Assumption of convolution method

- The **excess rainfall** has a constant intensity within the effective duration.
- The excess rainfall is uniformly distributed throughout the whole drainage area
- The base time of the direct runoff hydrograph resulting from an excess rainfall of given duration is constant
- The ordinates of all direct runoff's of a common base time are directly proportional to the total amount of direct runoff represented by each hydrograph

Application of UH

- To calculate the direct runoff and stream
- flow hydrographs
- Computation of flood hydrograph for
- design of structures
- Flood forecasting models
- Comparing the catchment characteristics

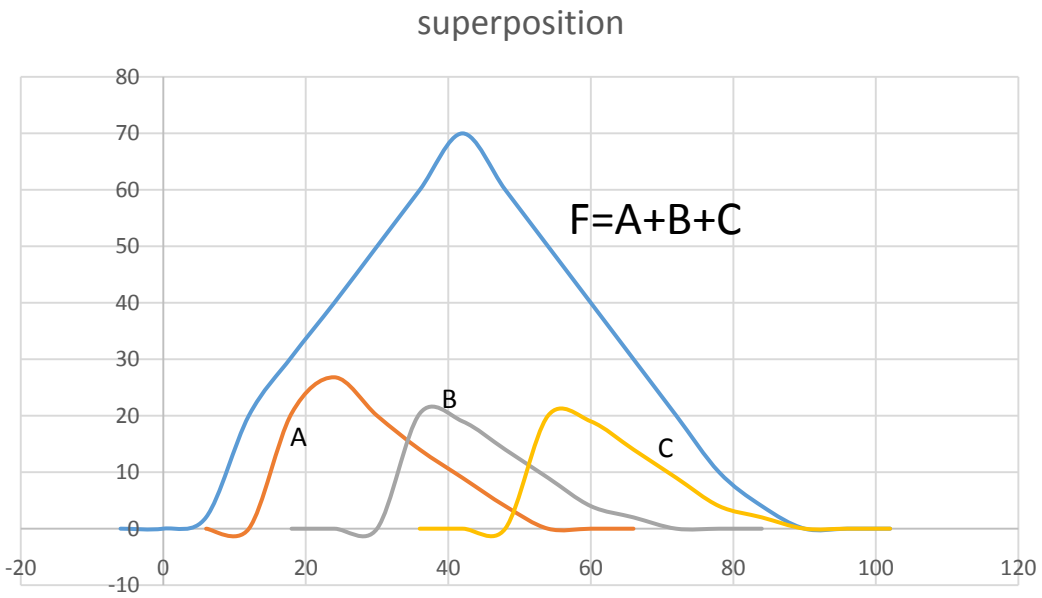
UNIT HYDROGRAPH OF DIFFERENT DURATION (+-20%D)

– Method of superposition

– S-curve method

Method of superposition

- If a D-h unit hydrograph is available and it is desired to develop a unit hydrograph of nDh,where n is an integer,it is done by superposing n unit hydrographs with each graph separated from the previous on by Dh.



example

- Given the ordinate of a 4 hr unit hydrograph as below derive the ordinates of 12h unit hydrograph for the same catchment

Time (hr)	0	4	8	12	16	20	24	28	32	36	40	44
4-hUH	0	20	80	130	150	130	90	52	27	15	5	0

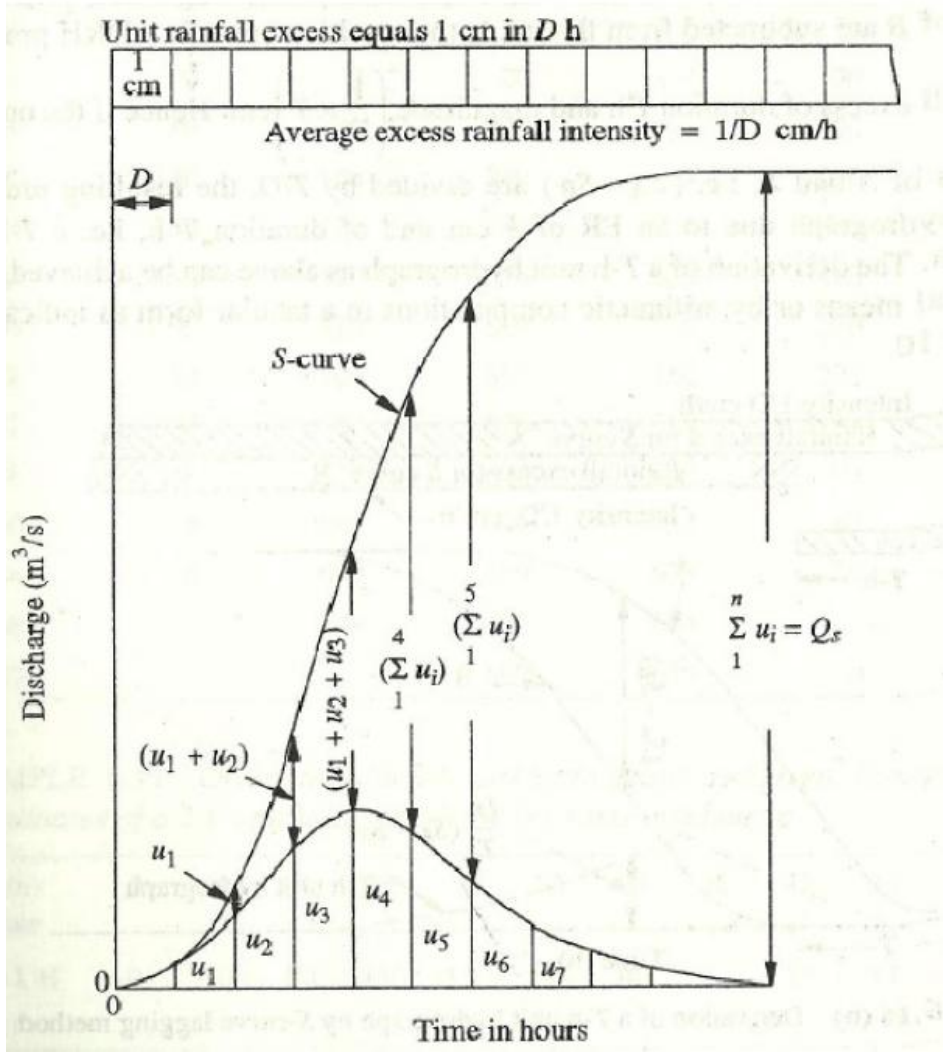
- solution

SCS AND HYDROGRAPH\superposition and SCSexp.xlsx

The S curve

- S-hydrograph is a hydrograph produce by a continuous effective rainfall at a constant rate for an infinite period.
- It is a curve obtained by summation of an infinite series of D-hr unit hydrographs spaced D-hr apart.
- The S-hydrograph method use for the conversion of an X- hour unit hydrograph into a Y-hour unit hydrograph, regardless of the ratio between X and Y.

S curve


Unit rainfall excess equals 1 cm in D h
1 cm
Average excess rainfall intensity = 1/D cm/h
D
S-curve
Discharge (m³/s)
$\sum_{1}^{4} u_i$
$\sum_{1}^{5} u_i$
$\sum_{1}^{n} u_i = Q_s$
$(u_1 + u_2)$
$(u_1 + u_2 + u_3)$
u_1
u_2
u_3
u_4
u_5
u_6
u_7
0
0
Time in hours

example

- Derive a 2-hr UH from 4-hr UH. The 4-hr UH is given below

t	0	2	4	6	8	10	12	14	16	18	20	22
ordinate 4hr UH	0	8	20	43	80	110	130	146	150	142	130	112

24	26	28	30	32	34	36	38	40	42	44
90	70	52	38	27	20	15	10	5	2	0

- Derive a 3-hr UH from 2-hr UH. The 2-hr UH is given below

Time (hr)	Ordinate (m3/sec)	Time (hr)	Ordinate (m3/sec)
0	0	8	450
1	50	9	350
2	150	10	250
3	300	11	150
4	600	12	50
5	750	13	0
6	650	14	0
7	550	sum	4300

The scs dimension less UH(synthetic UH)

- The SCS dimensionless hydrograph is a synthetic unit hydrograph in which the discharge is expressed by the ratio of discharge *q* to peak discharge *qp* and the time by the ratio of time *t* to the time of rise of the unit hydrograph, *Tp*. Given the peak discharge and lag time for the duration of excess rainfall, the unit hydrograph can be estimated from the synthetic dimensionless hydrograph for the given basin.

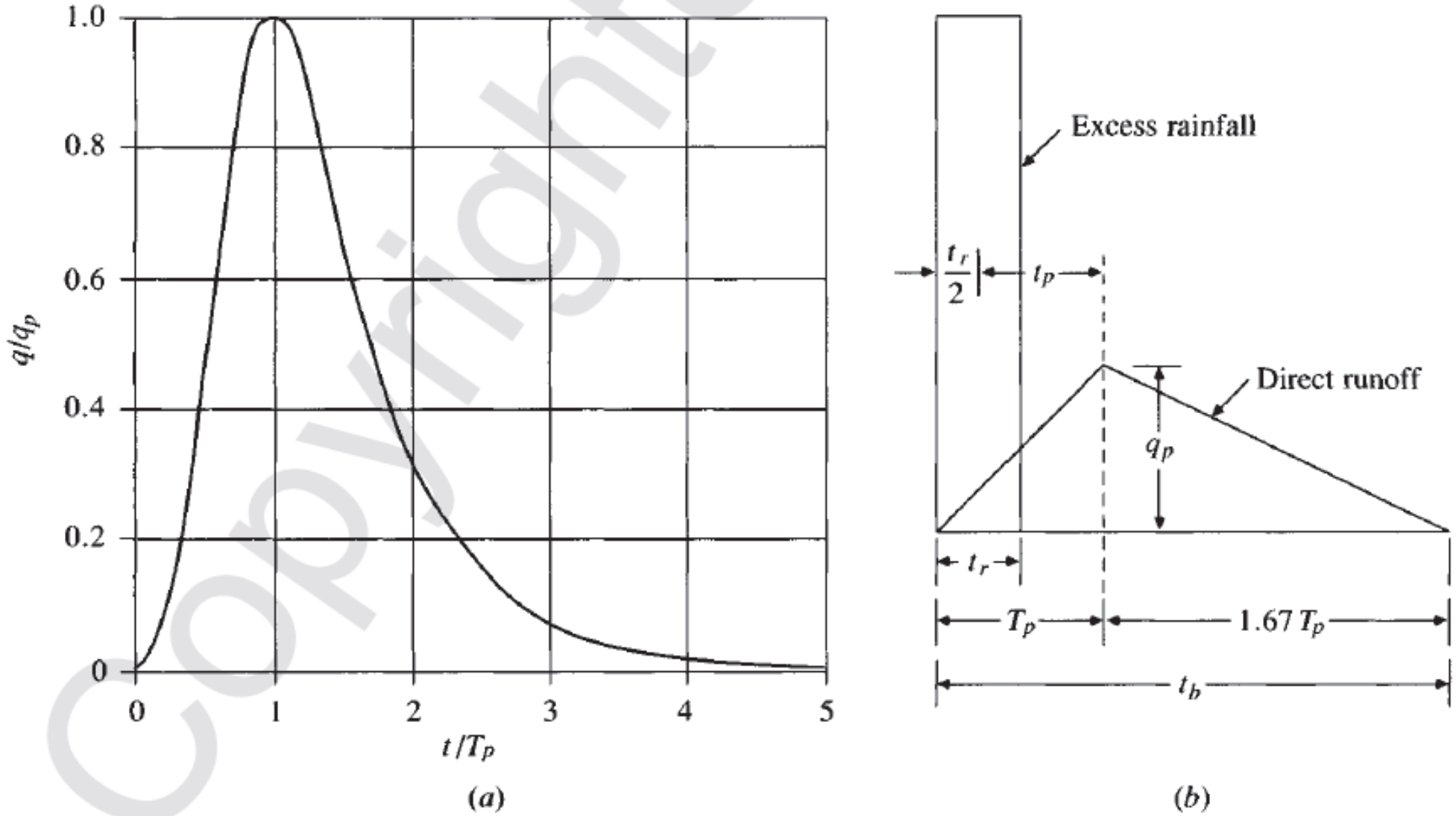
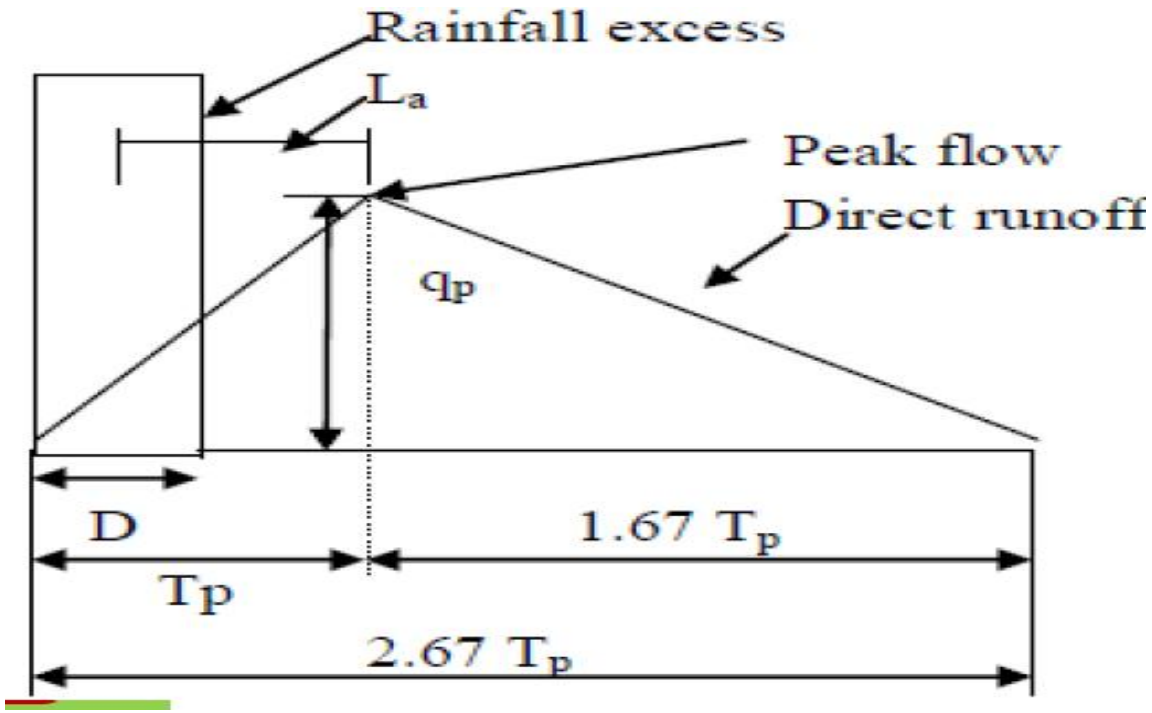


FIGURE 7.7.4
Soil Conservation Service synthetic unit hydrographs (*a*) Dimensionless hydrograph and (*b*) triangular unit hydrograph. (*Source*: Soil Conservation Service, 1972.)

- The dimensionless hydrograph in the fig may be converted to the required dimensions by multiplying the values on the horizontal axis by *Tp* and those on the vertical axis by *qp*



- lag La of the peak flow, time from the centroid of rainfall excess to the peak of the hydrograph, is assumed to be 0.6 tc.
- The base length of the hydrograph is assumed to be 2.67Tp.
- Then the time of rise Tp to the peak of the hydrograph is

$$T_p = \frac{t_r}{2} + t_p$$

$$T_p = 0.5D + 0.6t_c$$

$$q_p = \frac{0.208Ar_d}{0.5D + 0.6t_c}$$

Where:

q_p = peak discharge (m^3/s)

r_d = the excess rainfall depth (mm)

A = watershed area (km^2)

t_c = time of concentration (hr)

D = duration of excess rainfall (hr)

example

- Construct a 10-minute SCS unit hydrograph for a basin of area 3.0 km2 and time of concentration 1.25 h.

- The duration *tr* = 10 min =0.166 h,
- lag time *tp = 0.6Tc* = 0.6 x 1.25 =0.75 h,
- rise time *Tp = trl2 + tp* = 0.166/2 + 0.75 = 0.833 h.
- *qp* = 2.08 x 3.0/0.833 = 7.49 m3/s-cm.

$$q_p = \frac{0.208 A r_d}{0.5D + 0.6t_c}$$

$$T_p = 0.5D + 0.6t_c$$

Alternatively, the triangular unit hydrograph can be drawn with

- *tb = 2.61Tp* = 2.22 h.