AIR-1 Notes

Pages: 149

HYDOLOGY

Handwritten notes by

Kartikay Kaushik

AIR-1 ESE 2021

IES Master classroom Student

HYDROLOGY

CONTENT

DATE
PAGE

Hydrology

ESE - Objective (3-5 Ques)
- Conventional (25-45 Marks)

GATE - (2-4 Ques)

1) Introduction
2) Precipitation
3) Abstraction from ppt.
4) Surface Runoff
5) Hydrograph → Test (2)
6) Stream flow Measurement.
7) Flood / Flood Routing
8) Ground water.

} Test (2)

1. INTRODUCTION

→ Hydrology is an earth science involving study of water of earth.

→ Hydrological cycle

→ It is a global sun driven process in which water is transported from oceans to the atmosphere, then to the land and then back to the sea.

→ It is a continuous process with no definite starting point

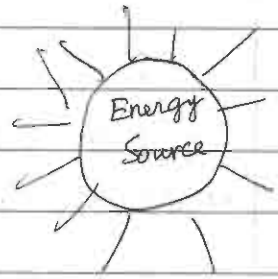
→ A convenient starting point to describe the cycle is taken as ocean

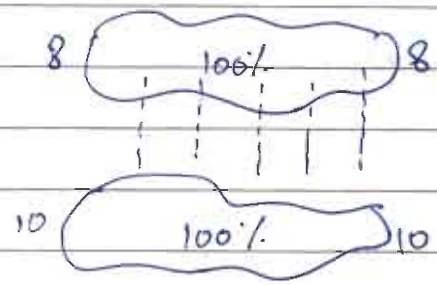
→ Extent → 1 km below the earth surface to 15 km above earth surface.

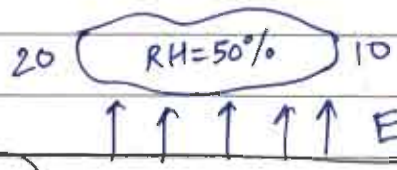
→ Relative Humidity

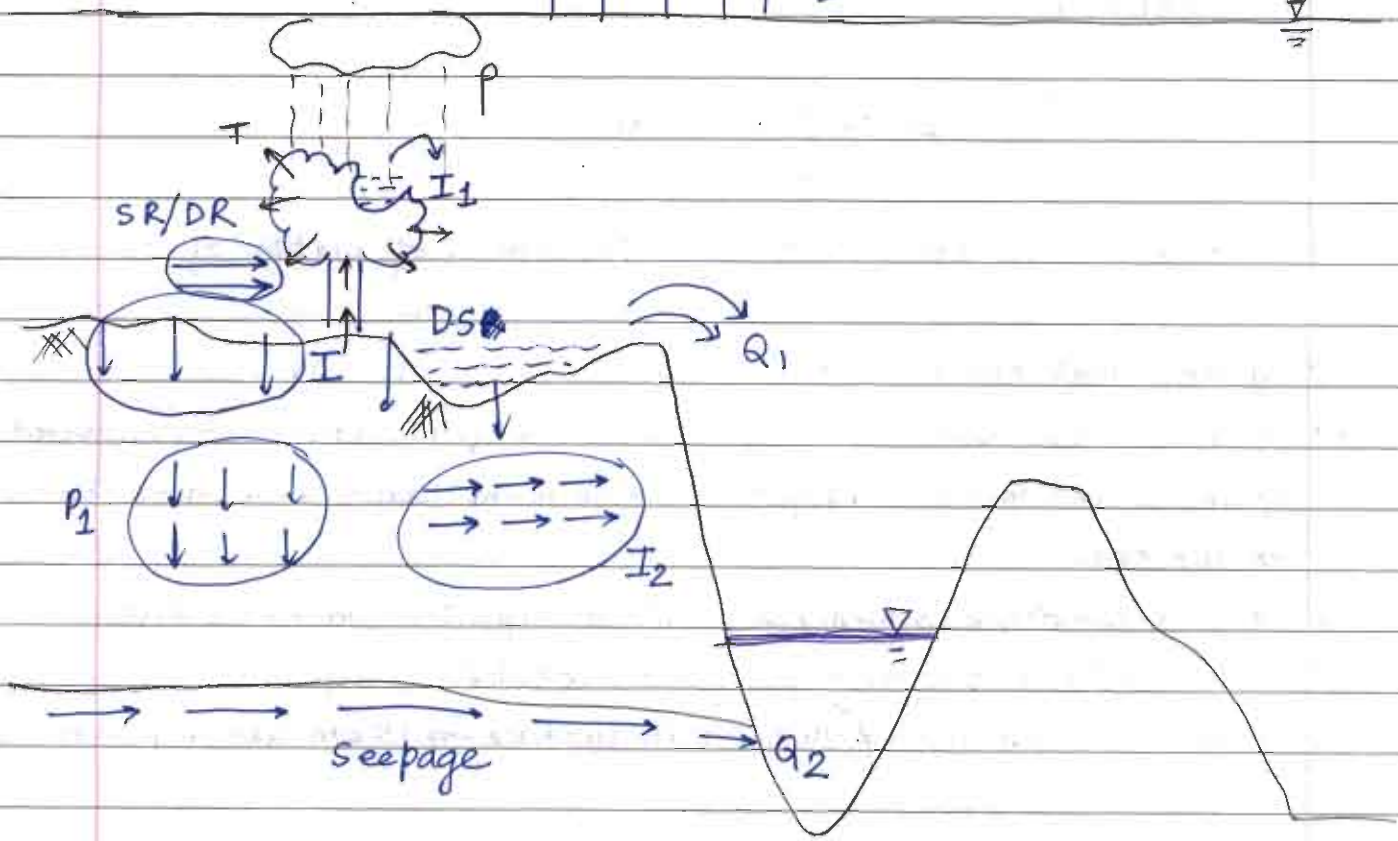
$$RH = \frac{\text{Actual vapour Carried}}{\text{Vapour carrying capacity}} \times 100\% \quad (\text{at constant temp.})$$

→ With decrease in temperature, RH increases and vice-versa









→ Due to ~~Solar~~ solar radiation falling on ~~earth~~ ocean surface, water surface, water evaporates and mixes with the dry air → moist air. Moist air being lighter than dry air rises and in the

I_1 → Interception
I → Infiltration

process cools down thereby increasing its RH. RH subsequently reaches 100% (cloud formation). Any further rise in moist air causes condensation (in presence of condensation nuclei) followed by precipitation.

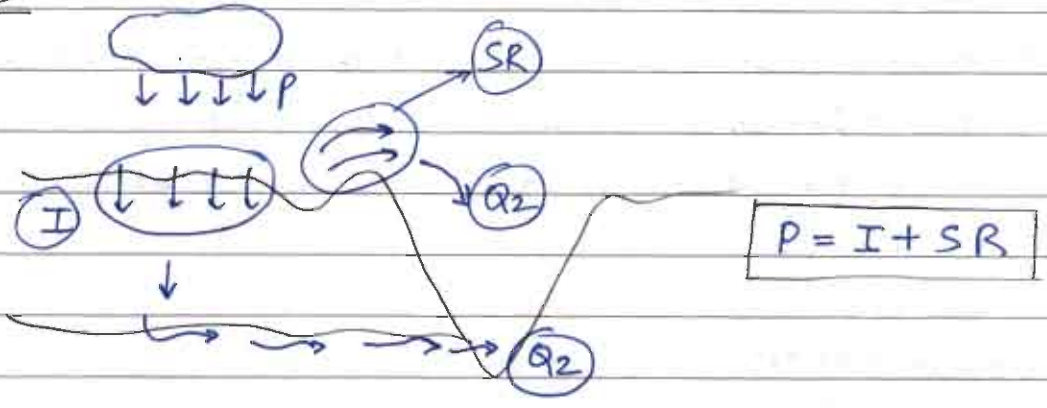
1) Evaporation (E): Change of water from liq to gaseous state.
2) Precipitation (P): Deposition of water on earth surface as rain, snow, hail etc
3) Interception (I_1): Short term retention of rain water by vegetation, roof top, pavements etc.
4) Infiltration (I): It is the movement of water into the soil at the surface.
5) Percolation (P_1): Movement of water from one soil zone to a lower soil zone.
6) Transpiration (T): It is the water absorbed from ground and evaporated into the atmosphere through leaves
7) Interflow (I_2): It is the groundwater flowing horizontally above the water table. It is also called sub-surface flow.
8) Depression Storage (DS): Rainwater accumulated in small depressions or ditches above the surface.
9) Surface Runoff (SR): It is the part of rain which reaches the stream outlet soon after the rainfall flowing over the surface. Also, sometimes called Direct Runoff (DR), effective Rainfall or Rainfall excess.

NOTE:
Actually DR is slightly more than SR but for all practical calculations they are treated as same.

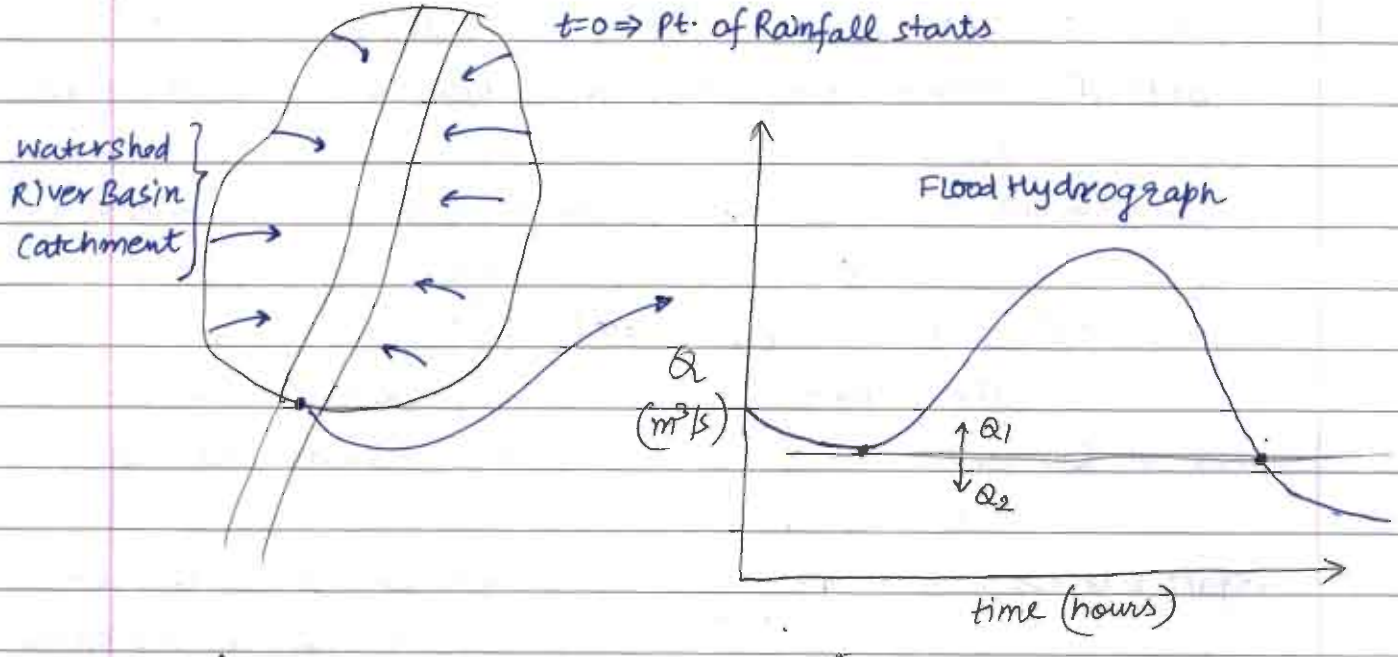
10) Q_2: It is the discharge obtained in the stream due to ground water table through seepage. It is also known as Base flow, Dry weather flow. or effluent seepage

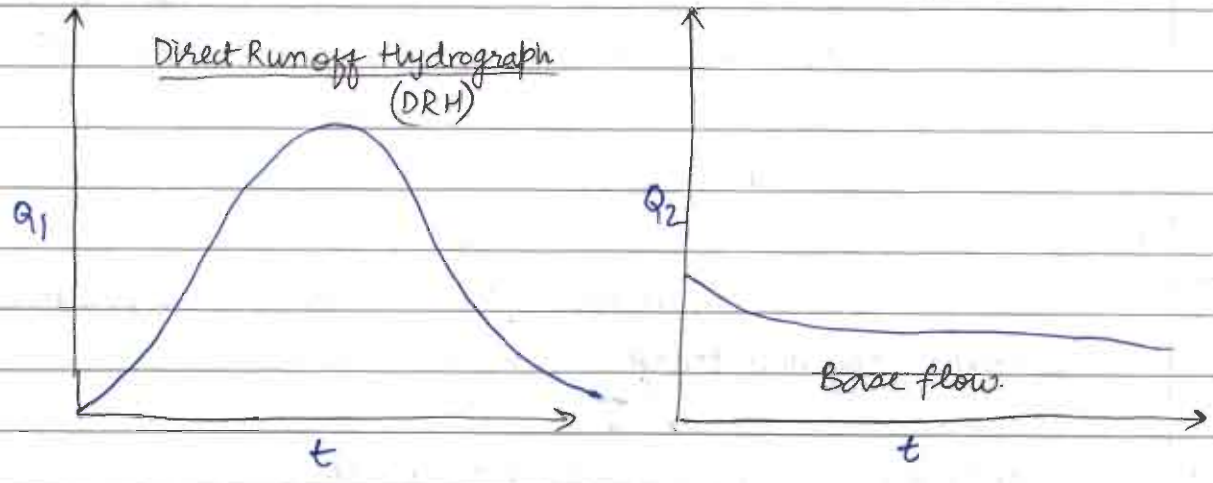
11) Q_1 : It is the discharge obtained in the stream due to SR/DR.

⇒ EXTRAS



Hydrograph: It is a plot of run off (discharge) v/s time.



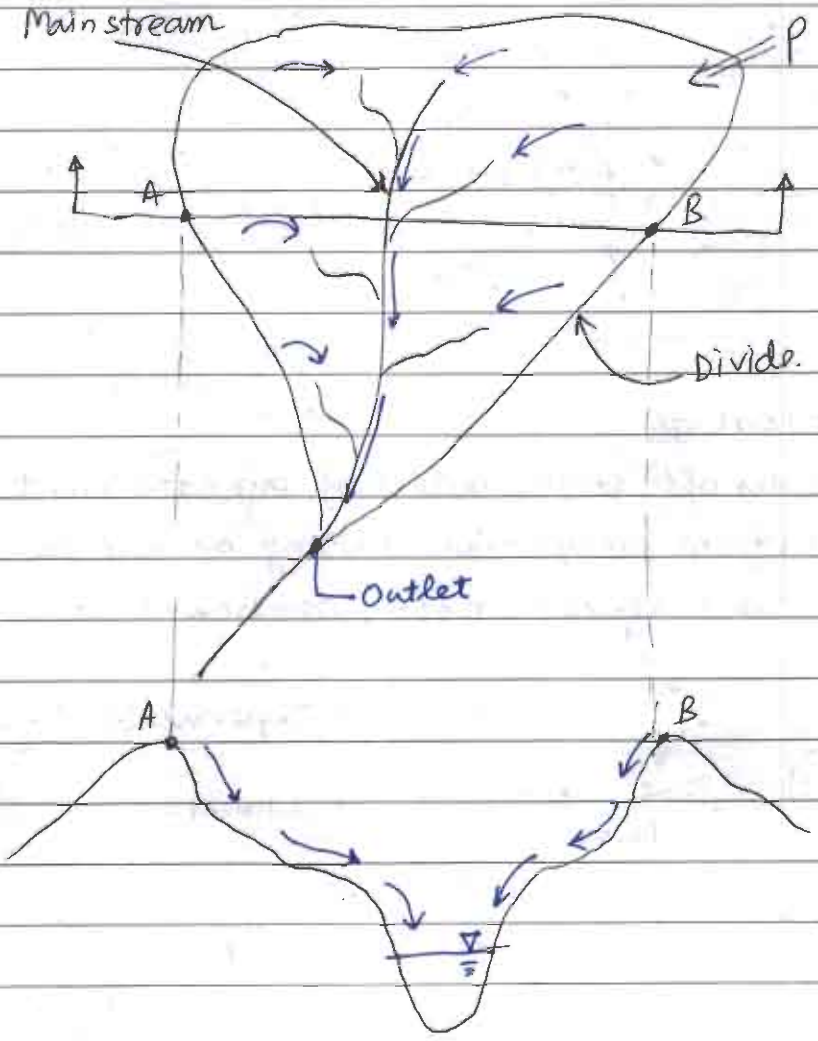


DATE
PAGE

Area of DRH = Volume of SR/DR/Effective Rainfall/Rainfall excess.

→ Evaporation from oceans contributes to 90% of atmospheric moisture.
→ In oceans about 9% more water evaporates than falls back as precipitation.

→ Catchment Area: It is an area of land where surface water from rain and melting snow converges to a single point known as catchment outlet where the water joins another water body like lake, river or ocean.
→ Catchment area is also known as watershed, river basin or simply basin.



DATE
PAGE

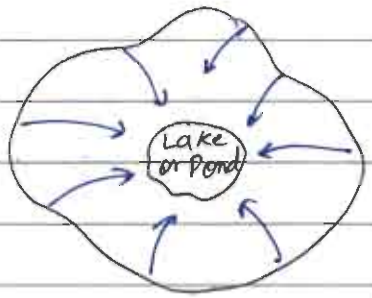
→ Each catchment is separated topographically from adjacent catchment by a geographical barrier such as mountains or hills or ridge

→ The line which divides the SR b/w 2 adjacent catchments is called as topographic divide / watershed divide / water divide or simply divide.

→ The divide follows the ridge line crossing the main stream only at the outlet

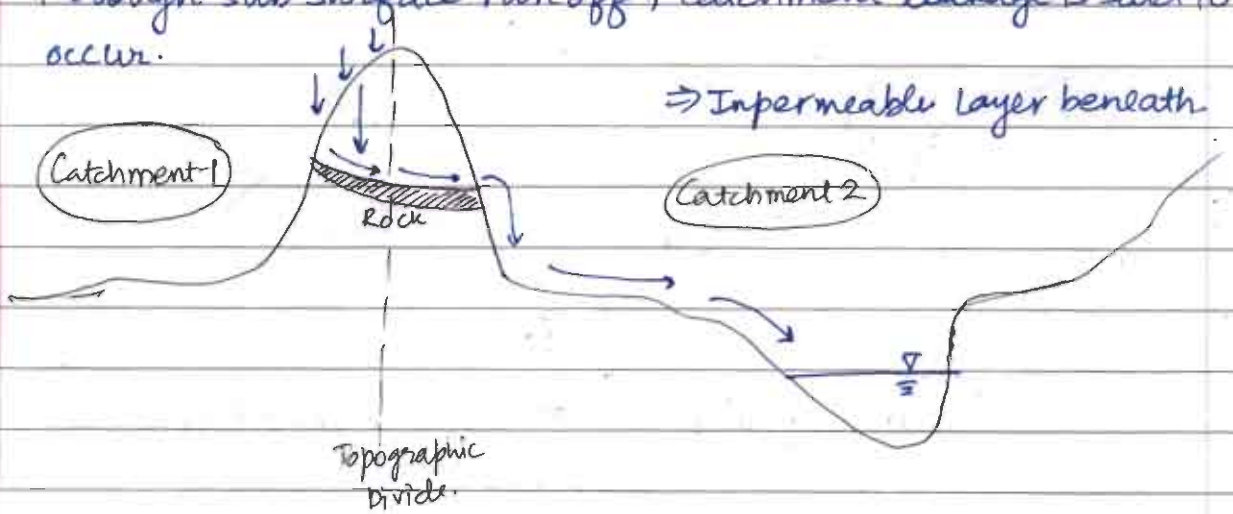
NOTE:

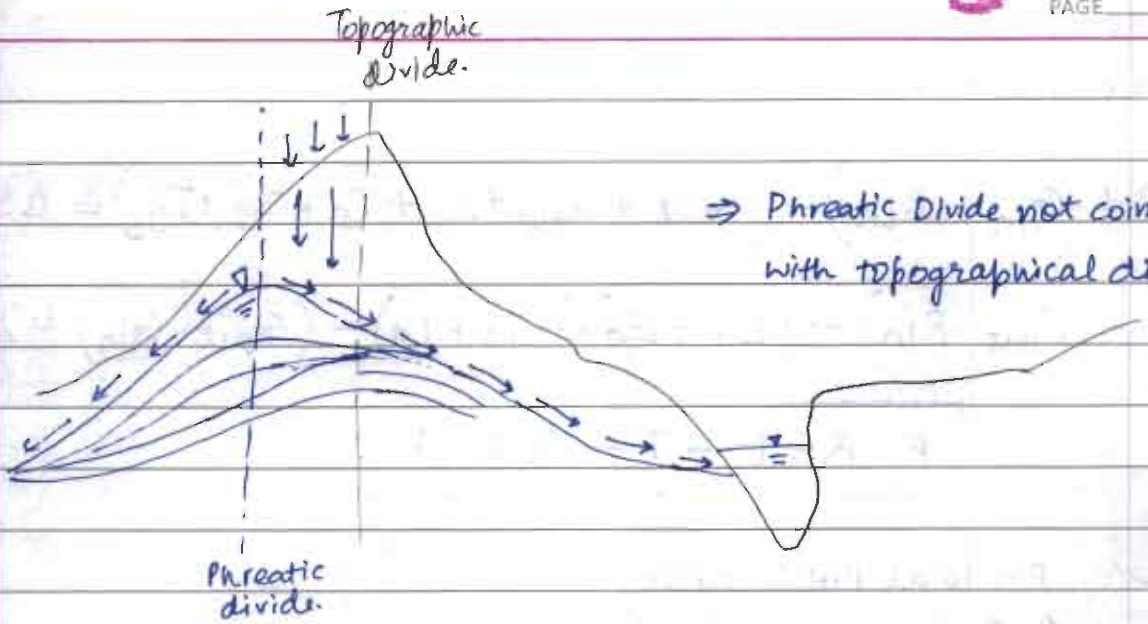
If all water converges to a single point inside the basin it is known as closed catchment



⇒ Catchment Leakage

→ When the runoff at the outlet of one catchment contains contribution from precipitation falling on adjacent catchment through sub-surface run off, catchment leakage is said to occur.





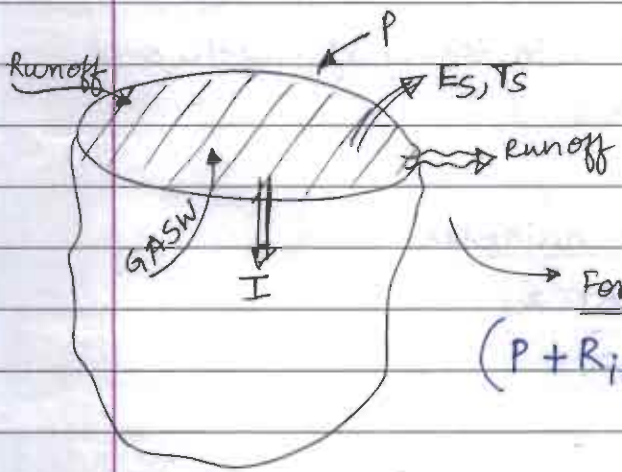
⇒ Phreatic Divide not coinciding with topographical divide.

⇒ Water budget / hydrological budget

→ It is based on law of conservation of mass.

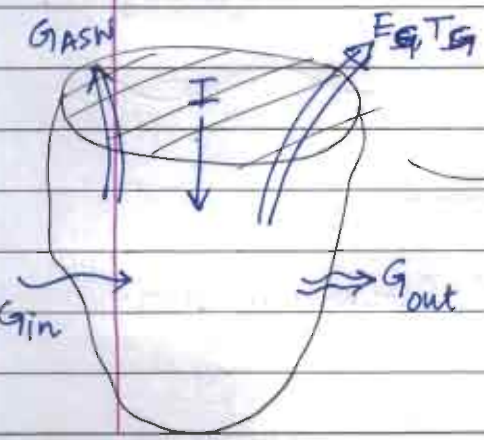
→ It states that:

Mass inflow - Mass outflow = change in storage $(S_f - S_i)$ (ΔS)



→ For surface Runoff,

$$(P + R_{in} + G_{ASW}) - (I + E_S + T_S + R_{out}) = \Delta S_{surface}$$



→ For ground water flow

$$(I + G_{in}) - (G_{ASW} + G_{out} + E_G + T_G) = \Delta S_{ground}$$

DATE
PAGE

⇒ Adding both terms, we have,

$$(P + G_{in} + R_{in}) - (R_{out} + G_{out} + E_s + T_s + E_g + T_g) = \Delta S_{Total}$$

$$P - (R_{out} - R_{in}) - (E_s + E_g) - (T_s + T_g) - (G_{out} - G_{in}) = \Delta S$$

$$\boxed{P - R - E - T - G = S}$$

where, P → total Precipitation
R → Net Runoff (out)
E → Total evaporation
T → Total Transpiration
G → Net Groundwater outflow
S → Change in Storage (Final - Initial)

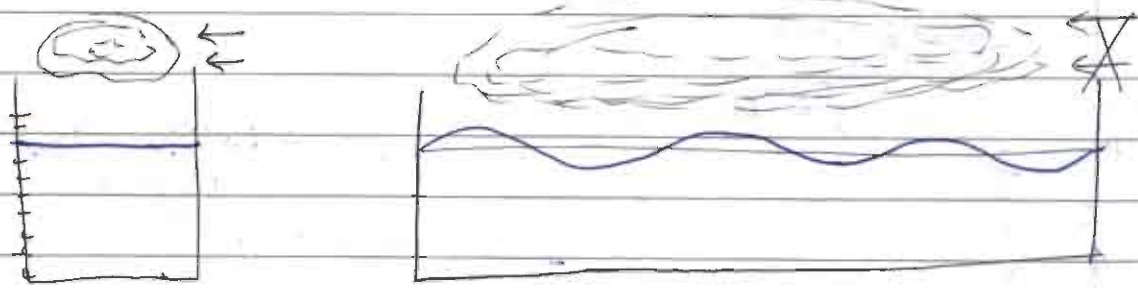
Important Points

1) Precipitation as Rainfall is expressed in terms of depth over the horizontal projection of the area.

$$\text{Depth of Rainfall} = \frac{\text{Volume of Rainfall}}{\text{Projected Area}}$$

(Same goes for evaporation also)

2)



$$\text{Lake Evaporation} = (\text{Pan coeff}) \times \text{Pan evaporation}$$
$$(<1)$$

→ (depth of evaporation per unit time)

Q- A lake has water surface elevation of 103.2 m above datum. In a month the lake receives an ~~annual~~ average inflow of 6 cumec and in the same period, the outflow from the lake was 6.5 cumec. In the same month, the lake receives a rainfall of 145 mm. and the evaporation from lake surface ~~fe~~ was 6.1 cm. The surface area of the lake is 5000 ha. Calculate the surface elevation of lake at the end of this month.

$$103.2 + \left[\frac{-0.5 \times 86400 \times 30 + 0.145 \times 5000 \times 10^4 - 0.061 \times 5000 \times 10^4}{5000 \times 10^4} \right]$$

$$103.2 + \left[\frac{-0.5 \times 86400 \times 30}{5000 \times 10^4} + (0.145 - 0.061) \right] = 103.258 \text{ m}$$

Q- Following observations were made while conducting a water budget for a reservoir for a period of 1 month.

→ Average S.A. = $10 km^2$

→ Mean Surface Inflow rate = 10 cumec.

→ Mean " Outflow rate = 15 cumec.

→ Rainfall = 10 cm

→ Fall in Reservoir level = 1.5 m

→ Pan evaporation = 20 cm

⇒ Assuming pan coeff. as 0.7, Estimate the average seepage discharge from the reservoir during this month.

$$1.5 = \frac{(5 + Q) \times 86400 \times 30}{10 \times 10^6} + \frac{0.7 \times 20 - 10}{100}$$

$$\boxed{Q = 0.6327 \text{ cumec}}$$

DATE
PAGE

2. Precipitation

⇒ Forms of precipitation

1) Rain
- Principal mode of ppt. in India (approx. 120cm annualy)
- Denotes water droplets, size ranges from 0.5 to 6.0mm
- On the basis of intensity it is classified as:
  (a) light (0-2.5 mm/hr)
  (b) medium (2.5-7.5mm/hr)
  (c) heavy (>7.5mm/hr)

2) Snow - They are flaky ice crystals having a density of 0.1g/cc

3) Drizzle - Are water droplets less than 0.5 mm with intensity less than 1 mm/hr.

4) Sleet - Frozen rain drops

5) Hail - It consists of large spheres of ice having diameter 5mm to 50 mm.

6) Glaze - When water droplet comes in contact with cold surface it freezes to form an ice coating known as glaze.

⇒ Intensity of rainfall: If x depth of rain falls over a catchment area in time, t, then the average intensity of rainfall, i is given by:

$$i = \frac{x}{t}$$

It is generally expressed in mm/hr or cm/hr.

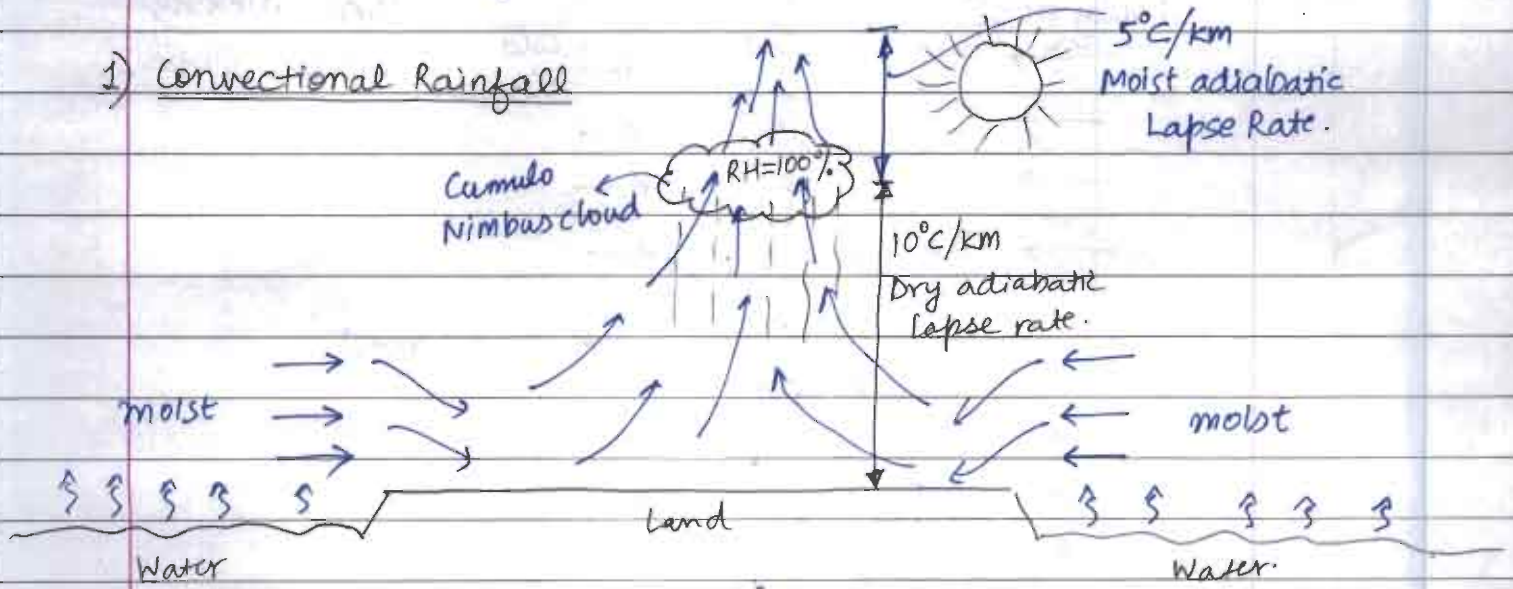
Q- The intensity of rainfall and time interval of a typical storm is given below. The maximum intensity of rainfall for a 20 minute duration of rainfall in mm/min is ?

time interval (min)	intensity (mm/min)		
0-10	0.7		
10-20	1.1		
20-30	2.2	→ 22 mm	⇒ 37mm in 20min
30-40	1.5	→ 15 mm	
40-50	1.2		⇒ $\frac{37}{20}$ = 1.85 mm/min.
50-60	1.3		
60-70	0.9		
70-80	0.4		

⇒ Types of Rainfall

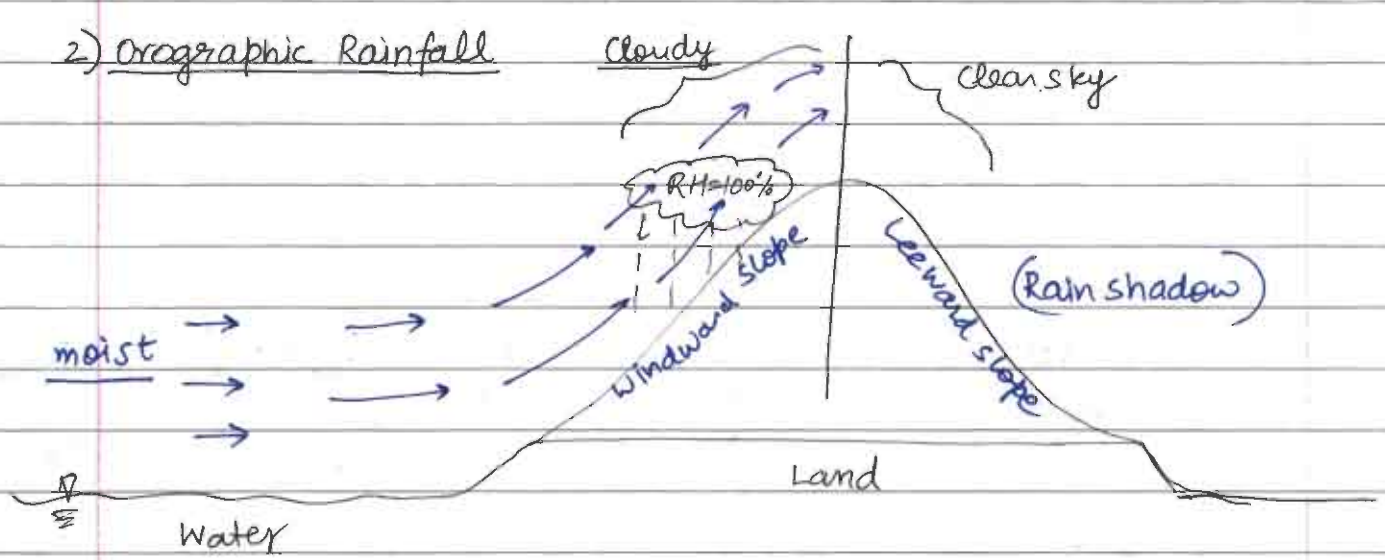
→ Precipitation as Rainfall is classified on the basis of conditions and mechanism of upward movement of moist air.

1) Convectional Rainfall



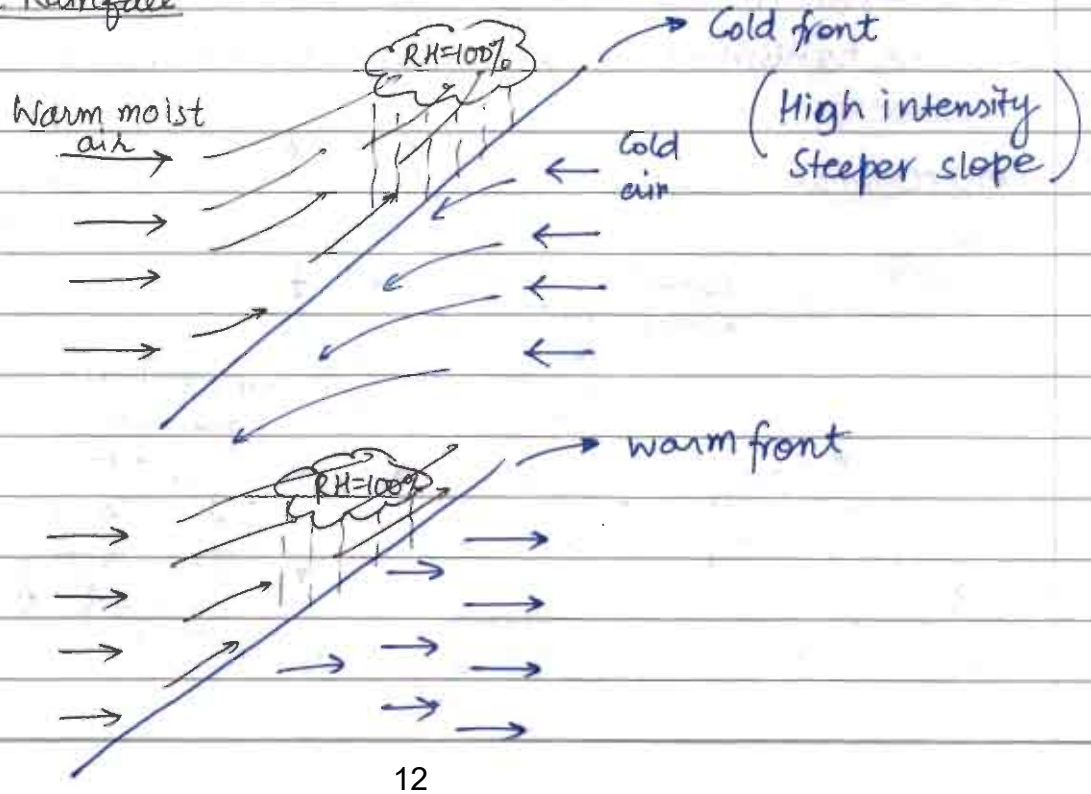
→ It occurs due to thermal convection current formed by heating of ground surface.
→ Moist adiabatic lapse rate is less than dry adiabatic lapse rate due to release of latent heat of vapourization

2) Orographic Rainfall



→ This ppt. is caused by ascent of air from large water bodies forced by mountain barriers.
→ Most of world's pptation including India's occurs through orographic rainfall.

3) Frontal Rainfall



→ This pptation occurs due to conflict between 2 air masses of different temperatures and densities

4) Cyclonic Rainfall

→ This pptation is the result of lifting of air masses due to pressure differences. If low pressure occurs in an area, air will flow in horizontally from all directions causing the air in the low pressure area to lift, resulting in condensation followed by pptation.
→ The air that rushes horizontally changes into a whirling mass due to the rotation of the earth (coriolis effect) and is called cyclone.

Cyclone	Anticyclone
→ Low pressure at the centre	→ High pressure at the centre
→ Counter-cw in Northern hemisphere and cw in Southern hemisphere	→ cw in northern hemisphere and a.c.w in southern hemisphere.
→ Indicator of Rain.	→ Indicator of good weather
→ EX- Hurricane, Typhoon	

⇒ Measurement of Precipitation

→ Precipitation as Rainfall is measured by a device known as rain gauge
→ It is also known as Ombrometer, Pluviometer or hydrometer.

→ Types of Rain gauges

1) Non-Recording Type
→ They do not give a continuous plot (variation) of rainfall against time.
→ Non Recording gauge widely used in India, is Symon's Rain gauge