Al-Mansour University College

قسم الهندسة المدنية

Civil Eng. Dept.

المرحلة الثالثة

3rd. Stage

HYDROLOGY

2022 – 2023

Lec.1

هيدرولوجي

Dr. Basher Faisal
Lec. Azad hameed

Hydrology

Syllabus (Course Outline)

3 hour per week

1. Introduction
    1.1. Hydrological cycle.
    1.2. Hydrology in engineering.
2. Weather and hydrology.
3. Precipitation.
    3.1. Formation of type of precipitation.
    3.2. Measurement of precipitation.
    3.3. Estimating missing precipitation data.
    3.4. Average precipitation over area.
    3.5. Variations in precipitation.
    3.6. Measurements of snow.
4. Stream flow
    4.1. Water stage.
    4.2. Discharge.
    4.3. Stage-discharge relation.
5. Evaporation
    5.1. Evaporation from water surface.
    5.2. Reservoir evaporation.
    5.3. Water budget method.
    5.4. Energy budged method.
    5.5. Penman's equation.
6. Wells.
    6.1. Well with aquifers.
    6.2. Well with uniform recharge.
    6.3. Super position (no equilibrium hydraulic of wells)
    6.4. Multiple wells.
7. Stream flow hydrograph.
    7.1. Components of runoff.
    7.2. Stream recession.
    7.3. Hydrograph separation.
    7.4. Analysis of complex hydrographs.

    7.5. Rainfall runoff relations.
    7.6. Unit hydrographs.
    7.7. Derivation of hydrograph.
    7.8. S-curve method.
8. Flood waves
    8.1. Wave measurements
    8.2. Storage equation (water budget equation).
    8.3. Determination of storage.
    8.4. Reservoir routing.

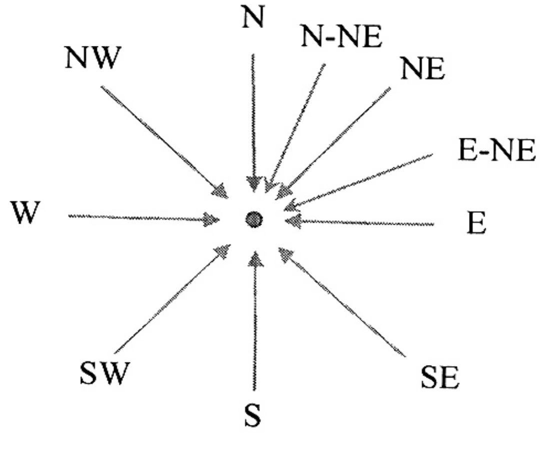
3.4. Hydrology in engineering.

Hydrology is used in engineering to:

- ✓ design and operate the hydraulic structures.
- ✓ expect the flood discharge over a spillway,
- ✓ design the city drainage system,
- ✓ expect the reservoir capacity to comfort adequate quantity of water for irrigation,
- ✓ find the effect of flood discharge or stream on the reservoirs, canals, and other control works, and
- ✓ select the practical boundaries for the flood plan.

2. Weather and hydrology.

Wind direction:



Wind Speed:

Wind speed is given in kilometer per hour, miles per hour, meter per seconds, or knots.

Km/hr = 0.621 mil/hr = 0.278 m/s = 0.540 kn

Kn = 1.852 km/hr = 1.151 mil/hr = 0.514 m/s

Precipitation: This word denots all forms of water that reach the earth from the atmosphere as Rain & Ice.

* Forms of Precipitation :-

1- Rains
 - light rain ; when (2.5 mm/hr)
 - Moderate rain ; when (2.5 – 7.5) mm/hr
 - Heavy rain ; when (> 7.5) mm/hr

Tensity

2- Snow

3- Drizzle

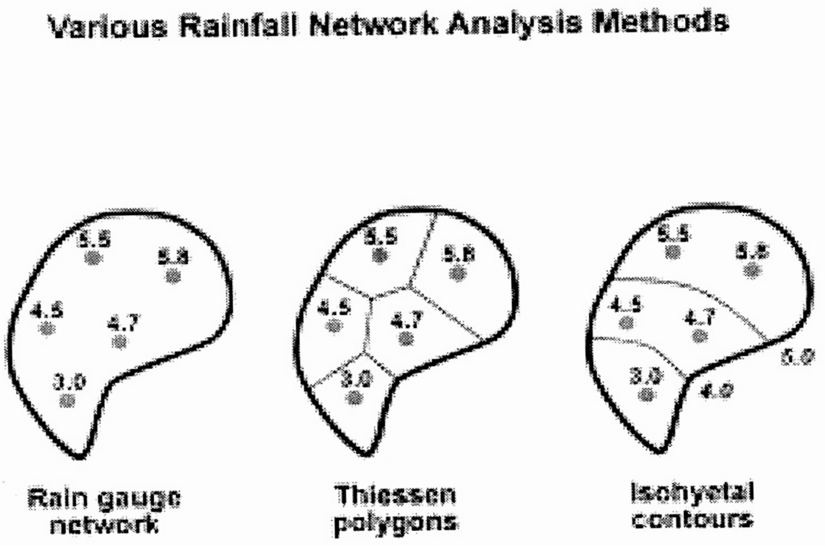
4- Glazes

5- Sleet

6- Hail

3.4. Average precipitation over area.

There are three ways to estimate the average precipitation over area can be explained below:



1) Arithmetic mean:

This method yields good estimates in flat country if the gage are uniformly distributed and the individual gage catches do not vary widely from the mean.

$$P_{av} = \frac{\sum_{i=1}^{n} P_i}{N}$$

2) Thiessen method:

The Thiessen method attempts to allow for non-uniform distribution of gages by providing a weighting factor for each gage.

The method can be described as:

Perpendicular bisectors of these connecting from polygons around each station. The sides of each polygon are the boundaries of the effective area assumed for the station. The area of each polygon is

* Precipitation :-

Terminal Velocity :-

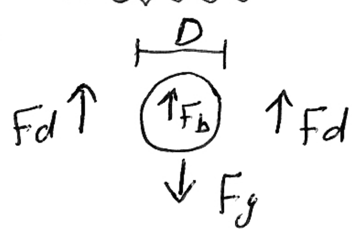
There are 3 forces acting in a falling rain drop;

1- Gravity force, F_g
2- Bouyancy force, F_b
3- Drag force, F_d, due to friction between drop and air.

The Volume of Sphere $= \frac{\pi D^3}{6}$

$$F_g = \rho_w \cdot g \, \frac{\pi D^3}{6} \quad ; \quad F_b = \rho_a \cdot g \, \frac{\pi D^3}{6} \quad ; \quad F_d = C_d \, \rho_a \, A \, \frac{V^2}{2}$$

where :-



$C_D = C_d =$ drag Coeff.

$V =$ Falling velocity

$A =$ Cross section area $= \frac{\pi D^2}{4}$

-If the drop is released from rest it will accelerate until it reaches its terminal velocity (V_t), at which the three forces are balanced.

$$F_d = F_g - F_b$$

let $V = V_t$

$$C_d \, \rho_a \, \frac{\pi D^2}{4} \, \frac{V_t^2}{2} = \rho_w \, g \, \frac{\pi D^3}{6}$$

$$V_t = \sqrt{\frac{8\left(\rho_w \frac{\pi D^3}{6} - \rho_a \frac{\pi D^3}{6}\right)}{C_d \, \rho_a \, \pi D^2}} = \sqrt{\frac{4 g D}{3 C_d}\left(\frac{\rho_w}{\rho_a} - 1\right)}$$

Drag Coefficient for Spherical rain drop at standard atmospheric Pressure (101.3 kPa) and air temp. (20 °C).

Drop Diameter	Drag Coeff.
0.2	1.2
0.4	1.66
0.6	1.07
0.8	0.515
1	0.671
2	0.517
3	0.503
4	0.559
5	0.66

Example:- Calculate the terminal Velocity for (1 mm) diameter rain drop falling in still air at standard atmosphere (101.3 kPa) and air Temp. (20) °C.

sol.

$C_d = 0.671$ from table.

$\left(\rho_w = 998 \frac{kg}{m^3}\right)$ & $\left(\rho_a = 1.2 \frac{kg}{m^3}\right)$ at 20 °C

$$V_t = \sqrt{\frac{4gD}{3C_d}\left(\frac{\rho_w}{\rho_a} - 1\right)}$$

$$V_t = \sqrt{\frac{4 * 9.81 * 0.001}{3 * 0.671}\left(\frac{998}{1.2} - 1\right)}$$

$V_t = 4.02$ m/sec.

3.3. Estimating the missing precipitation data.

Many precipitation station have short disruptions in their records because of absences of the observer or because of instrumental failure.

A. Simple arithmetic: -

In this method the amounts at the index station are equal weighted with all other stations. This method used when the normal annual precipitation at any index station differs from that at the station in question by less than 10 percent.

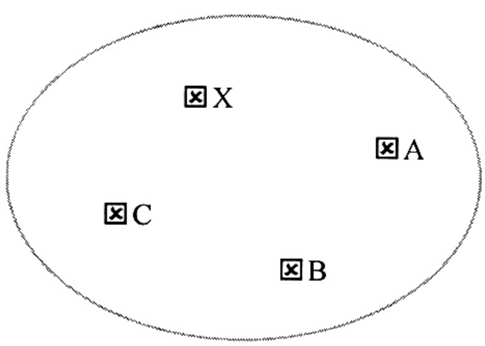
$$P_x = \frac{1}{N} * (P_A + P_B + P_C)$$

where:

P_x= precipitation of station x,

N= number of stations, and

P_A, P_B, P_C= precipitations of stations A, B, and C



B. Normal-ratio method: -

In this method the amounts at the index station are weighted by the ratio of the normal-annual-precipitation values. This method used when the normal annual precipitation at any index station differs from that at the station in question by more than 10 percent.

$$P_x = \frac{1}{N}\left[\frac{N_x}{N_A} P_A + \frac{N_x}{N_B} P_B + \frac{N_x}{N_C} P_C\right]$$

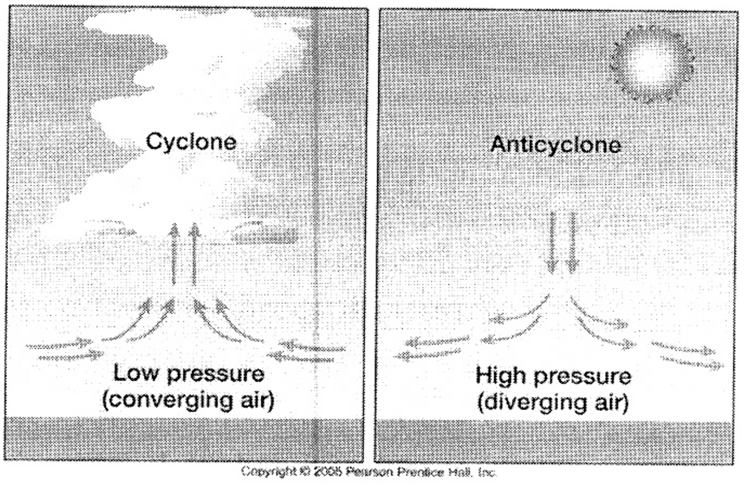
$$= \frac{N_x}{n}\left[\frac{P_A}{N_A} + \frac{P_B}{N_B} + \cdots + \frac{P_n}{N_n}\right]$$

3. Precipitation:

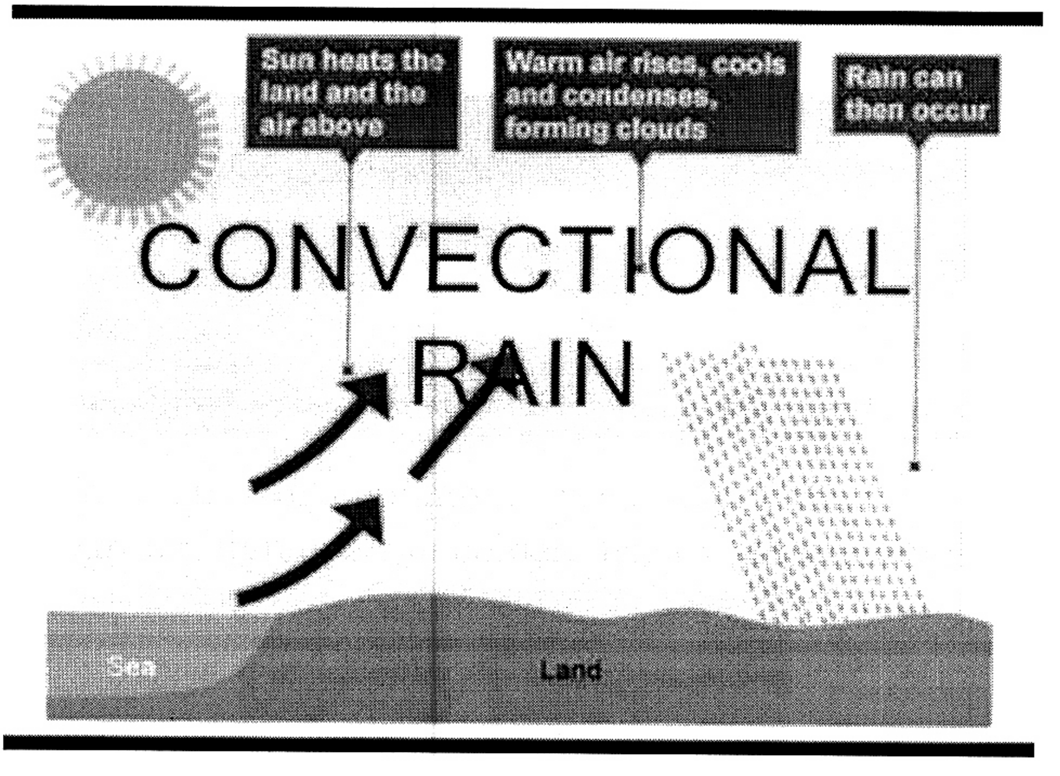
3.1. Formation of type of precipitation.

Precipitation is often typed according to the factor mainly responsible for the lifting which causes it. The types of precipitation can be classified as:

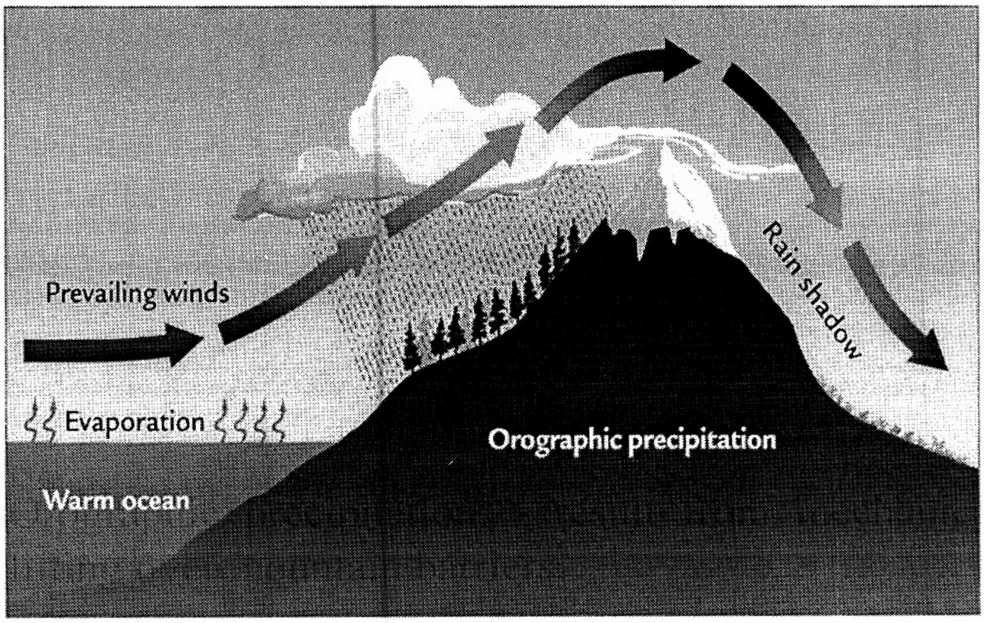
1) Cyclonic precipitation: - resulting from the lifting of air converging into low-pressure area or cyclone.



2) Convective precipitation: - is caused by the raising of warmer, lighter air in colder, density surroundings.



3) Orographic precipitation: - result from mechanical lifting over mountain barriers.



3.2. Measurement of precipitation:

Rain gages: -

A. The standard 8" gage: -

Rain pass from the collector into a cylindrical measuring tube inside the overflow can. The measuring tube has a cross-sectional area one-tenth that collector that of collector so that 0.1-in rainfall will fill the tube to a depth of 1-in.

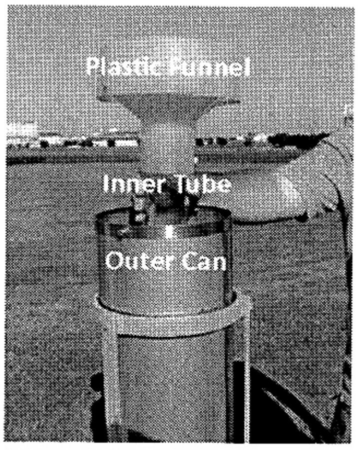
$$V = A * H$$

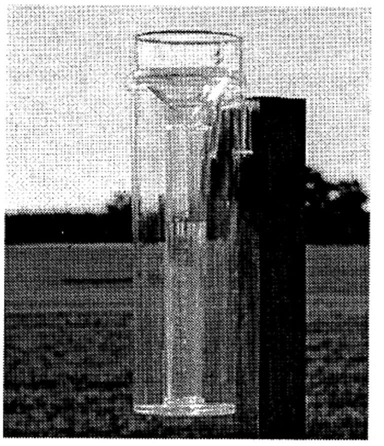
$$= \frac{\pi}{4} D^2 * 1 \ldots\ldots\ldots\ldots\ldots \textit{for the collector}$$

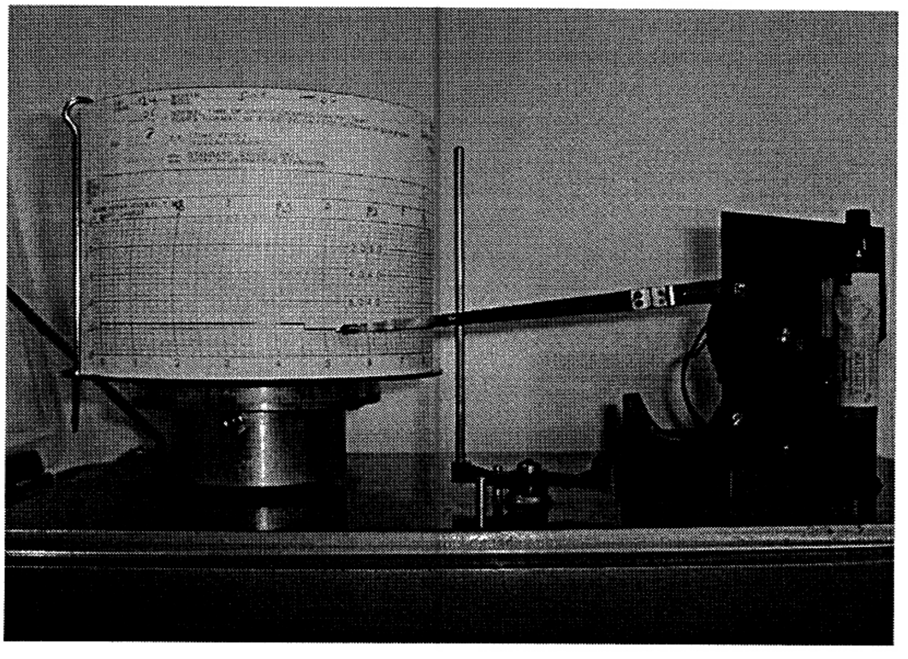
$$= \frac{\pi}{4} d^2 * 10 \ldots\ldots \textit{for the measuring tube}$$

To find the diameter of measuring tube this form can be used..

$$d = \frac{D^2}{10}$$

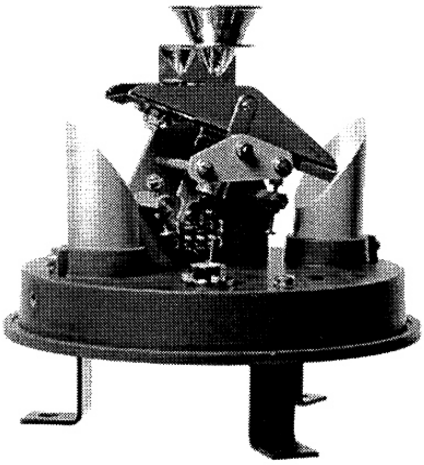


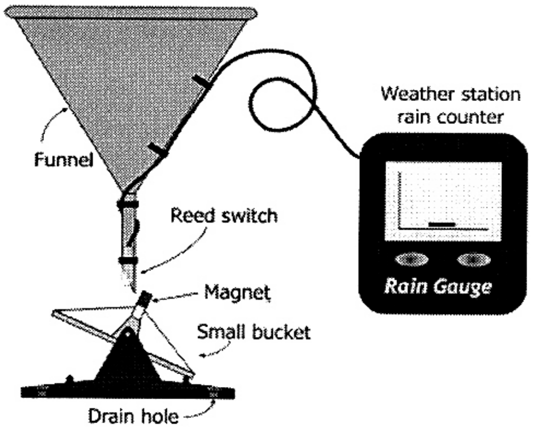




B. Tipping-bucket Rain gages:

In the tipping-bucket gage water caught in the collector and guided into a two-compartment bucket 0.1 mm or some other designed quantity of rain will fill one compartment (partition) and overbalance the bucket so that it tips, emptying into a reservoir and moving the second compartment into place below the funnel. As bucket is tipped, it actuates an electric circuit.

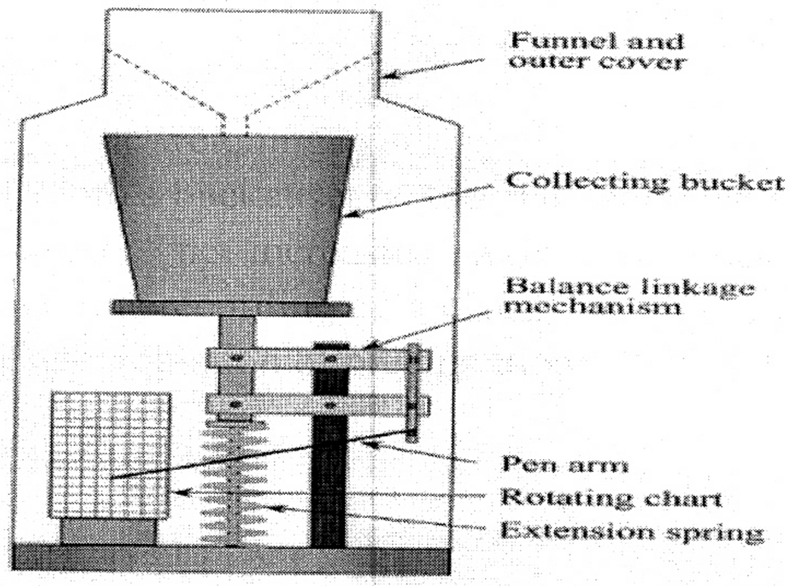




C. The weighing-type gage: -

The weighing-type gage is weighs the rain which falls into a bucket set on the platform of spring or level balance. The increasing weight of bucket and its content is recording on a chart. The record thus shows the accumulation of precipitation.

WEIGHING BUCKET TYPE



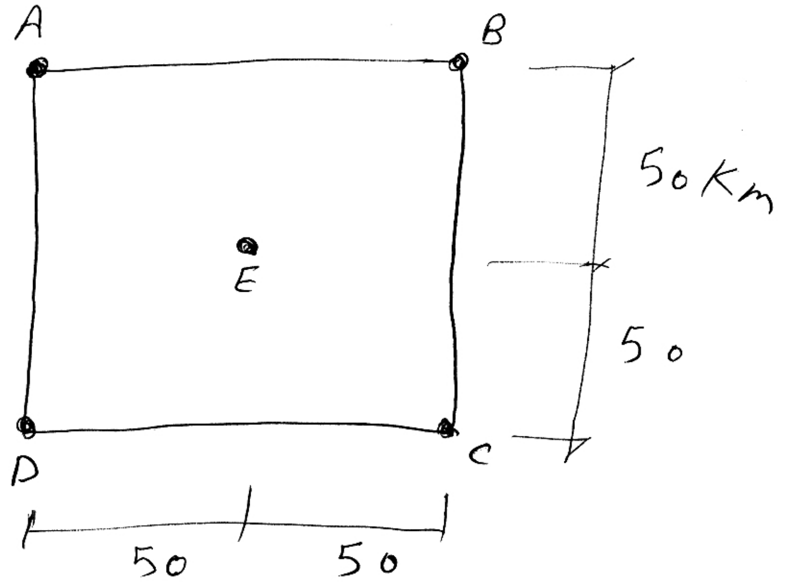
Example: find precipitation of station D using data in Table (3-1).

Station name	Precipitation (cm)	Annual precipitation (cm)
A	4.2	44.1
B	3.5	36.8
C	4.8	47.2
D	?	38.5

Solution:

EX 3 Compute the average PPt. over an area shown below. use 2 methods

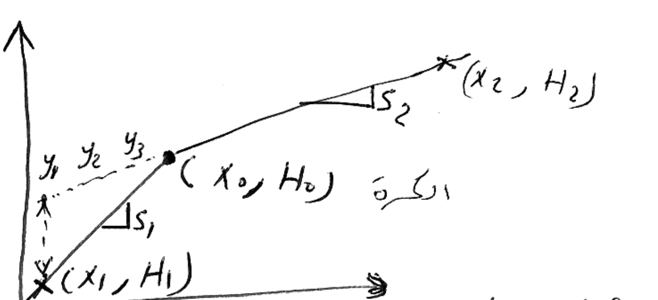
Station	Rainfall (mm)
A	15
B	22
C	25
D	30
E	20



Test of Consistency of Records [Double Mass Curve]

The trend of the rainfall records at station (X) may be changed after some years due to:-

1) Change in Environment
2) Change in building, plant, ----
3) A break in the slope of the resulting plot points to the inconsistency of the data indicating a change in (ppt) regime of station (X).



$$S_1 = \frac{H_0 - H_1}{X_0 - X_1}$$

$$S_2 = \frac{H_2 - H_0}{X_2 - X_0}$$

but $S_2 = \dfrac{H_0 - y_1}{X_0 - X_1}$ (عند التمديد)

$$\frac{S_1}{S_2} = \frac{(H_0 - H_1)/(X_0 - X_1)}{(H_0 - y_1)/(X_0 - X_1)} = \frac{H_0 - H_1}{H_0 - y_1}$$

$$H_0 - y_1 = \frac{S_2}{S_1}(H_0 - H_1)$$

$$y_1 = H_0 - \frac{S_2}{S_1}(H_0 - H_1)$$

$$\therefore \; y_c = H_0 - \frac{S_2}{S_1}(H_0 - H_c)$$

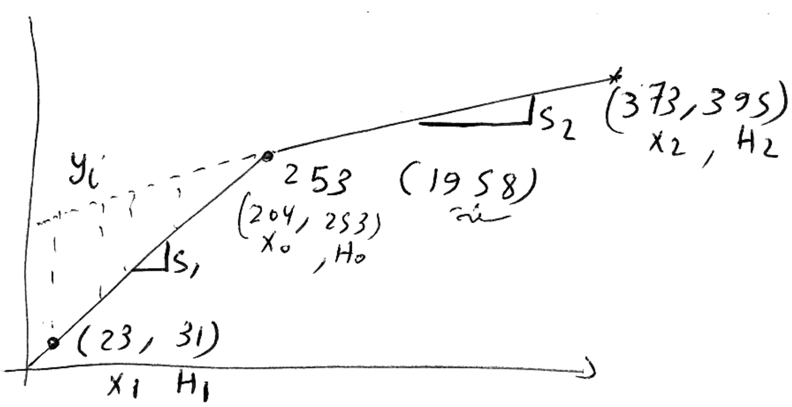
EX) The annual rainfall at station (X) and the average of 18 stations surrounding are given in the table below. Check the consistency of the records at station (X) and show the year in which the change in regime occur.

Sol.

Year	annual rainfall (X) station	annual rainfall 18st	accumulative Statio (X) (محور y)	accumulative (X محور) (18)st	Y
1952	31	23	31	23	$y_1 = 101$
1953	38	35	69	58	127
54	44	30	113	88	157
55	32	27	145	115	179
56	27	25	172	140	198
57	32	28	204	168	219
58	49	36	253 = H_0	204	253
59	28	28	281	232	281
60	25	25	306	257	306
61	22	24	328	281	328
62	28	33	356	314	356
63	17	23	373	337	373
1964	22	36	395	373	395

(Y values 101–219: جديدة; Y values 253–395: نفسها)

تراكمي للعمود ② (H) — تراكمي للعمود ③ (X)



$$S_1 = \frac{H_0 - H_1}{X_0 - X_1} = \frac{253 - 31}{204 - 23} = 1.23$$

$$S_2 = \frac{H_2 - H_0}{X_2 - X_0} = \frac{395 - 253}{373 - 204} = 0.84$$

$$y_1 = H_0 - \frac{S_2}{S_1}(H_0 - H_1) = 253 - \frac{0.84}{1.23}(253 - 31) = 101$$

$$y_2 = 253 - \frac{0.84}{1.23}(253 - 69) = 127$$

$y_3 = 157$

$y_4 = 179$

$y_5 = 198$

$y_6 = 219$

determined by *geometrical method*; where the area can be classified as a geometrical shapes; or by using *Planimetry*. Weighted average rainfall for the total area is computed by multiplying the precipitation at each station by its assigned percentage of area and totaling.

Example: By using Thiessen method find the average precipitation of gages located as shown in figures below where.

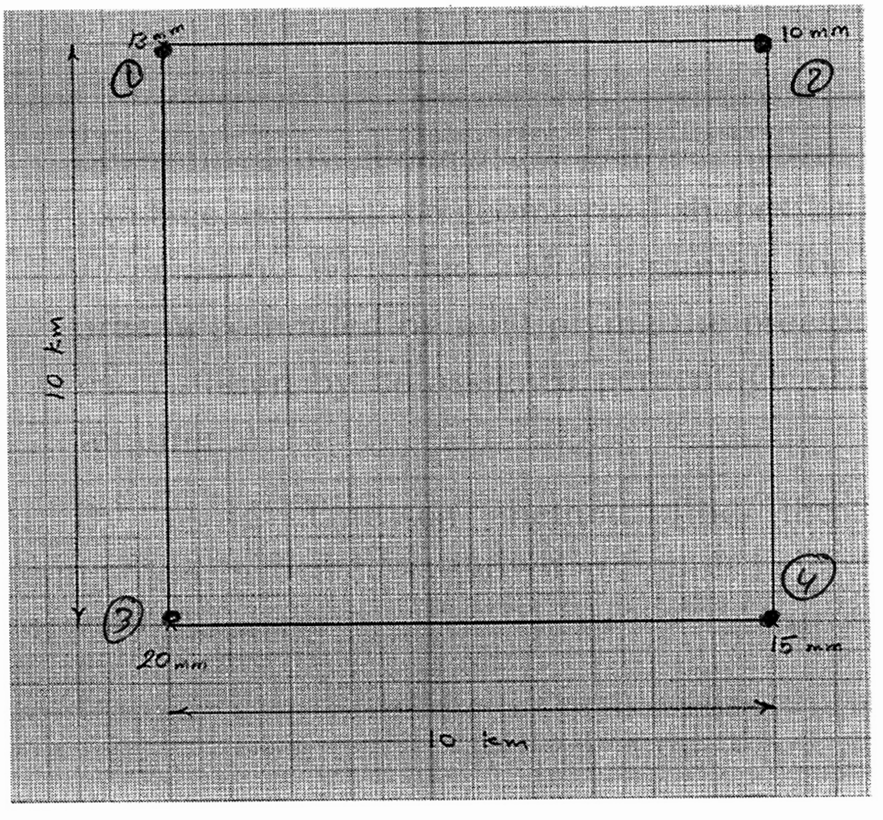


Fig. (3-A)

$$P_{avg} = P_1 \frac{A_1}{A_T} + P_2 \frac{A_2}{A_T} + \cdots + P_n \frac{A_n}{A_T}$$

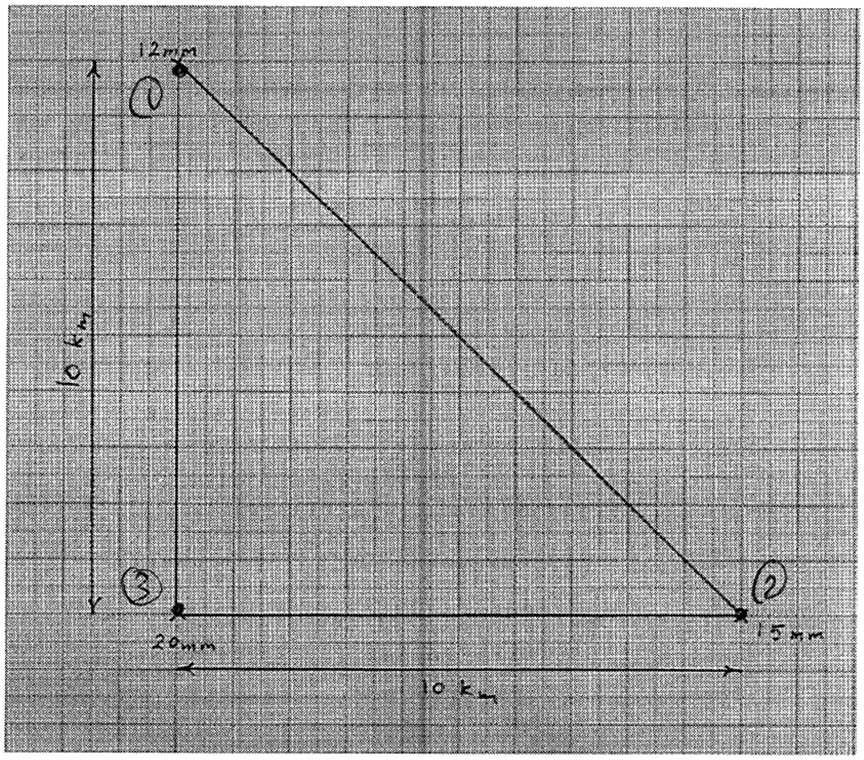
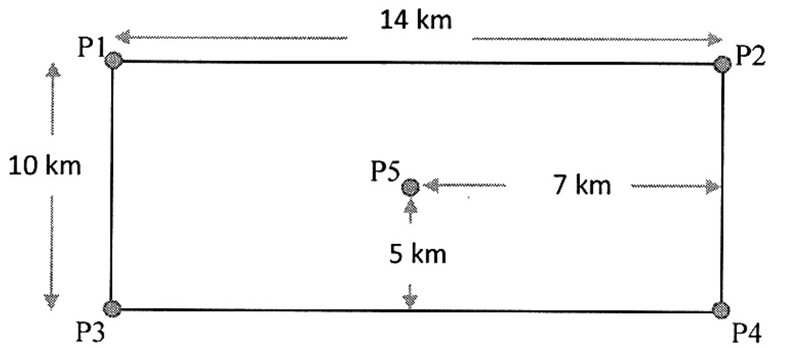


Fig. (3-B)

H.W1: Estimate the average precipitation over the sector area shown below using Thiesen polygon method.



3.5. Variation of precipitation:

3.5.1. Geographical variation:

In general precipitation is heaviest near the equator and decreases with increasing coordinate.

3.5.2. Time variation:

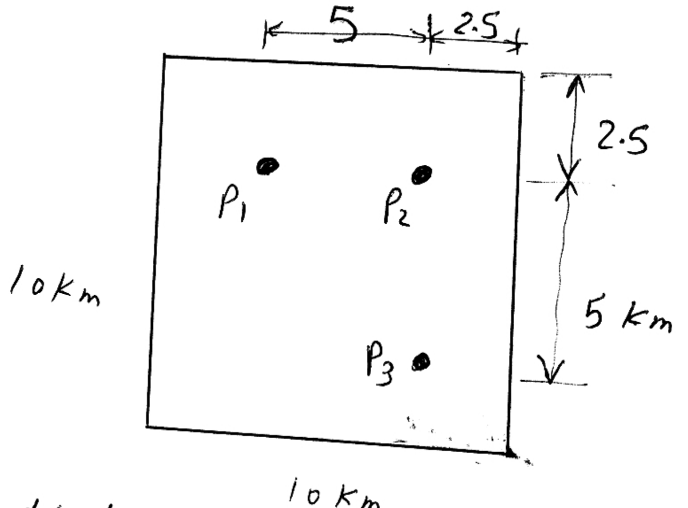
With the allowance of daytime and seasonal variation, no persistent steady cycles of any considerable magnitude have been conclusively demonstrated.

The time distribution of rain fall within storms is important for estimating flood hydrographs. Distribution vary with storm type, intensity, and duration; there is no typical distribution that is applicable to all situation.

* EXAMPLES

EX 1: A square area of $(100\ km^2)$ is gaged by three rainfall gages at (2.5 KM) from the sides as shown in the fig.. The data Recorded is ;-

Station:	1	2	3
Rainfall:	106 mm	15.2 cm	127 mm



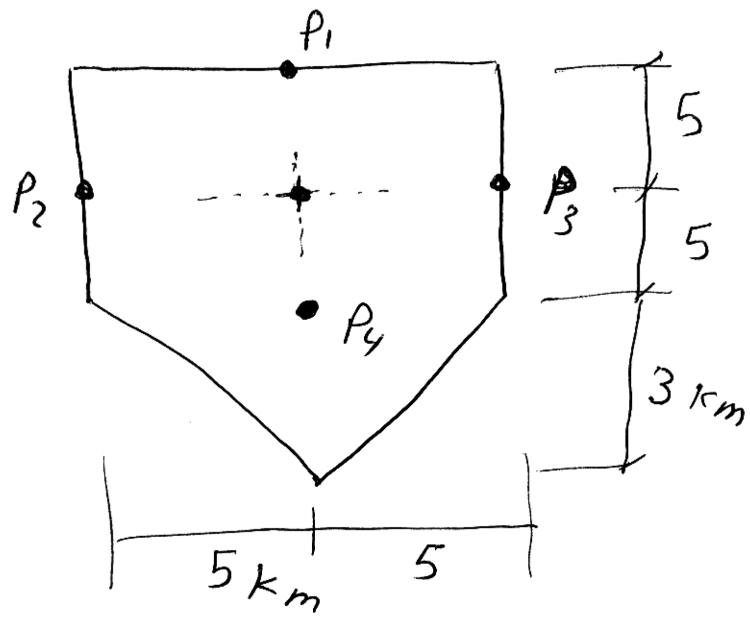
Use 2-methods to estimate average Pricipitation?

Sol.

Ex 2 Compute the average PPt. over an area shown below? 2 methods

Station	P_1	P_2	P_3	P_4
Rainfall	1.5 cm	22 mm	30 mm	2 cm

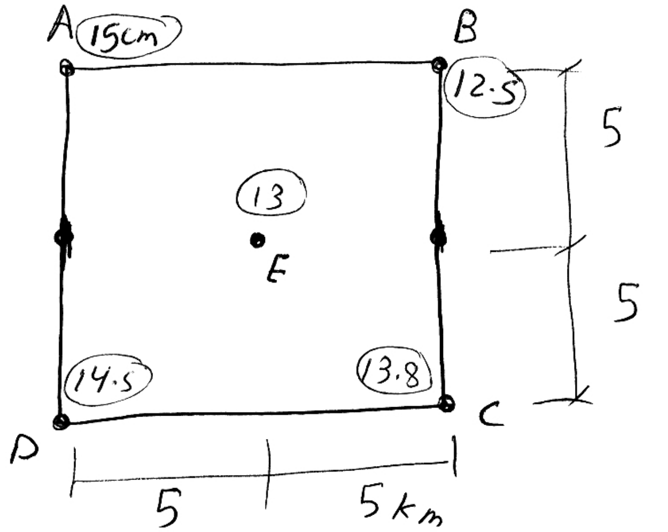
then calculate the Volume of Rain in m^3



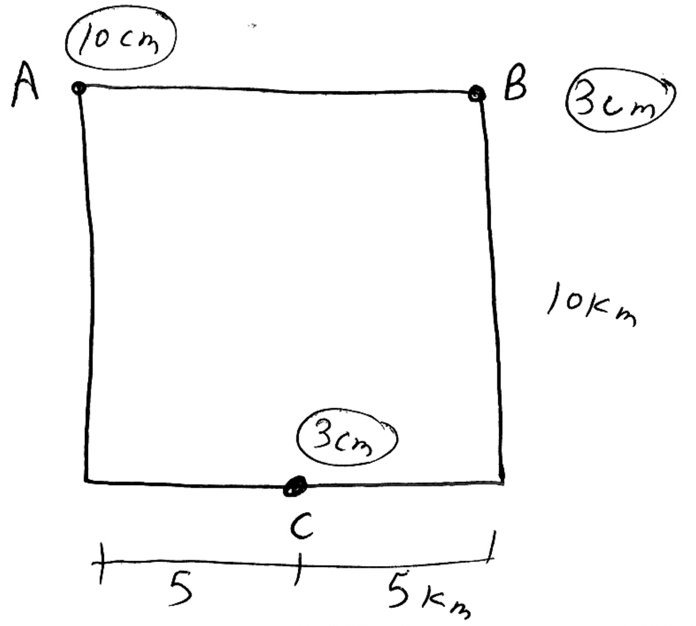
Home Work

Q : Compute the average ppt. over an area shown below, using 2 methods

A-

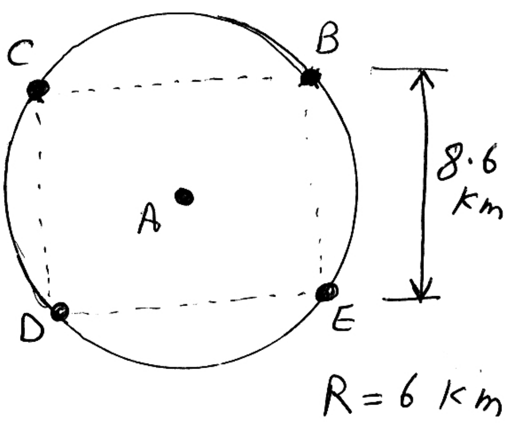


B-



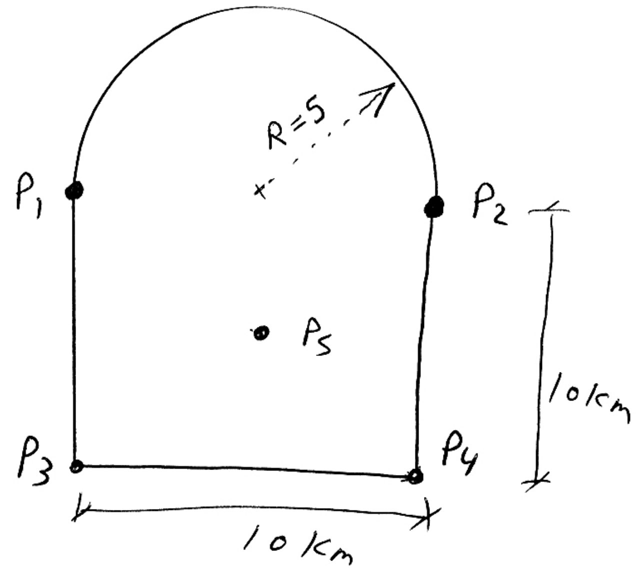
C-

station	A	B	C	D	E
rainfall (cm)	15	12.5	13.8	14.5	13



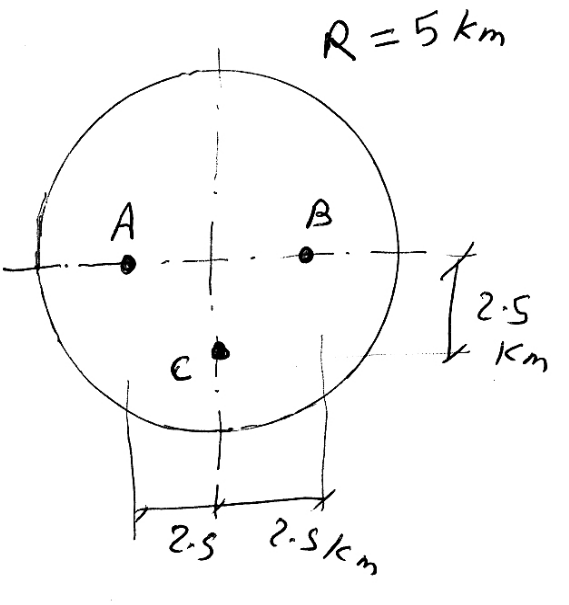
D-

station	P1	P2	P3	P4	P5
Rainfall cm	12	6	4	9	5.2



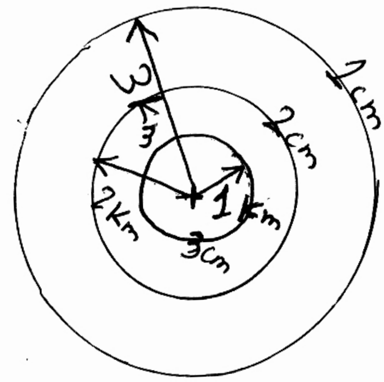
E-

st.	A	B	C
Rainfall	8cm	40mm	12cm



Home work

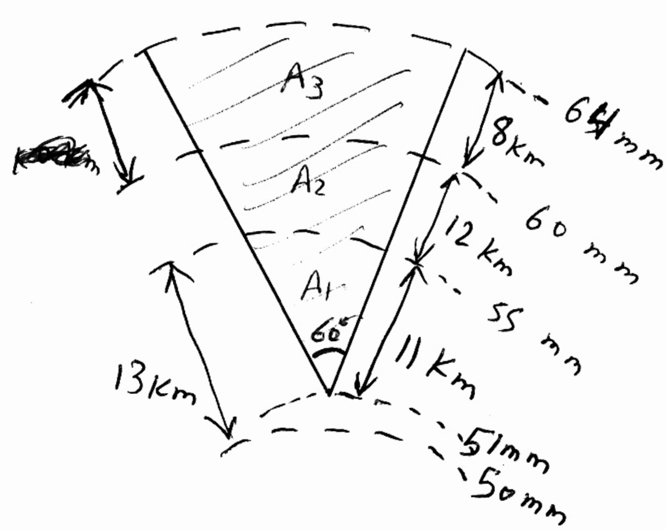
F) A circular area of Radius = 3 km;
Isohyets are also circular with centers coinciding with that of the total area, as shown below.
Estimate the mean ppt. of the area. (Use isohyetal m.)



G) The area show below of 60° sector of circular sec.

Determine :-

1. average amount of Rain over the basin?
2. Volume of Rain in cubic meters?



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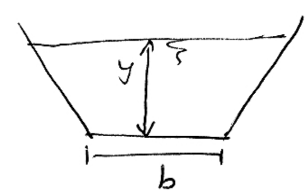
② Discharge measurement by moving boat method:

In this method the data are collected while the observer is on a boat which is rapidly traversing the cross-section which may called Dynamic approach while static approach the observer in a stationary position.

③ Discharge measurement by slope-area method:

Chezy eq. $Q = C\sqrt{RS}\, A$

$R = A/P$



Manning eq.

$$Q = \frac{1}{n} R^{2/3} S^{1/2} A$$

④ Dilution method:

⑤ Electromagnetic induction method:

⑥ Ultrasonic method

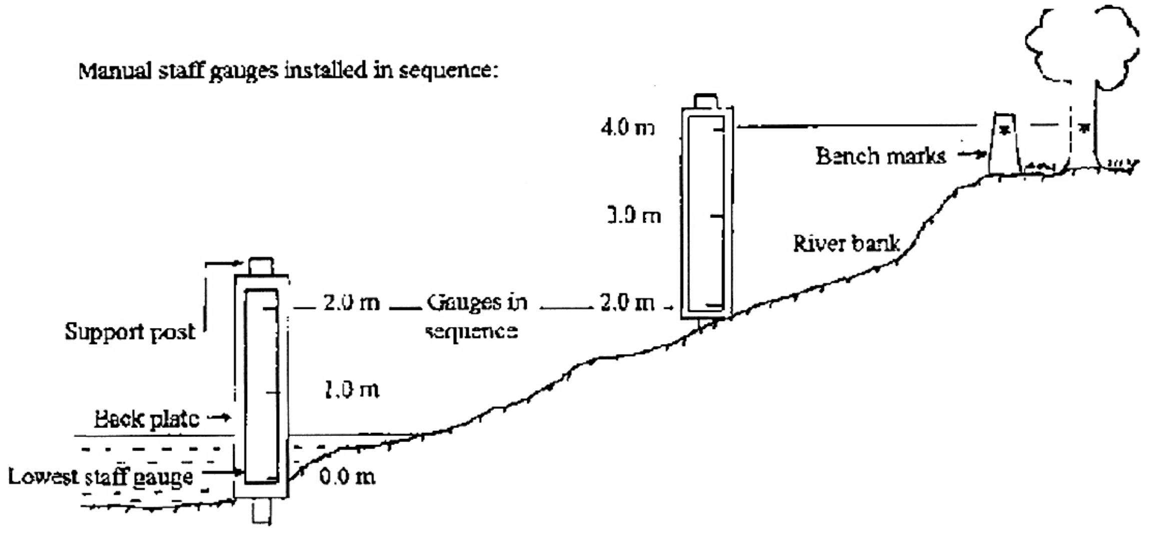
4. Stream flow

4.1. Water stage.

Evaluation of water (L)

1) Manual Gages.

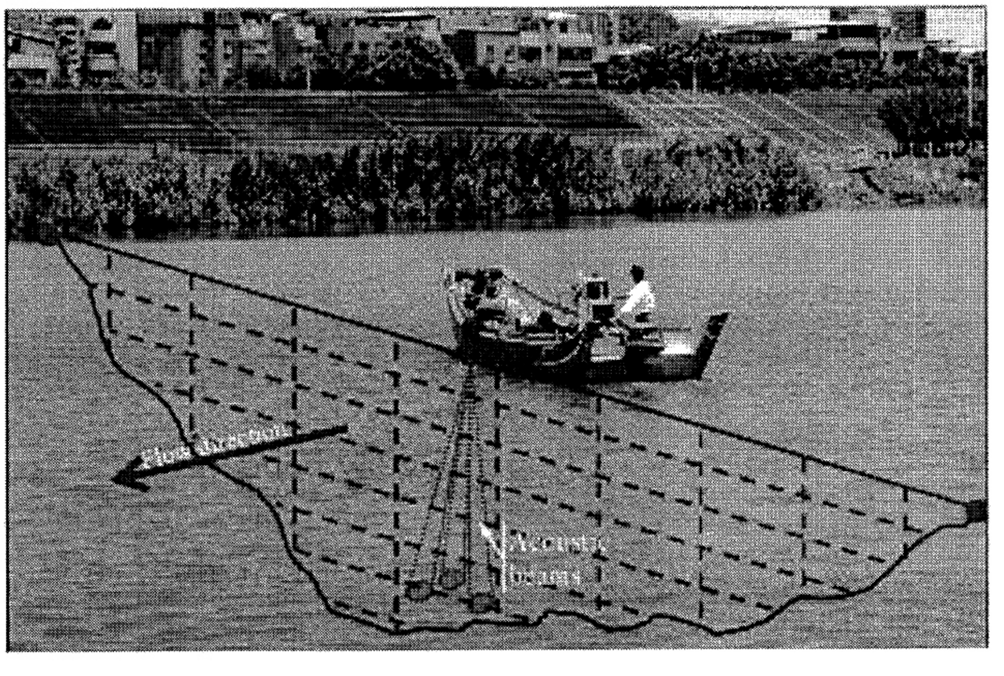
a) Simple stuff gages: it is a simplest method to measure the water stage.



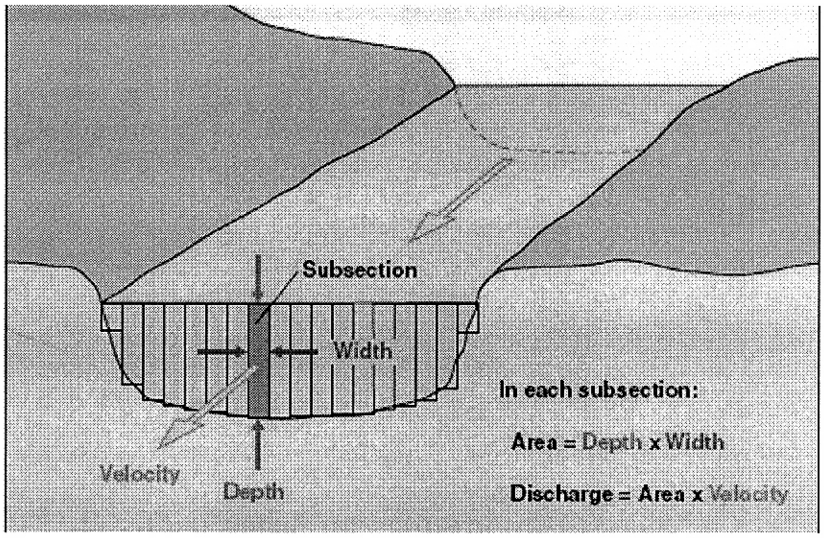
2) Suspended weight gages. المعلقة الموزونة

3) Recording gages.

4) Bathymetric method survey field.



4.2. Discharge measurement (Q):



① By area – Velocity method

$$Q = V * A$$

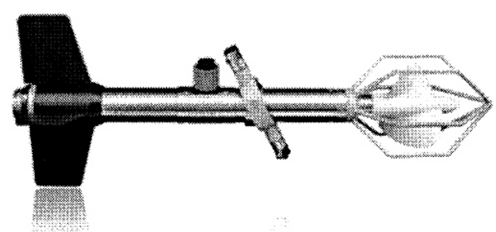
$$Q = \frac{Vo}{T}$$

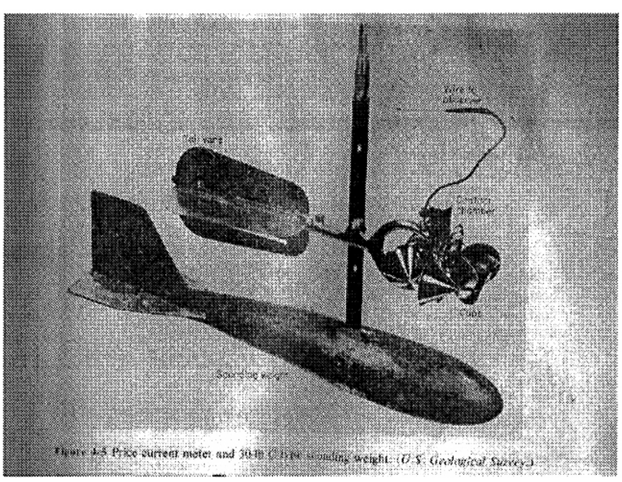
a) Current meters: جهاز قياس سرعة الجريان للماء

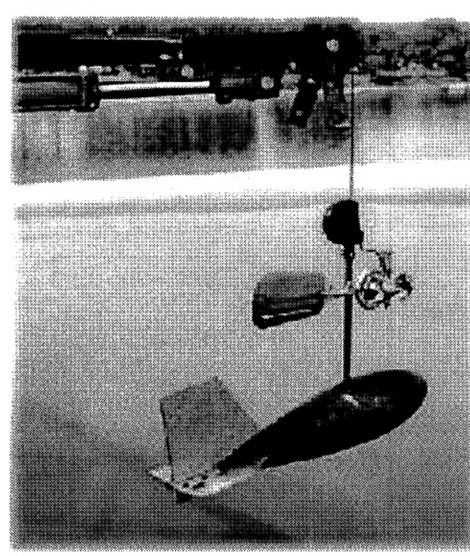
$V = a + bN$

a, b = constant

N = speed of the water in revolutions per second ($\frac{rev}{sec}$)







Cup & Propeller

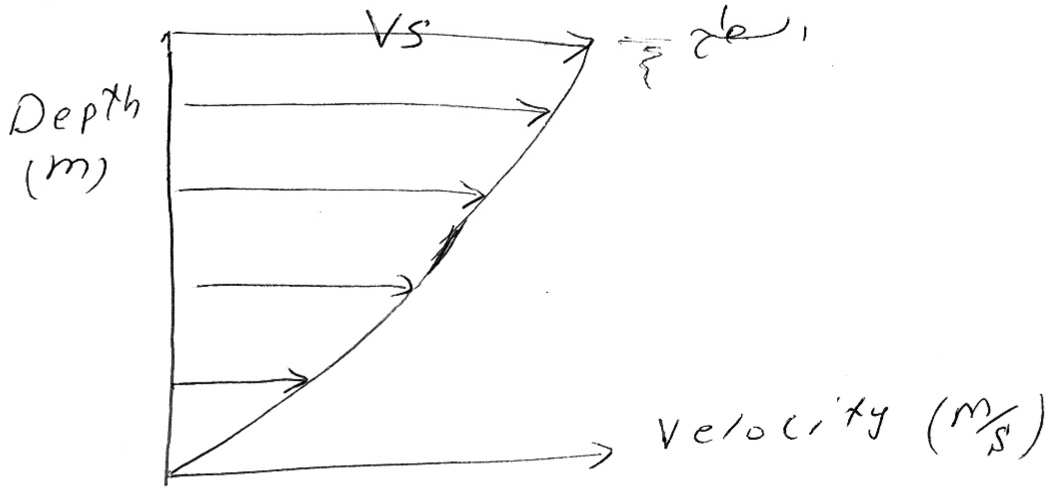
Current-Meter measurements:

A discharge measurements requires determination of sufficient point velocities to permit computation of an average velocity in the stream. Cross-sectional area multiplied by the average velocity gives the total discharge.

Practical method to find the discharge of rivers:

The practical procedure involves dividing the stream into a number of vertical section. No section should include more than about 10% of the total flow; thus 20 to 30 vertical sections are typical, depending on the width of stream.

Velocity distribution can be shown as below:



Velocity equations:

$$V_s = 1.2\, V_{av} = 0.9\, V_{max}$$

$$V_{av} = \frac{V_{0.2d} + V_{0.8d}}{2}$$

❖ At river approaches the average velocity can be calculated at 0.6 of the depth.

$$V_{av} = V_{0.6d}$$

❖ The total discharge can be calculated from the summation of discharges of the section $Q_{total} = \sum_{i=1}^{n} q_i$

$q_i = V_{av_i} * A_i$

Example: Compute the discharge in the stream from the following data, the current meter constant $a = 0.01$ and $b = 2.4$

distance from the bank (m)	Depth (m)	observation depth (%)	Revolution	Time (sec.)
1	0.95	0	0	0
4	1.2	0.6	5	40
7	2	0.6	7	43
10	2.1	0.2 0.8	15 10	50 50
13	2.3	0.2 0.8	10 15	52 40
15	2	0.2 0.8	10 15	55 54
16	1.5	0.6	15	40
17	0	0	0	0

Sol.

– Velocity calculation :-

$$V = a + b(N) = 0.01 + 2.4\,N$$

wher N = Revolution / time

$\therefore V_1 =$ ~~[illegible]~~ = بدون ماء = zero لا يوجد دوران

$V_2 = 0.01 + 2.4\left(\frac{5}{40}\right) = 0.31$ m/s

$V_3 = 0.01 + 2.4(7/43) = 0.4$ m/s

$V_4' = 0.01 + 2.4(15/50) = 0.73$
$V_4'' = 0.01 + 2.4(10/50) = 0.49$ } $V_4 = \frac{0.73 + 0.49}{2} = 0.61$ m/s

$V_5' = 0.01 + 2.4(10/52) = 0.47$
$V_5'' = 0.01 + 2.4(15/40) = 0.91$ } $V_5 = \frac{0.47 + 0.91}{2} = 0.69$

$V_6' = 0.44$
$V_6'' = 0.67$ } $V_6 = 0.555$ m/s ; $V_7 = 0.91$ m/s

وكذلك $V_8 =$ zero

$$Q_{total} = \sum_{i=1}^{n} q_i$$

$$Q_{total} = \sum_{i=1}^{n} V_{avi} * A_i$$

❖ The equation below can be used to calculate the velocity from a Current-Meter:

$$V = a + b * N$$

H. W.

Example: Compute the stream flow discharge from the measurement data below?

Distance from bank (m)	0	5	7	11	18
River Depth (m)	0	4	2	3	0
Average velocity (m/s)	0	1.5	0.5	1.0	0

2) Manning formula

$$V = \frac{1}{n} R^{2/3} S^{1/2} \quad ; \quad Q = V \cdot A$$

n = Manning roughness coeff.

R = hydraulic radius

S = longitudinal slope of canal

Type of surface	n
concrete	0.013
earth	0.022
Natural cannel with grass	0.03

Example: Calculate the Diameter of drain pipe needed to discharge maximum flow resulting from 40 mm/hr rain over an area of 2600 m². The slope of surface is 0.05, runoff Coeff. is 0.40 roughness of drain pipe is 0.13.

Sol. Manning eq $Q = \frac{1}{n} \cdot R^{2/3} \cdot S^{1/2} \cdot A$

Run off = runoff Coeff. * Rainfall

$= 0.40 * 40 = 16 \ mm/hr$

Volume of Runoff $= 16 * 10^{-3} * 2600 = 41.6 \ \frac{m^3}{hr}$

$$R = \frac{A}{P} = \frac{\frac{\pi}{4}(D^2)}{\pi D} = \frac{D}{4}$$

$$Q = \frac{1}{n} S^{1/2} A R^{2/3}$$

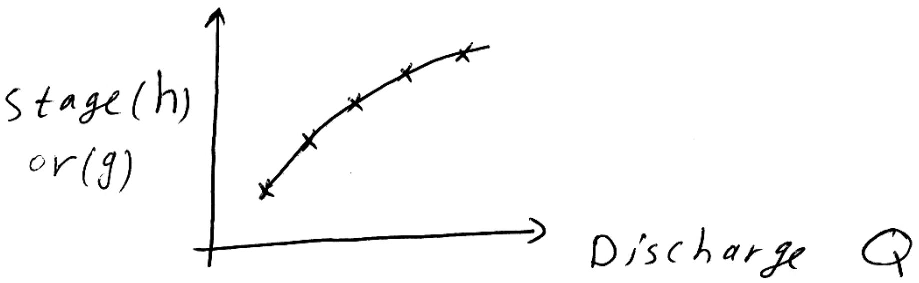
$$41.6 = \frac{1}{0.13} \left(\frac{D}{4}\right)^{2/3} (0.05)^{1/2} \frac{\pi}{4} D^2$$

$$41.6 = 0.536082 \ D^{8/3} \Rightarrow D^{8/3} = 77.6$$

$$D = (77.6)^{3/8} = 5 \ m$$

* Stage – discharge relation

Periodic meter measurments of flow and simultaneous stage observations provide data for calibration curve called a rating curve or Stage – discharge relation.



* stage - discharge measures 10 - 15 time every year to the river to get the relation stage and discharge of the river

$$Q = K(h-a)^b \quad \text{——} (1)$$

Q : Discharge of stream (m^3/s)

h : stage or Level (m)

a, b, K : Constants of Rating curve

- To find a put $\boxed{\dfrac{Q_1}{Q_2} = \dfrac{Q_2}{Q_3}}$ —— (2) تتعامد العلاقة الأخيرة (3)

sub (1) in (2)

$$\frac{K(h_1-a)^b}{K(h_2-a)^b} = \frac{K(h_2-a)^b}{K(h_3-a)^b}$$

$$(h_1-a)\cdot(h_3-a) = (h_2-a)\cdot(h_2-a)$$

$$h_1 h_3 - h_2^2 = h_1 a + h_3 a - 2h_2 a$$

$$\boxed{a = \frac{h_1 h_3 - h_2^2}{h_1 + h_3 - 2h_2}}$$

if $Q = 0$ @ $h = h'$ $\Rightarrow$ $h' = a$ *

- To find K and b

we need for regression convert eq. ① to eq. of (Line strait)

$$Q = K(h-a)^b$$

take Log for above eq.

$$\text{Log } Q = \text{Log } K + b \text{ Log}(h-a)$$

$Y = \text{Log } Q$; $A = \text{Log } K$; $X = \text{Log}(h-a)$

$$\boxed{Y = A + bX}$$

from regression

$$A = \frac{\sum Y \cdot \sum X^2 - \sum XY \cdot \sum X}{n \cdot \sum X^2 - (\sum X)^2}$$

$$b = \frac{n \cdot \sum XY - \sum Y \cdot \sum X}{n \cdot \sum X^2 - (\sum X)^2}$$

where n = No. of points

$A = \text{Log } K \Rightarrow \boxed{K = 10^A}$

Q	h	Y	X	X·Y	X^2
⋮	⋮	⋮	⋮	⋮	⋮
	Σ	—	—	—	—

in examples you find Q from h } not in table
or h from Q }

Example:- The following discharges & corresponding stage reading are obtained from measurments. Find the stage corresponding to the discharge of 500 m^3/s from the rlashion of the form;

$$Q = K\,(H - 20)^b \; ?$$

(h) Stage (m)	20.8	21.3	21.95	22.4	23	23.52	23.9
Q (m^3/s)	20	40	60	80	120	160	200

Sol.

Here $a = 20$ given — معلوم

$Q = K\,(h - 20)^b$; by Log

$$\underbrace{\log Q}_{Y} = \underbrace{\log k}_{A} + b\,\underbrace{\log (h - 20)}_{X}$$

$$Y = A + b\,X$$

h (m)	Q (m^3/s)	$Y = \log Q$	$X = \log(h-20)$	XY	X^2
20.8	20	1.301	−0.097		
21.3	40	1.602	0.1139		
21.95	60	1.778	0.29		
22.4	80	1.903	0.38		
23	120	2.079	0.477		
23.52	160	2.204	0.546		
23.9	200	2.301	0.591		
[illegible] Σ		13.2	2.3	4.9	1.126

$$A = \frac{\Sigma y\, \Sigma x^2 - \Sigma x\, \Sigma xy}{n\,\Sigma x^2 - (\Sigma x)^2} = \frac{(13.2 * 1.126) - (2.3 * 4.9)}{(7 * 1.126) - (2.3)^2} = 1.386$$

$$B = \frac{n\,\Sigma xy - \Sigma x\, \Sigma y}{n\,\Sigma x^2 - (\Sigma x)^2} = 1.52$$

$$A = \log k \Rightarrow K = 10^A = 10^{1.386} = 24.32$$

$$\therefore Q = K\,(h-20)^b = 24.32\,(h-20)^{1.52}$$

$$Q = 500 \Rightarrow 500 = 24.32\,(h - 20)^{1.52}$$

$$H - 20 = \left(\frac{500}{24.32}\right)^{1/1.52} \Rightarrow h = 27.308\ m$$

H.W.

Example: given data below of stage-discharge find:

- ❖ the relation of stage-discharge where

$$q = k * (g + 0.103)^{b},$$

- ❖ what is the discharge when the stage of water 20 m, and
- ❖ what is the stage of water if the discharge 500 $\frac{m^3}{sec}$?

Stage (m)	Discharge ($\frac{m^3}{sec}$)
5	20
6	45
7	80
9	180
10	254
12	405
15	720
17	920

Solution:

H.W. The recorded discharges and water levels are shown below estimate the following relation and find Q when g = 13 m

$$Q = k * (g - 3)^b$$

Q (m^3/s)	1	2	4	10
g (m)	6	8	10	11

Solution:

Equations to find the discharge:

1) Chezy formula

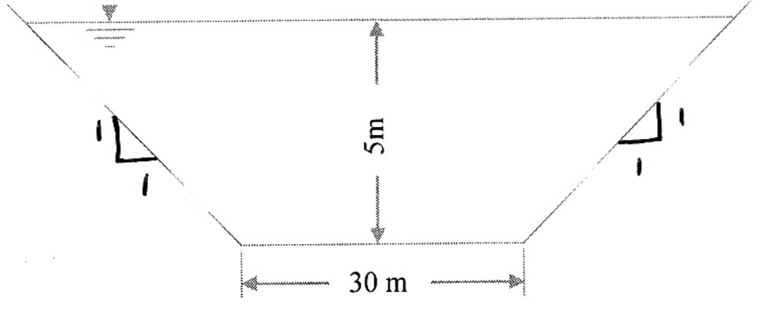
$$V = C\sqrt{R * S}$$

Hydraulic radius $= R = \frac{A}{P} = \frac{\text{area}}{\text{wetted perimeter}}$

C: chezy's coeff. $\sqrt{m}/s$

S: hydraulic gradient (Long. slope)

Example: Given canal section what is the hydraulic radius?



$$A = \left(\frac{40 + 30}{2}\right) 5 = 175 \ m^2$$

$$P = 2 * \sqrt{5^2 + 5^2} + 30 = 44.142$$

$$R = \frac{A}{P} = \frac{175}{44.142} = 3.96 \ m$$