin area. The process usually occurs in the vadose zone below the plant roots & is often expressed as a flux to the water table surface.

ii) **Direct runoff** :- It is that 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 case of snow-melt, the resulting flow entering the stream is also called direct runoff.

iii) Drainage density :- It is the ratio of the total lengths of streams of all orders within the basin to its area. Thus, if L = length of a stream in a basin, then Dd $= \frac{\Sigma L}{A}$. The drainage density is a measure of how well the drainage basin is drained by the stream network.

iv) Form factor :- It is one of the catchment shape parameters defined as the ratio of area of catchment to the square of the length of catchment. (A/L^2)

v) Overland flow :- It is defined as water that flows over the land surface as either diffuse sheet flow or concentrated flow.

5. b) What is runoff? List and explain factors affecting it. (10M)

Ans:- The portion of precipitation which appears in the surface streams of either perennial of intermittent nature is called "runoff".

Factors affecting runoff are - (Climatic)

i) Type of precipitation ii) Intensity of rainfall iii) Duration of rainfall. iv) Areal distribution of rainfall. v) Direction of storm movement vi) Antecedent Precipitation vii) Other climatic factors.

Factors affecting runoff (Physiological) are -

i) Land use. ii) Type of soil. iii) Area of the basin. iv) Shape of the basin. v) Elevation vi) Slope vii) Orientation viii) Type of drainage network. ix) Indirect drainage x) Artificial drainage

i) Type of Precipitation :- If the precipitation occurs in the form of rain, it will immediately produce a runoff than

in the form of snow.

ii) Rain intensity :- If the intensity of rain increases, the runoff increases.

iii) Duration of rainfall :- A longer duration rain may produce considerable runoff even when its intensity is mild.

iv) Rainfall distribution :- The rainfall distribution is generally expressed by the distribution coefficient. For a given total rainfall and for other conditions remaining the same, the greater distribution coefficient of rainfall, the greater will be peak runoff.

v) Direction of storm movement :- The non-uniform areal distribution of precipitation over a region is the result of movement of storm while it is yielding precipitation. The runoff from the basin is generally influenced by the direction of storm movement, esp. w.r.t direction of flow of the drainage system.

vi) Antecedent Precipitation :- Very intense rains falling in late summer, when the soil moisture is at its least, rarely produce high discharges because most of the water enters the soil moisture under the existing high infiltration capacity rates and is held there reducing the runoff.

vii) Other climatic conditions :- Temperature, wind velocity, atmosphere pressure, radiation, humidity etc also affect the runoff.

viii) Land use :- In urban areas there is a little scope for infiltration and transpiration and all the rainfall immediately becomes direct runoff producing high discharges.

ix) Type of soil :- Open textured sandy soil will tend to have higher infiltration rates and therefore produce less peak discharges. Fine-grained and closely compacted clays soils will have the opposite effect on runoff.

x) Area of basin :- Larger area of basin produces larger runoff.

xi) Shape of Catchment :- The separate runoff peaks generated by

a heavy rainfall in the individuals tributaries are likely to reach the main stream in approximately the same locality and at approximately same time, thereby resulting in a large and rapid increase in the runoff.

xii) Elevation :- The variation in elevation of basin may influence runoff in as much as they decide the proportion of precipitation falling in the form of snow and the evaporation and transpiration losses.

xiii) Slope :- Steepy sloped catchment will tend to produce higher runoff peaks.

xiv) Orientation :- The orientation of the basin decides the amount of solar radiation received from the sun. Thus it may affect runoff through its influence on evaporation, transpiration and snow melt processes.

xv) Drainage Network :- If the basin is well drained with large number of tributaries shortening the length of the overland flow, the surface runoff concentrates quickly resulting in high peaks.

xvi) Indirect drainage :- The runoff from the sinkholes and fissures and various outlets is called indirect drainage.

xvii) Artificial drainage :- Conditions of artificial drainage exists in areas provided with the system of open ditches or tile drains and paved areas in urban regions.

Q.NO.-6) a) How the hydrograph is affected by the following
i) Shape of the basin. ii) Non-uniform distribution of rainfall. (06M)

Ans :- i) Shape of the basin :-

- The shape of the basin influences the time taken for water from the remote parts of the catchment to arrive at the outlet.

. Thus the occurrence of the peak and shape of the hydrograph are affected by the basin shape.

ii) Non-uniform aerial distribution of rainfall.

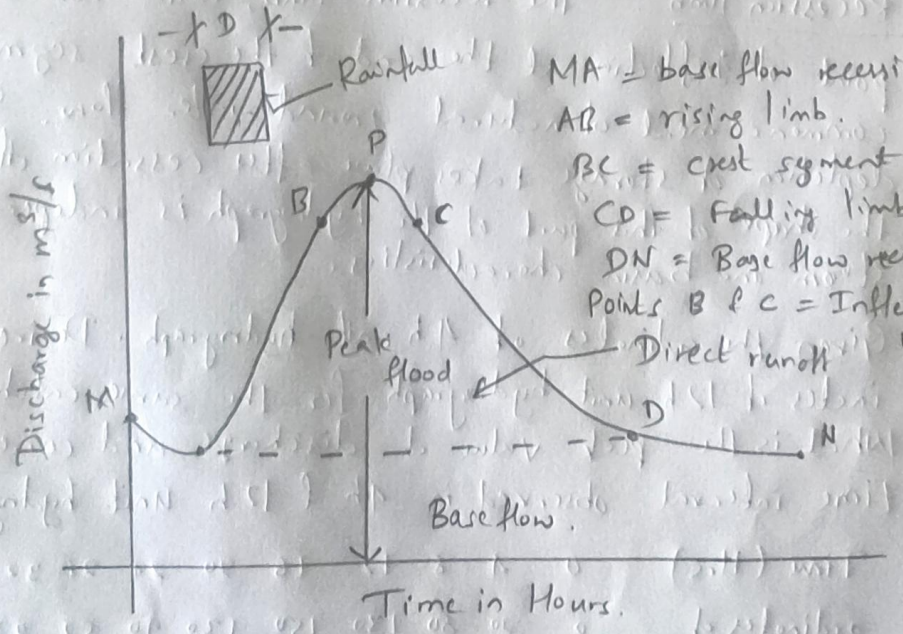
→ It can cause variation in hydrograph shape. If the area of high rainfall is near to the basin outlet, a rapid rise, sharp peak and rapid recession of the hydrograph usually result.

→ If a larger amount of rainfall occurs in the upper reaches of the basin, the hydrograph exhibits a lower and broader peak.

6) b) Define 'unit hydrograph'. With the help of a neat sketch, explain the various components of a flood hydrograph. (06 M)

Ans:- A 'unit hydrograph' is defined as the hydrograph of direct runoff resulting in 1 unit depth (1 cm) of rainfall excess occurring uniformly over a basin and at a uniform rate for a specified duration (D hours).

Various components of a ~~flood~~ flood hydrograph:



Rising limb :- The rising limb of a hydrograph, also known as concentration curve represents the increase in discharge due to the gradual building up of storage in channel and over the catchment surface. The initial losses and high infiltration losses during the early period of storm cause the discharge to rise rather slowly in the initial periods. The basin and storm characteristics control the shape of the rising limb of hydrograph.

Crest segment :- It is one of the most important part of hydrograph as it contains the peak flow. The peak flow occurs when the run off from various parts of the catchment simultaneously contribute amounts to achieve the maximum amount of flow at the basin outlet. Generally, for large catchments, the peak flow occurs after the cessation of rainfall, the time interval from the centre of mass of rainfall to the peak being essentially controlled by storm & basin characteristics.

Recession limb :- The recession limb, which extends from the point of inflection at the end of the crest segment to the commencement of natural ground water flow. Since the depletion of storage takes place after cessation of rainfall, the shape of this part of the hydrograph is independent of storm and basin characteristics.

Q.No:6) c) Given the ordinates of 4 h unit hydrograph. Derive the ordinates of 12 h unit hydrograph for the same catchment. What is the peak value of discharge and corresponding time interval observed in 4h & 12 h unit hydrograph. (8M)

Sol:-

Time (Hrs)	0	4	8	12	16	20	24	28	32	36	40	44
ordinates of 4-h UH in m³/s	0	20	80	130	150	130	90	52	27	15	5	0

Time (h)	Ordinates of 4h - UH			DRH of 3cm 12h. (2)+(3)+(4)	Ordinates of 12h UH. = (5)/(3) in m^3/s.
	A	B lagged by 4h	C lagged by 8-h		
(1)	(2)	(3)	(4)	(5)	(6)
0	0	—	—	0	0
4	20	0	—	20	6
8	80	20	—	100	33.33
12	130	80	20	230	76
16	150	130	80	360	120.0
20	130	150	130	410	136.7
24	90	130	150	370	123.3
28	52	90	130	272	90
32	27	52	90	169	56.3
36	15	27	52	94	31.3
40	5	15	27	47	15.7
44	0	5	15	20	6.7
48	0	0	5	5	1.7
52	—	—	0	0	0

	Time interval	Peak discharge
4h UH	16hr.	150 m^3/s.
12h UH	20 hr	136.7 m^3/s.

Module - 4

Q. No - 7) a) Define irrigation. Discuss in brief the benefits and ill effects of irrigation. (8m)

Ans:- Irrigation may be defined as the process of artificially supplying water to the soil for raising crops.

Benefits of Irrigation are -

i) Increase in food production.
ii) Protection from famine
iii) Cultivation of Cash crops.
iv) Elimination of mixed cropping
v) Addition to the wealth of the country
vi) Increase in prosperity of people
vii) Generation of Hydro-electric power.
viii) Domestic and Industrial water supply.

ix) Inland navigation. x) Improvement of communication
xi) Canal plantations xii) Improvement in ground water storage.
xiii) Aid in cultivation. xiv) General development of the country.

Ill-effects of irrigation.

i) Breeding places for mosquitos.
ii) Water-logging
iii) Damp Climate.

Benefits of Irrigation:-

i) Increase in food production:- Due to the controlled and timely supply of water to the crop, the yield is increased. For a given crop, the optimum quantity of water required may be determined experimentally, and then applied scientifically to the crop.

ii) Protection from famine:- During the construction of the irrigation works, employment is carried to the people and thus they get relief against famine. After the construction of such works, continuous supply of water is maintained during drought.

iii) Cultivation of Cash crops:- Irrigation makes it possible to grow cash crops. such as sugar-cane, tobacco & cotton etc

iv) Elimination of mixed cropping:- The availabilities of irrigation facility in an area gives the farmers the protection against the vagaries in weather, resulting in the elimination of mixed cropping.

v) Addition to the wealth of the country:- It adds to the wealth of country by making the country self-sufficient in food requirements and reduces foreign exchange.

vi) Increase in prosperity of people:- The value of land increases. The standard of living of farmers get improved.

vii) Generation of Hydro-Electric power:- Major river valley projects are usually provided hydro-electric power

viii) Domestic and Industrial water supply :- The canals may be utilised for domestic and industrial water supply. Some of the irrigation reservoirs also supply water to nearby rural and urban areas.

ix) Inland navigation :- Large canals can also be used for inland navigation.

x) Improvement in communication :- Allmost all the irrigation channels are provided with inspection roads. These roads are means of communication.

xi) Canal plantations :- The stripped area along the canal is always damp and trees are planted along the canal banks which reduce soil erosion.

xii) Improvement in ground water storage :- Due to the constant percolation and seepage of water, the GWT is raised.

xiii) Aid in civilisation :- Due to the introduction of river valley projects, the violent tribes adopt irrigation as their profession and settle peacefully.

xiv) General development of the country :- As India is dependent on agriculture for the revenues, due to rise in the living standards of the people revenue increases which may be utilised for building schools, hospitals & other facilities.

Ill Effects of irrigation :-

i) Breeding places for mosquitoes :- Due to excess application of water and due to leakage of water, ponds and depressions get filled up with water and create breeding places for mosquitoes.

ii) Water-logging :- Over irrigation leads to rise in water table resulting water-logging.

iii) Damp Climate :- The areas which are already damp and cold, become damper & colder due to irrigation.

Q.No:- 7) b) Distinguish b/w :- Direct irrigation & Storage irrigation. (6M)

Ans:-

Direct Irrigation	Storage Irrigation
i) No storage of water upstream of diversion weir is provided	i) A dam is constructed across the reservoir to store water.
ii) Water is directly diverted to canals without any storage	ii) Water is stored first and then diverted to canals.
iii) Lower magnitude of water	iii) Large quantity of water.
iv) Low cost scheme	iv) The scheme is costlier
v) Network of canal is simple.	v) Large network of canal
vi) Water is available in rainy season	vi) Since water is stored supply water throughout year.

7) c) What is Bhandara irrigation? List advantages & disadvantages (06M)

Ans:- Bhandhara irrigation is a special type of irrigation scheme, somewhere in between inundation and permanent type. It is a mixed irrigation scheme. Bhandara is a ~~small~~ low masonry weir (obstruction) of height 1.2m to 4.5m constructed across the stream to divert water to small canals.

Advantages of Bhandara Irrigation are :-

i) Small quantity of flow in streams can be fully utilised or otherwise might have gone as waste

ii) As the length of the canal is short, seepage and evaporation losses are less.

iii) Intensive irrigation with high duty may be achieved and the area to be irrigated is close to the source.
iv) The initial investment and maintenance cost of the system is low.

Disadvantages of Bhandaras :-

i) The supply of water is unreliable when flow in streams become lesser.
ii) Excess water available cannot be utilized for cultivation below each Bhandara is fixed.
iii) In dry season, people living on the downstream side of Bhandaras may be deprived of water for domestic purposes.

Q.No: 8) a) Define duty and delta. Derive the relation between them. (6M)

Ans:- "Duty (D)" represents the irrigating capacity of unit of water. It is a relationship b/w the area of crop irrigated & quantity of water required during entire period of the growth of that plant.

"Delta" is the total depth of water required by crops during the entire period crop is in the field. and is denoted by symbol 'Δ'.

Relationship between Duty and delta :-

Let 'D' be duty in hectares/cumec, 'Δ' be the total depth of water supplied in m, and 'B' be the base period in days.

If we take a field area of 'D' hectares, water supplied to the field corresponding to water depth (Δ) meters will be = Δ × D hectare-meters.

= Δ × D × 10^4 m^3 ⟶ (1).

Again, for the same field of 'D' hectares one cumecs of water is required to flow during the entire base period. Hence, the water supplied to field is —

$$B \times 24 \times 60 \times 60 \ m^3 \rightarrow (2)$$

Equating (1) & (2)

$$D \times D \times 10^4 = B \times 24 \times 60 \times 60$$

$$\Rightarrow D = \frac{8.64B}{D} \quad \text{... m.}$$

8) b) Define the following. i) Permanent wilting point ii) field Capacity. (06M)

Ans :- i) Permanent wilting point :- (Wilting coefficient)

It is that water content at which plants can no longer extract sufficient water from soil for its growth. The permanent wilting point is at lower end of available moisture range. If the plant does not get sufficient water to meet its needs, it will permanently.

ii). Field Capacity :- It is moisture content of soil after free drainage has removed most of the gravity water. The concept of field capacity is extremely useful in arriving at the amount water available in the soil for plant use. Most of the gravitational water drains through the soil before it can be used consumptively by plants.

8) c) After how many days water supply is required to ensure good yield of —

i) field capacity of soil = 30%, Permanent wilting point = 12%, Density of soil = 1.4 g/cc, Effective root zone depth = 80 cm. Daily consumptive use = 15 mm. Readily available moisture = 65%.

Soln:- Available moisture = 30 - 12
= 18 %.

Readily available moisture = $18 \times \frac{85}{100}$
= 15.3 %.

Min. water content = Field capacity soil - Readily available moisture content
= 30 - 15.3
= 14.7 %.

Depth of water stored in root zone
= $\frac{1400}{1000} \times 0.4 [0.3 - 0.147]$.
= 0.171 m = 171 mm.

For the give crop, Cu = 15 mm.

∴ No. of days of watering interval = $\frac{171}{15}$ = 11 days.

Module - 5

Q. No:- 1) a) Write an explanatory note on Canal classification on the basis of alignment. (06 M)

Ans:- Canal classification based on alignments are -
i) Contour canal.
ii) Watershed Canal / Ridge canal
iii) Side slope canal.

i) Contour Canal:- A channel aligned nearly parallel to the contours of the area is called contour canal. The contour canal irrigate only one side. As the ground level on the other side is very high, there is no necessity of the bank on this side. Hence two types of canals - single bank canals & double bank canals.

The contour canals does not follow the same contour all along. To enable the water to flow by gravity, some surface slope is given.

ii) Ridge / watershed canal :- A ridge or a watershed canal is aligned along a watershed and runs for most of its length on a watershed. When a channel is on the watershed, it can command areas on both banks and hence a large area can be brought under cultivation. Also, no drainage can intersect a watershed and hence, the necessity of constructing cross-drainage works are obviated.

iii) Side slope canal :- It is a channel aligned roughly at right angles to the contours of the country and is neither on the watershed nor in the valley. Such a channel would be roughly parallel to the natural drainage of the country and would not intercept any cross-drainage.

Q.No:- 9) b). Enumerate the basic differences b/w Lacey's & Kennedy's theory. (6m)

Ans:-

Kennedy's theory	Lacey's theory.
i) The section of canal is trapezoidal.	i) Cup shaped section
ii) Uses critical velocity ratio.	ii) Uses silt factor
iii) No equation for bed slope is provided.	iii) Equation for bed slope is available
iv) Cannot attain final regime.	iv) Cannot attain final regime
v) No distinction b/w two types of resistances in channels	v) Made distinction b/w the resistances in channels
vi) V & D are considered in equation.	vi) V & R are considered in the equation.

Q.No:- 9) c) A channel section is to be designed for following data Discharge Q = 5 cumecs. ; silt factor = 1.0 ; side slope = 0.5H = 1V. Also determine bed slope of channel. Use Lacey's theory. (8m)

Sol:- Velocity = $V = \left(\frac{Qf^2}{140}\right)^{1/6}$

$= \left(\frac{5 \times 1}{140}\right)^{1/6} = 0.574$ m/sec.

Area = $A = \frac{Q}{V} = \frac{5}{0.574} = 8.71 m^2$

Perimeter = $P = 4.75\sqrt{Q} = 10.62$ m

$\therefore A = BD + \frac{D^2}{2}$

$8.71 = BD + 0.5D^2 \rightarrow (1)$

$P = B + \sqrt{5}D \rightarrow (2)$.

Solving (1) & (2) we get

$B = 8.44$ m, $D = 0.99$ m

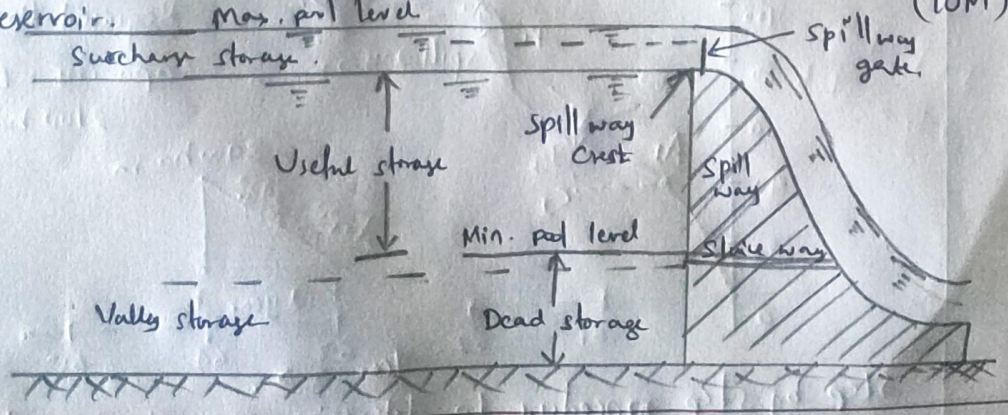
$R = \frac{BD + 0.5D^2}{B + D\sqrt{5}} = 0.823$ m

$R = \frac{5V^2}{2f} = 0.824$ m checked

Bed slope = $\frac{f\,5/3}{3340 \times Q^{1/6}} = \frac{1}{4400}$.

Q.10) a). With a neat sketch, Explain different zones of a storage reservoir. (10M)

Ans:-



The following are various zones of storage in reservoir.
i) Useful storage ii) Surcharge storage iii) Dead storage
iv) Bank storage v) Valley storage.

i) Useful storage :- The volume of water stored blw the normal pool level and the minimum pool level is known as useful storage

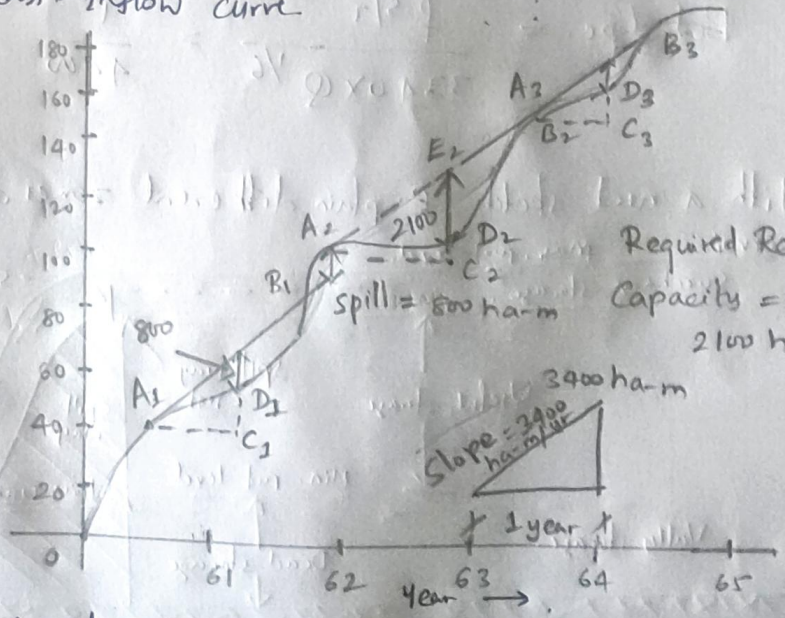
ii) Dead storage :- The volume of water below the minimum pool level. is known as the dead storage.

iii) Surcharge storage :- The volume of water stored between the normal pool level and maximum level corresponding to flood is called surcharge storage

iv) Bank storage :- The volume of water stored in the pervious formations of the river banks and the soil above it. The bank storage effectively increases the capacity of reservoir above that indicated by the elevation storage curve.

b) With a neat sketch, explain step by step procedure of determining reservoir capacity for a specific yield using the mass-inflow curve

Ans :-



Step by step procedure to determine reservoir capacity —

1. From the flood hydrograph of inflow for several years, prepare the mass inflow curve. Also prepare the mass curve of demand on the same scale
2. From the apices A_1, A_2, A_3 .... etc. of the mass inflow curve, draw tangents parallel to the demand curve.
3. Measure the maximum vertical intercepts E_1D_1, E_2D_2, E_3D_3 etc., between the tangent and the mass inflow curve. The vertical intercepts indicate the volume by which the inflow falls short of demand. Hence, the volume E_3D_3 has to be provided from reservoir storage.
4. The biggest of the vertical ordinates amongst E_1D_1, E_2D_2, E_3D_3 etc. to represent the required reservoir capacity.

It should be noted that the vertical distance between successive tangents represents water ~~is~~ wasted over the spillway. The spillway must have sufficient capacity to discharge the flood volume.

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