

CVG3120-ASSIGNMENT 5

Due date: Friday, December 9, 23:59

PROBLEM 1

The following data are from the 2.15-acre watershed W-15, Cherokee, Oklahoma, for the storm of November 16, 1964. Assume that baseflow equals 0 and that all rainfall prior to the start of runoff is initial abstraction. Determine the distribution of rainfall excess using the phi-index method. [Note: Rainfall values give the average intensity over the interval; runoff values are ordinates.]

Time	Rainfall (in/h)	Time	Hydrograph (in/h)	Time	Hydrograph (in/h)
0530	0.00	0732	0.0000	0826	0.5430
0630	0.01	0736	0.0014	0828	0.4180
0730	0.00	0738	0.0049	0830	0.3220
0745	0.44	0754	0.0049	0834	0.2180
0800	0.12	0756	0.0096	0838	0.1520
0805	1.92	0758	0.0228	0842	0.1040
0810	1.92	0800	0.0441	0900	0.0904
0815	1.20	0802	0.0597	0910	0.0654
0820	0.72	0804	0.0972	0920	0.0490
0825	0.36	0806	0.1270	0930	0.0393
0830	0.24	0808	0.2180	0940	0.0266
0845	0.12	0809	0.3350	0950	0.0155
0900	0.16	0810	0.4940	1000	0.0124
0945	0.00	0812	0.6870	1030	0.0124
0950	0.24	0814	0.8070	1056	0.0096
1000	0.00	0816	0.9370	1110	0.0049
1015	0.16	0817	1.0500	1130	0.0049
1035	0.03	0820	0.8710	1220	0.0014
		0824	0.6680	1350	0.0000

SOLUTION

1) Let's calculate cumulative rainfall:

$$CumP(t + dt) = CumP(t) + dt * 0.5 * (i(t) + i(t + dt))$$

Time	Hours	Min	h	Rainfall (in/h)	Cumulative rainfall
530	5	30	5.5	0	0
630	6	30	6.5	0.01	0.005
730	7	30	7.5	0	0.01
745	7	45	7.75	0.44	0.065
800	8	0	8	0.12	0.135
805	8	5	8.083333	1.92	0.22
810	8	10	8.166667	1.92	0.38

815	8	15	8.25	1.2	0.51
820	8	20	8.333333	0.72	0.59
825	8	25	8.416667	0.36	0.635
830	8	30	8.5	0.24	0.66
845	8	45	8.75	0.12	0.705
900	9	0	9	0.16	0.74
945	9	45	9.75	0	0.8
950	9	50	9.833333	0.24	0.81
1000	10	0	10	0	0.83
1015	10	15	10.25	0.16	0.85
1035	10	35	10.58333	0.03	0.881666667

The initial abstraction is the total precipitation before 7:30, i.e 0.01 in;

2) Let's calculate cumulative rainfall:

$$CumQ(t + dt) = CumQ(t) + dt * 0.5 * (q(t) + q(t + dt))$$

Time	Hours	Min	h	Hydrograph (in/h)	Cumulative runoff
530	5	30	5.5	0	0
630	6	30	6.5	0	0
730	7	30	7.5	0	0
732	7	32	7.533333	0	0
736	7	36	7.6	0.0014	4.67E-05
738	7	38	7.633333	0.0049	0.000152
754	7	54	7.9	0.0049	0.001458
756	7	56	7.933333	0.0096	0.0017
758	7	58	7.966667	0.0228	0.00224
800	8	0	8	0.0441	0.003355
802	8	2	8.033333	0.0597	0.005085
804	8	4	8.066667	0.0972	0.0077
806	8	6	8.1	0.127	0.011437
808	8	8	8.133333	0.218	0.017187
809	8	9	8.15	0.335	0.021795
810	8	10	8.166667	0.494	0.028703
812	8	12	8.2	0.687	0.048387

814	8	14	8.233333	0.807	0.073287
816	8	16	8.266667	0.937	0.102353
817	8	17	8.283333	1.05	0.118912
820	8	20	8.333333	0.871	0.166937
824	8	24	8.4	0.668	0.218237
826	8	26	8.433333	0.543	0.23842
828	8	28	8.466667	0.418	0.254437
830	8	30	8.5	0.322	0.26677
834	8	34	8.566667	0.218	0.28477
838	8	38	8.633333	0.152	0.297103
842	8	42	8.7	0.104	0.305637
900	9	0	9	0.0904	0.334797
910	9	10	9.166667	0.0654	0.34778
920	9	20	9.333333	0.049	0.357313
930	9	30	9.5	0.0393	0.364672
940	9	40	9.666667	0.0266	0.370163
950	9	50	9.833333	0.0155	0.373672
1000	10	0	10	0.0124	0.375997
1030	10	30	10.5	0.0124	0.382197
1056	10	56	10.93333	0.0096	0.386963
1110	11	10	11.16667	0.0049	0.388655
1130	11	30	11.5	0.0049	0.390288
1220	12	20	12.33333	0.0014	0.392913
1350	13	50	13.83333	0	0.393963

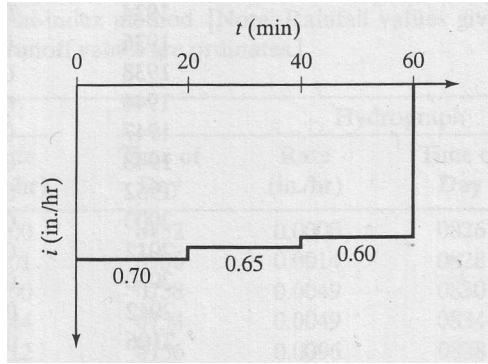
- Initial value of Φ is (total rainfall – initial abstraction- total runoff)/duration of the rainfall after initial abstraction= $(0.88\text{in}-0.39\text{in})/(10.58-7.5)=0.1581$ in/h
- The initial value is then optimized using solver to get 0.393963in as effective precipitation. The optimized value is 0.3157

Time	Rainfall (in/h)	Phi (in/h)	Effective rainfall (in/h)	Cumulative effective rainfall
7.75	0.44	0.31576062	0.124239385	0
8	0.12	0.31576062	0	0.015529923
8.083333	1.92	0.31576062	1.604239385	0.082373231
8.166667	1.92	0.31576062	1.604239385	0.216059846
8.25	1.2	0.31576062	0.884239385	0.319746462
8.333333	0.72	0.31576062	0.404239385	0.373433077
8.416667	0.36	0.31576062	0.044239385	0.392119692
8.5	0.24	0.31576062	0	0.393963
8.75	0.12	0.31576062	0	0.393963
9	0.16	0.31576062	0	0.393963
9.75	0	0.31576062	0	0.393963
9.833333	0.24	0.31576062	0	0.393963
10	0	0.31576062	0	0.393963
10.25	0.16	0.31576062	0	0.393963
10.58333	0.03	0.31576062	0	0.393963

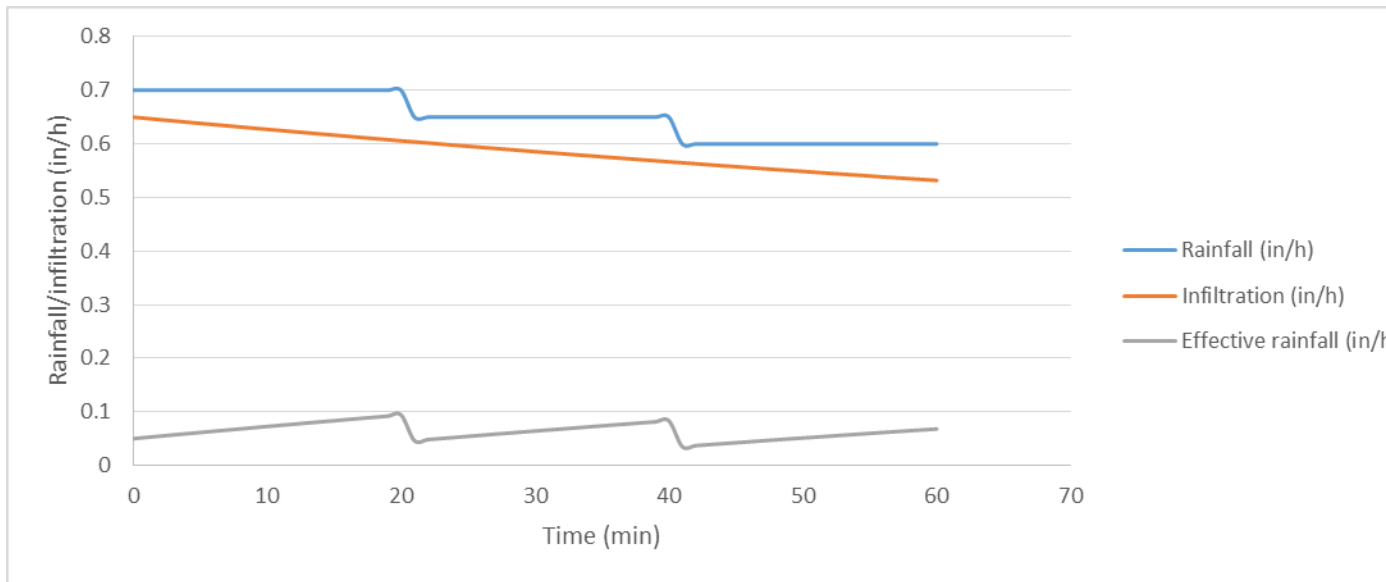
Time	Rainfall (in/h)	Phi (in/h)	Effective rainfall (in/h)	Cumulative effective rainfall
7.75	0.44	0.31576062	0.124239385	0
8	0.12	0.31576062	0	0.015529923
8.083333	1.92	0.31576062	1.604239385	0.082373231
8.166667	1.92	0.31576062	1.604239385	0.216059846
8.25	1.2	0.31576062	0.884239385	0.319746462
8.333333	0.72	0.31576062	0.404239385	0.373433077
8.416667	0.36	0.31576062	0.044239385	0.392119692
8.5	0.24	0.31576062	0	0.393963
8.75	0.12	0.31576062	0	0.393963
9	0.16	0.31576062	0	0.393963
9.75	0	0.31576062	0	0.393963
9.833333	0.24	0.31576062	0	0.393963
10	0	0.31576062	0	0.393963
10.25	0.16	0.31576062	0	0.393963
10.58333	0.03	0.31576062	0	0.393963

PROBLEM 2

If $f_0 = 0.65$ in./hr, $f_c = 0.25$ in./hr, and $K = 0.35$ hr⁻¹, determine the distribution of losses and the depth of rainfall excess for the following hyetograph:



SOLUTION



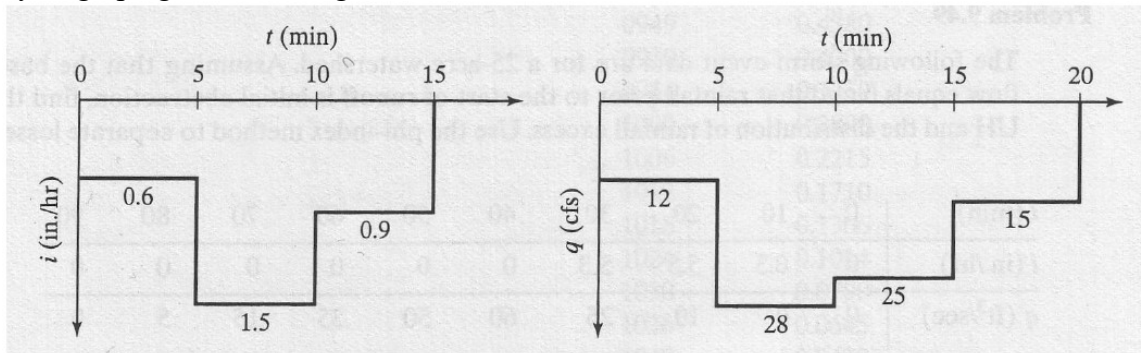
Time (min)	Rainfall (in/h)	Infiltration (in/h) $0.25+(0.65-0.25)*\exp(-0.35*time_in_h)$	Effective rainfall (in/h)
0	0.7	0.65	0.05
1	0.7	0.647673	0.052327
2	0.7	0.64536	0.05464
3	0.7	0.643061	0.056939
4	0.7	0.640775	0.059225
5	0.7	0.638502	0.061498
6	0.7	0.636242	0.063758
7	0.7	0.633996	0.066004
8	0.7	0.631762	0.068238
9	0.7	0.629542	0.070458

10	0.7	0.627334	0.072666
11	0.7	0.625139	0.074861
12	0.7	0.622958	0.077042
13	0.7	0.620788	0.079212
14	0.7	0.618632	0.081368
15	0.7	0.616488	0.083512
16	0.7	0.614356	0.085644
17	0.7	0.612237	0.087763
18	0.7	0.61013	0.08987
19	0.7	0.608035	0.091965
20	0.7	0.605953	0.094047
21	0.65	0.603882	0.046118
22	0.65	0.601824	0.048176
23	0.65	0.599778	0.050222
24	0.65	0.597743	0.052257
25	0.65	0.595721	0.054279
26	0.65	0.59371	0.05629
27	0.65	0.591711	0.058289
28	0.65	0.589723	0.060277
29	0.65	0.587747	0.062253
30	0.65	0.585783	0.064217
31	0.65	0.58383	0.06617
32	0.65	0.581888	0.068112
33	0.65	0.579958	0.070042
34	0.65	0.578039	0.071961
35	0.65	0.576131	0.073869
36	0.65	0.574234	0.075766
37	0.65	0.572348	0.077652
38	0.65	0.570473	0.079527
39	0.65	0.568609	0.081391
40	0.65	0.566756	0.083244
41	0.6	0.564913	0.035087
42	0.6	0.563082	0.036918
43	0.6	0.561261	0.038739
44	0.6	0.55945	0.04055
45	0.6	0.557651	0.042349

46	0.6	0.555861	0.044139
47	0.6	0.554082	0.045918
48	0.6	0.552313	0.047687
49	0.6	0.550555	0.049445
50	0.6	0.548807	0.051193
51	0.6	0.547069	0.052931
52	0.6	0.545341	0.054659
53	0.6	0.543623	0.056377
54	0.6	0.541916	0.058084
55	0.6	0.540218	0.059782
56	0.6	0.53853	0.06147
57	0.6	0.536851	0.063149
58	0.6	0.535183	0.064817
59	0.6	0.533524	0.066476
60	0.6	0.531875	0.068125

PROBLEM 3

Compute the DRH resulting from the hietograph (figure at the left) given the unit hydrograph given at the right.



SOLUTION

a) Unit hydrograph:

Time	UH (cfs)
0	12
5	28
10	25
15	15
20	0

b) DRH

Time	$0.6 \cdot 5/60 \cdot \text{UH}$	$1.5 \cdot 5/60 \cdot \text{UH}$ (lag = 5min)	$0.9 \cdot 5/60 \cdot \text{UH}$ (lag = 10min)	DRH (cfs)
0	0.6	0	0	0.6
5	1.4	1.5	0	2.9
10	1.25	3.5	0.9	5.65
15	0.75	3.125	2.1	5.975
20	0	1.875	1.875	3.75
25	0	0	1.125	1.125
30	0	0	0	0

PROBLEM 4

A 2-hour unit hydrograph is given by a triangle whose base is 4 hours and height at the midpoint of the base is 0.5/hour. Compute the direct runoff due to a 4-hour effective rainfall whose intensity is 2 cm/h. compute the peak discharge. Derive a 3-hour unit hydrograph. If a 3-hour effective rainfall occurs at a uniform rate of 1 cm/h, what should be the direct runoff?. Give its peak discharge.

Solution

1) 2h-UH

Time	1h-UH
0	0
1	0.25
2	0.5
3	0.25
4	0

2) Let's calculate the 4hUH, and the peak flow resulting from a precipitation of 8cm (4h X 2cm/h) and duration 4h

Time	2h-UH	2h-UH	SUM	SUM/2=4h-UH	DRH for a 8cm rainfall of duration 4h
0	0	0	0	0	0
1	0.25	0	0.25	0.125	1
2	0.5	0	0.5	0.25	2

3	0.25	0.25	0.5	0.25	2
4	0	0.5	0.5	0.25	2
5	0	0.25	0.25	0.125	1
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0

A 4h rainfall of intensity 2cm/h has a depth of 8 cm; its DRH is 8 times the 4h-UH, and it's peak is 2cm/h (see table above)

3) Let's calculate the S-hydrograph using the 2h-UH

Time	2h-UH	2h-UH	2h-UH	2h-UH	2h-UH	SUM	SH=2*SUM
0	0	0	0	0	0	0	0
1	0.25	0	0	0	0	0.25	0.5
2	0.5	0	0	0	0	0.5	1
3	0.25	0.25	0	0	0	0.5	1
4	0	0.5	0	0	0	0.5	1
5	0	0.25	0.25	0	0	0.5	1
6	0	0	0.5	0	0	0.5	1
7	0	0	0.25	0.25	0	0.5	1
8	0	0	0	0.5	0	0.5	1
9	0	0	0	0.25	0.25	0.5	1
10	0	0	0	0	0.5	0.5	1
11	0	0	0	0	0.25	0.5	1
12	0	0	0	0	0	0.5	1
13	0	0	0	0	0	0.5	1
14	0	0	0	0	0	0.5	1

4) Let's calculate the 3h UH using the SH, and the DRH resulting from a 3cm (3h*1cm/h) rainfall

Time	SH	SH (lagged 3h)	Difference	3H- UH=Difference/3	DRH of a 3cm rainfall=3UH
0	0	0	0	0	0
1	0.5	0	0.5	0.166666667	0.5
2	1	0	1	0.333333333	1
3	1	0	1	0.333333333	1
4	1	0.5	0.5	0.166666667	0.5
5	1	1	0	0	0
6	1	1	0	0	0
7	1	1	0	0	0
8	1	1	0	0	0
9	1	1	0	0	0
10	1	1	0	0	0
11	1	1	0	0	0
12	1	1	0	0	0
13	1	1	0	0	0
14	1	1	0	0	0

The peak flow after a 3 h rainfall of intensity 1 cm/h is 1cm/h