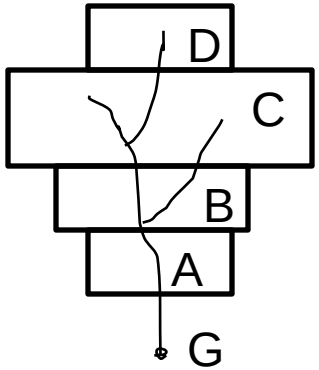
Example Problem

- Find the storm hydrograph for the following data using time area method. Given rainfall excess ordinate at time is 0.5 in./hr

	A	B	C	D
Area (ac)	100	200	300	100
Time to gage G (hr)	1	2	3	4



Time area histogram method uses

$$\mathbf{Q_n = R_i A_1 + R_{i-2} A_2 + \ldots\ldots + R_i A_j}$$

For n = 5, i = 5, and j = 5

$$Q_5 = R_5 A_1 + R_4 A_2 + R_3 A_3 + R_2 A_4$$

(0.5 in./ hr) (100 ac) + (0.5 in./hr) (200 ac) + (0.5 in./hr) (300ac) + (0.5 in./hr) (100)

Q5 = 350 ac-in./hr

Note that 1 ac-in./hr ≈ 1 cfs, hence

Q5 = 350 cfs

Example Problem Contd…

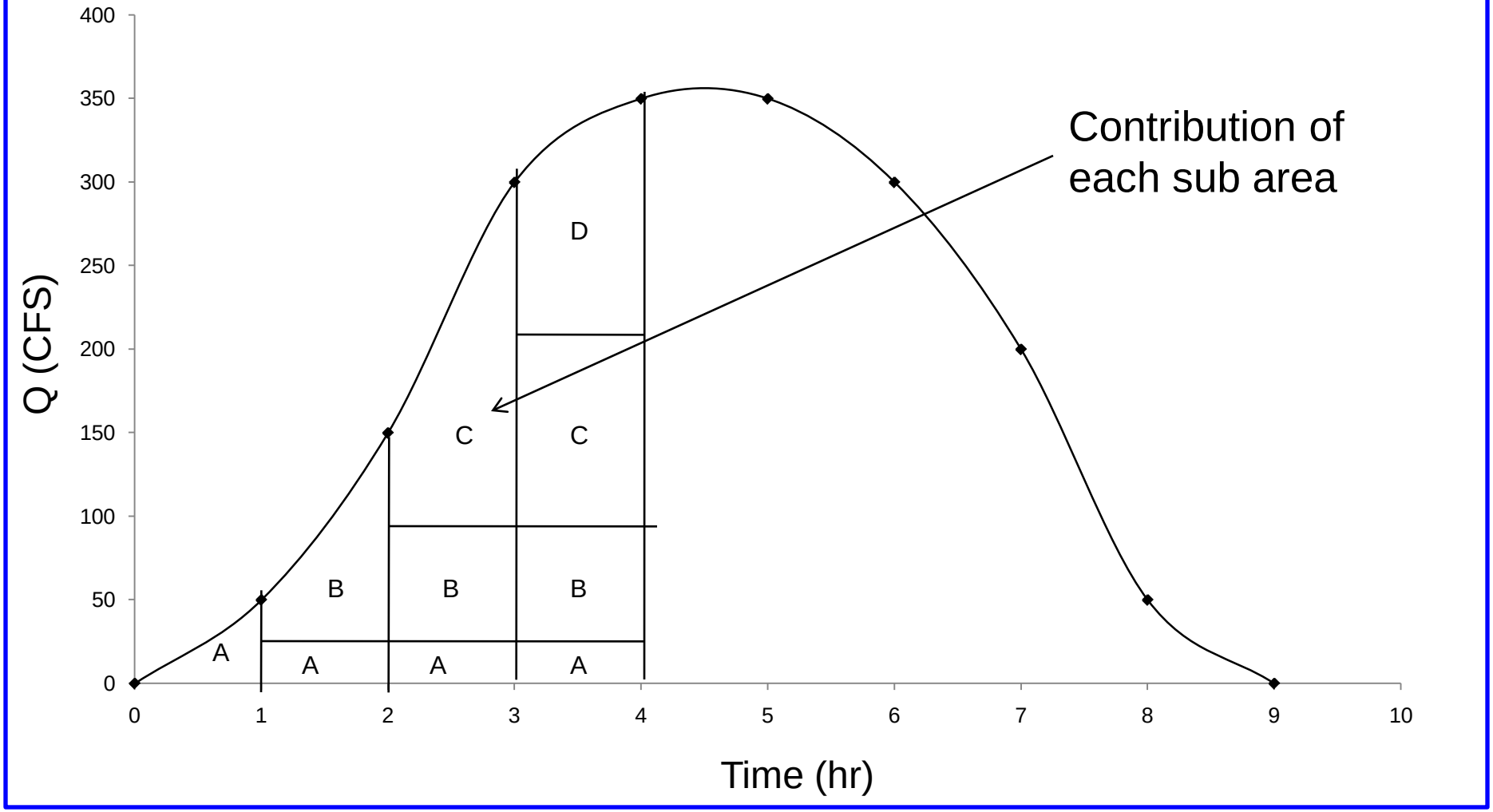
Excel spreadsheet calculation

Time (hr)	Hydrograph Ordinate (R1:Rn)	Basin No.	Time to gage	Basin area A1:An (ac)	R1:An	R2:An	R2:An	R2:An	R2:An	Storm hydrograph
0										0
1	0.5	A	1	100	* 50					50
2	0.5	B	2	200	100	50				+150
3	0.5	C	3	300	150	100	50			300
4	0.5	D	4	400	50	150	100	50		350
5						50	150	100	50	350
6							50	150	100	300
7								50	150	200
8									50	50
9										0

* =(R1*A1) = (0.5*100) and + = (adding the columns from 6 to 10)

Example Problem

Contd…



Example Problem-1

- Rainfall of magnitude 3.8 cm and 2.8 cm occurring on two consecutive 4-h durations on a catchment area 27km^2 produced the following hydrograph of flow at the outlet of the catchment. Estimate the rainfall excess and φ-index

Time from start of rainfall (h)	-6	0	6	12	18	24	30	36	42	48	54	60	66
Observed flow (m^3/s)	6	5	13	26	21	16	12	9	7	5	5	4.5	4.5

Baseflow separation:

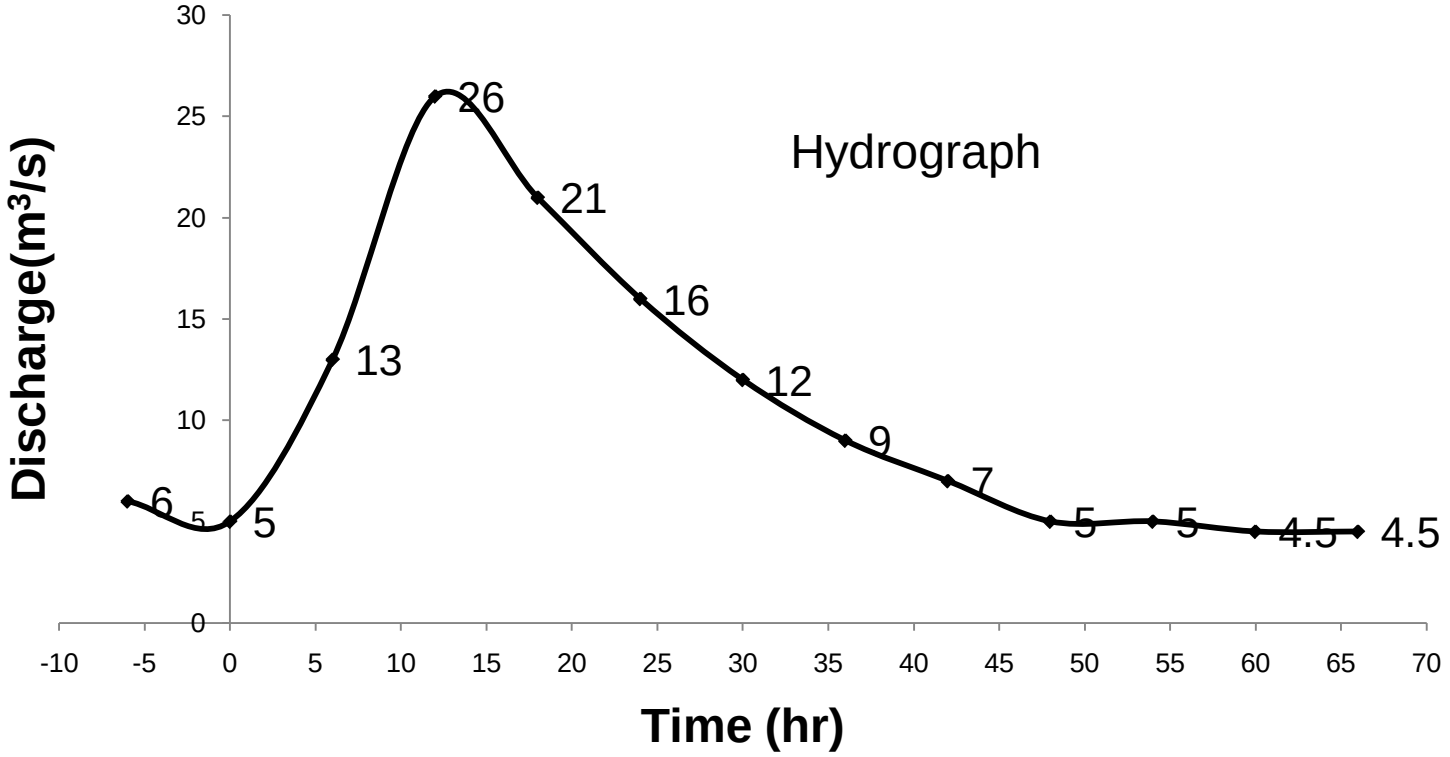
Using Simple straight line method,

$N = 0.83\ A^{0.2} = 0.83\ (27)^{0.2}$

$= 1.6$ days $= 38.5$ h

So the baseflow starts at 0^{th} h and ends at the point (12+38.5)h

Example Problem-1 Contd…



➔ 50.5 h (say 48 h approx.)

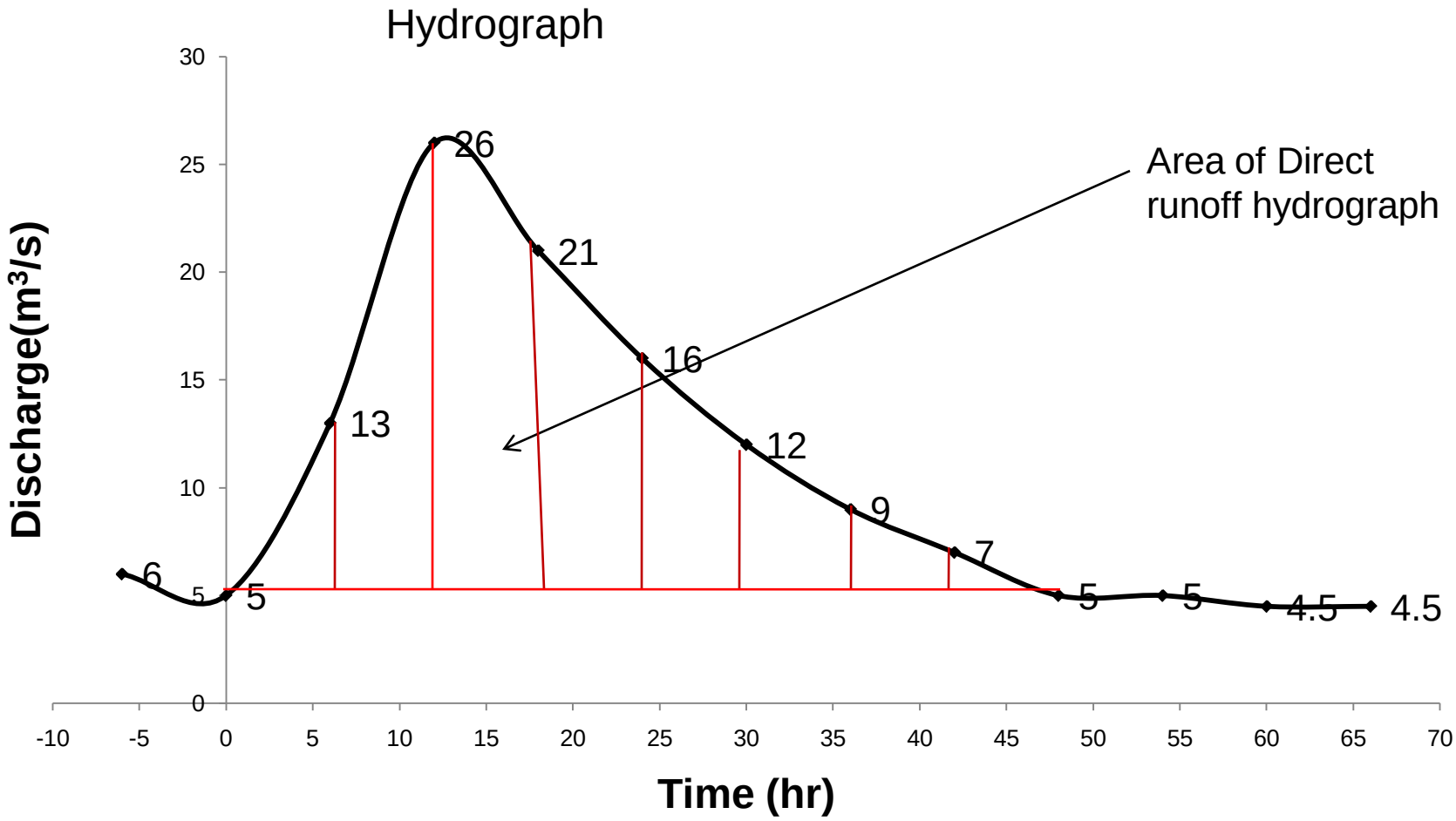
Constant baseflow of 5m³/s

Example Problem-1 Contd…

Time (h)	FH Ordinates(m3/s)	DRH Ordinates (m3/s)
-6	6	1
0	5	0
6	13	8
12	26	21
18	21	16
24	16	11
30	12	7
36	9	4
42	7	2
48	5	0
54	5	0
60	4.5	0
66	4.5	0

DRH ordinates are obtained from subtracting the corresponding FH with the base flow i.e. 5 m^3/s

Example Problem-1 Contd…



Example Problem-1 Contd…

Area of DRH = (6*60*60)[1/2 (8)+1/2 (8+21)+

1/2 (21+16)+ 1/2 (16+11)+

1/2 (11+7)+ 1/2 (7+4)+ 1/2 (4+2)+ 1/2 (2)]

= 1.4904 * $10^6 m^3$ (total direct runoff due to storm)

Run-off depth = Runoff volume/catchment area

= 1.4904 * $10^6/27* 10^6$

= 0.0552m = 5.52 cm = rainfall excess

Total rainfall = 3.8 +2.8 = 6.6cm

Duration = 8h

φ-index = (P-R)/t = (6.6-5.52)/8 = **<u>0.135cm/h</u>**

Example Problem-2

A storm over a catchment of area 5.0 km^2 had a duration of 14hours. The mass curve of rainfall of the storm is as follows:

Time from start of storm (h)	0	2	4	6	8	10	12	14
Accumulated rainfall (cm)	0	0.6	2.8	5.2	6.6	7.5	9.2	9.6

If the φ-index of the catchment is 0.4cm/h, determine the effective rainfall hyetograph and the volume of direct runoff from the catchment due to the storm.

Example Problem-2 Contd…

Time from start of storm(h)	Time interval Δt	Accumulated rainfall in Δt (cm)	Depth of rainfall in Δt (cm)	φ Δt (cm)	ER (cm)	Intensity of ER (cm/h)
0	_	0	_	_	_	_
2	2	0.6	0.6	0.8	0	0
4	2	2.8	2.2	0.8	1.4	0.7
6	2	5.2	2.4	0.8	1.6	0.8
8	2	6.7	1.5	0.8	0.7	0.35
10	2	7.5	0.8	0.8	0	0
12	2	9.2	1.7	0.8	0.9	0.45
14	2	9.6	0.4	0.8	0	0

- Total effective rainfall = Direct runoff due to storm = area of ER hyetograph
  = (0.7+0.8+0.35+0.45)*2 = 4.6 cm
- Volume of direct runoff = (4.6/100) * 5.0*$(1000)^2$
  = 230000m^3