Precipitation Measurements

Forms of Precipitation
- Rain
- Hail
- Snow
- Fog
- Dew
- Other Forms

Rain Formation: rain is caused by rising and cooling of moist air. When air rises, it expands (because pressure is Lower at high levels of the atmosphere) and cools

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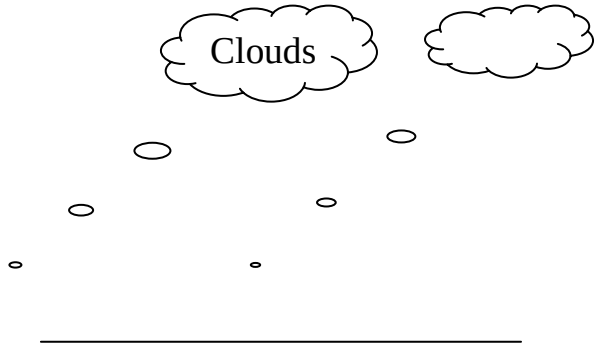
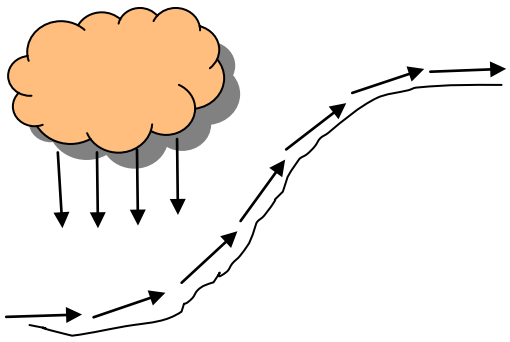
Type of Rain:

1. Conventional Rain: **السقيط الانقلابي**



2. Orographic (Relief) Rain: **السقيط التضاريسي(التصاعدي)**

[Warm air being forced to rise by high land]

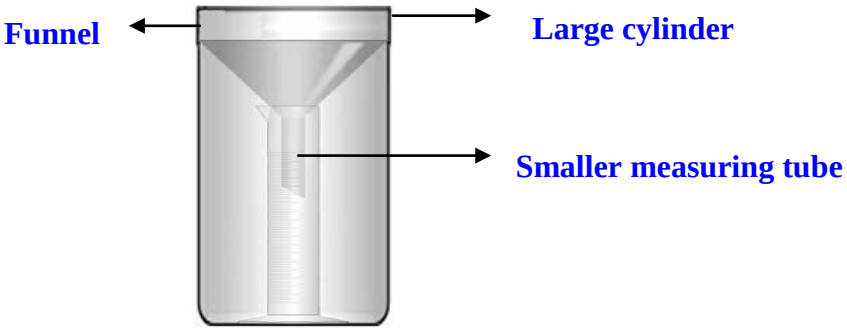


3. Frontal (Cyclonic) Rain: **سقيط الإعصار(الجبهة)**

Rainfall: rain measured by

1. Non-Recording (*Manual*) Gage: (Standard Rain Gauge)

- A rain gauge is a type of instrument used to gather and measure the amount of rainfall over a set period of time at a specific location
- Most rain gauges generally measure rainfall in millimeters but sometimes is reported as inches or centimeters
- Rain gauges should be placed far enough from structures and trees to ensure that any effects caused are minimized
- The most common rain gauge was invented over 100 years ago
- It consists of a large cylinder with a funnel and a smaller measuring tube inside it
- The rain gauge specified by the United States Weather Bureau is a 50 cm tall cylinder with a 20 cm diameter funnel
- Water is collected in a measuring tube that has exactly one-tenth the cross-sectional area of the top of the funnel
- As a result, the height of the water collected in the measuring tube is precisely ten times what it would be if it had been collected in the cylinder alone
- For example, one-tenth of a centimeter of rainfall would fill one centimeter of the measuring tube
- This exaggeration of the height of water in the tube enables meteorologists to make more precise rainfall measurements



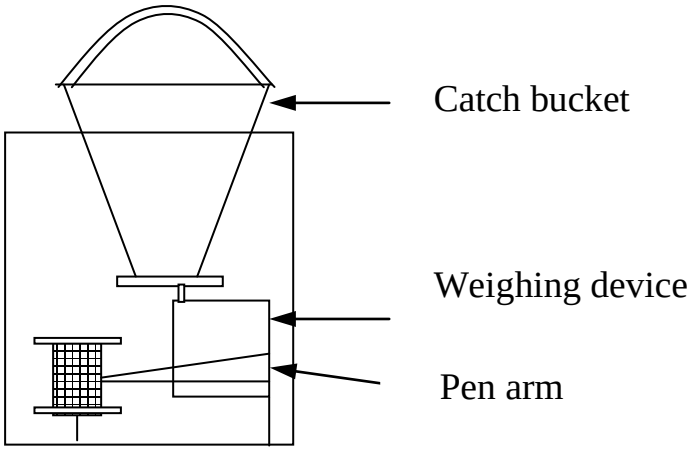
2. Tipping Bucket Rain Gage:

- The tipping bucket rain gauge consists of a large cylinder set into the ground
- At the top of the cylinder is a funnel that collects and channels the rain. The rain falls onto one of two small buckets which are balanced as a scale
- After an amount of precipitation falls, the lever tips, other bucket quickly moves into place to catch the next unit of rainfall, and an electrical signal is sent to the recorder.

يتصرف الماء من أسفل القمع في وعاء قلاب مكون من جزأين ، فالمطر القادم من القمع يملئ احد الجزأين فيحدث عدم اتزان للوعاء القلاب فيفرغ الجزء المملوء محتوياته في خزان تجميع كبير ، في نفس الوقت يدور الجزء الفارغ ليأتي تحت القمع ويستقبل المياه من خلاله وعند انقلاب الوعاء فأنه يقفل دائرة كهربائية متصلة بقلم يوقع بدوره على ورقة بيانية مثبتة على اسطوانة تدور بمعدل ثابت ومن ثم يتم معرفة عدد مرات انقلاب الوعاء وسمك المياه المتساقطة كذلك معدل سقوطها مع الزمن

3. Recording gage (weighing type gage):

The gage makes a record of cumulative precipitation.



4. Float Recording Gage:

تقوم فكرته على انه باستمرار سقوط المطر يرتفع سطح الماء في الجهاز والذي توجد على سطحه عوامة ترتفع هي الأخرى حيث تكون متصلة بقلم يسجل ارتفاع منسوب الماء في الجهاز أوتوماتيكيا على شكل رسم بياني.

Definitions:

1. **Intensity (i, mm/hr.):** the quality of rain falling in given time
2. **Duration (t,hr.)**: the period of time during which rain falls.
3. **Depth:** the total amount of rainfall (mm) for a given period of time
4. **Frequency (T,years)**: return period or recurrence interval in years with which the intensity is reached.

Return Period and Exceedance Probability

- Frequency can be represented as exceedance probability and return period
- Exceedance Probability: the probability that rainfall intensity is being exceeded during a given time period
- Return Period: the event with a return period of N years is the event that is expected to be equaled or exceeded every N years

Return Period

- If a 100-year storm occurs this year then it is totally wrong to assume that this storm will return in 100 years
- Instead, the storm can have the chance for returning two successive years in the near future or may not return for another 150 years
- It should be noted that the relationship between return period (T) and exceedance probability (P) is given as follows:

$$P = 1 / T$$

Relationships:

1. Intensity- Duration Relationship:

The greater the intensity of rainfall the shorter length of times it continuous.

$$i=a/(t+b)$$

where:

i=intensity,(mm/hr.);

t= duration,(hr.);

a&b= locality constants,(dimensionless).

$$i=c/t^n \quad \text{for } t \geq 2 \text{ hr.}$$

where:

c&n= locality constants,(dimensionless).

2. Intensity- Duration Frequency Relationship:

- One of the first steps in many hydrologic design projects is the determination of the rainfall event or events to be used in the design
- The most common approach is to use a design storm or event that involves a relationship between rainfall intensity (or depth), duration, and the frequency appropriate for the facility and site location

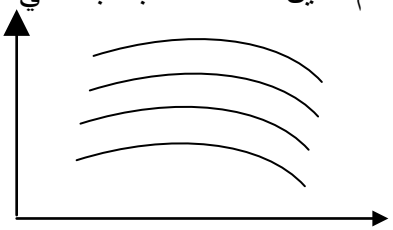
- As such, the IDF curves can be used by hydrologists
- IDF curves enables the hydrologists to develop hydrologic systems that consider worst-case scenarios of rainfall intensity and duration during a given interval of time
- The idea here is that high intensity rainfall in short periods may cause catastrophic consequences
- For instance, in urban watersheds, flooding may occur such that large volumes of water may not be handled by the storm water system
- Thus, appropriate values of precipitation intensities and frequencies should be considered in the design of the hydrologic systems

$$i=kT^x/(a+t^n)$$

where:

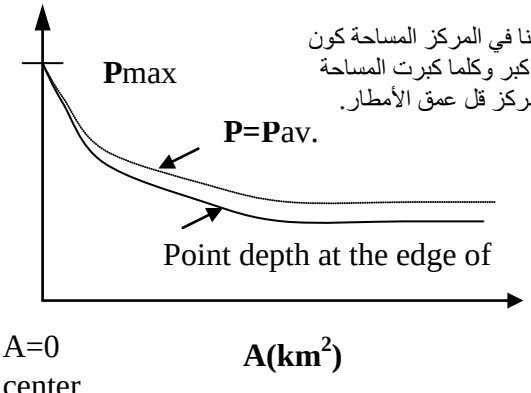
k,x,a,n= constants,(dimensionless).

اذا تم تمثيل العلاقة السابقة بمنحني تكون النتيجة بالشكل التالي:

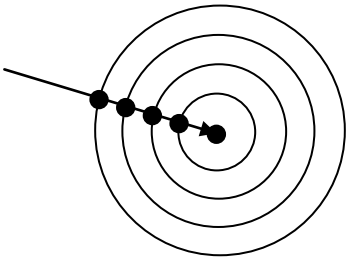


3. Depth- Area Relationship:

من النادر أن يحدث السقيط بصورة متجانسة على كل المساحة. حيث أن التغيير في الشدة والعمق الكلي للسقيط يحدث من المركز إلى محيط العاصفة، كما مبين في الشكل أدناه. حيث يلاحظ أن معدل العمق يقل من الحد الأعلى كلما زادت المساحة:



Where:
P=rain depth,(mm);
P=av. rain depth,(mm);
A= area,(km^2)



4. Intensity versus Depth of Rainfall

Intensity is expressed as:

$i = P / T_d$

Where P is the rainfall depth (mm) and T_d is the duration (hr).

Rainfall Intensity and Corresponding Depth

- In general, we may have different rainfall intensities but with the same depth
- Apparently, rainfall duration plays an important role in determining rainfall depth

Intensity (in/h)	Duration (h)	Depth (in)
12.0	0.25	3
6.0	0.50	3
4.0	0.75	3
3.0	1.00	3
1.5	2.00	3
0.5	6.00	3

For example

Intensity (in/h) = Depth (in) / Duration (h) = 3/0.25 = 12 in/h