CE 3354 Engineering Hydrology
Exam 1

1. For a watershed with a size of 120 km^2, the following data on precipitation P, evaporation E and runoff Q are recorded in watershed mm.

Table 1: Monthly Precipitation (P), Evapotranspiration (E), and Runoff (Q)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
P (mm)	250	205	165	50	5	0	0	5	10	55	65	190
E (mm)	5	25	30	50	80	100	150	70	60	20	10	5
Q (mm)	150	110	80	5	0	0	0	0	0	10	15	120

Determine:

a) The month (end) when the amount of water stored in the basin is the largest.

b) The month (end) when the amount of water stored in the basin is the smallest.

c) The difference (in m^3) in the amount of water stored in the basin between these two extremes.

d) The likely climate type (arid, humid temperate or humid tropical) one would expect to find this catchment.

Solution(s): Items 1,2, and 3 are determined using a water budget approach. An excel spreadsheet is shown in Figure(s) **??**, and **??**

Item 4 requires internet research to learn about climate classification. The model I used is *Köppen climate classification*, Gupta's classification(s), and Mays' classifications follow closely. A good starting place is Wikipedia `https://en.wikipedia.org/wiki/K%C3%B6ppen_climate_classification`.

For the supplied monthly values we can make the following assertions:

- Rainfall (P) is highly concentrated in Jan–Mar and Dec.
- Dry season from May–Sep (very low P, high E).
- E is high in May–Sep, reaching a peak in July (150 mm) when P is 0.

These data indicate a distinct wet/dry seasonality.

The Köppen classification scheme:

- Distinct wet and dry seasons
- Wet summer is not present — rainfall is in winter.

	A	B	C	D	E	F	G	H	I	J
1	ce3354-ex1-2025-2-problem1					S_0(mm)	225	<= Changed until non-negative computed storage, one can answer questions on the change in storage terms as well		
2	**DATA SUPPLIED**									
3	Area (km^2)	120				**COMPUTED VALUES**				
4	MONTH	P(mm)	E(mm)	Q(mm)		ΔS(mm)	S(mm)		S(m^3)	
5	Jan	250	5	150		95	320		38400000	
6	Feb	205	25	110		70	390		46800000	
7	Mar	165	30	80		55	445	MAXIMUM VALUE	53400000	
8	Apr	50	50	5		-5	440		52800000	
9	May	5	80	0		-75	365		43800000	
10	Jun	0	100	0		-100	265		31800000	
11	Jul	0	150	0		-150	115		13800000	
12	Aug	5	70	0		-65	50		6000000	
13	Sep	10	60	0		-50	0	MINIMUM VALUE	0	
14	Oct	55	20	10		25	25		3000000	
15	Nov	65	10	15		40	65		7800000	
16	Dec	190	5	120		65	130		15600000	
17										
18								ΔS(m^3)	53400000	

Figure 1: Rainfall-runoff plot for the catchment

- Dry summer with high E
- Total annual precipitation is moderate (1000 mm)

This pattern is typical of a Mediterranean Climate (Köppen: Csa or Csb) Csa: Hot, dry summer; mild, wet winter (likely match)

Characteristics:

- Summer drought
- 3+ months with P ¡ 30 mm and E ¿ 60 mm (May–Sep fits)
- Wet winters (P ¿ E in Jan–Mar, Dec)

The catchment is most likely in a Mediterranean climate (Köppen Csa), common in:

- Coastal California
- Southern Europe (e.g., Spain, Italy)

	A	B	C	D	E	F	G	H	I
1	ce3354-ex1					S_0(mm)	225	<= Changed until non-negative computed storage, one can answer questions on the change in storage terms as well	
2	**DATA SUPI**								
3	Area (km^:	120				**COMPUTED VALUES**			
4	MONTH	P(mm)	E(mm)	Q(mm)		ΔS(mm)	S(mm)		S(m^3)
5	Jan	250	5	150		=B5-C5-D5	=G1+F5		=0.001*G5*B3*1000*1000
6	Feb	205	25	110		=B6-C6-D6	=F6+G5		=0.001*G6*B3*1000*1000
7	Mar	165	30	80		=B7-C7-D7	=F7+G6	MAXIMUM VALUE	=0.001*G7*B3*1000*1000
8	Apr	50	50	5		=B8-C8-D8	=F8+G7		=0.001*G8*B3*1000*1000
9	May	5	80	0		=B9-C9-D9	=F9+G8		=0.001*G9*B3*1000*1000
10	Jun	0	100	0		=B10-C10-D10	=F10+G9		=0.001*G10*B3*1000*1000
11	Jul	0	150	0		=B11-C11-D11	=F11+G10		=0.001*G11*B3*1000*1000
12	Aug	5	70	0		=B12-C12-D12	=F12+G11		=0.001*G12*B3*1000*1000
13	Sep	10	60	0		=B13-C13-D13	=F13+G12	MINIMUM VALUE	=0.001*G13*B3*1000*1000
14	Oct	55	20	10		=B14-C14-D14	=F14+G13		=0.001*G14*B3*1000*1000
15	Nov	65	10	15		=B15-C15-D15	=F15+G14		=0.001*G15*B3*1000*1000
16	Dec	190	5	120		=B16-C16-D16	=F16+G15		=0.001*G16*B3*1000*1000
17									
18								ΔS(m^3)	=MAX(I5:I16)-MIN(I5:I16)

Sheet1

Figure 2: Rainfall-runoff plot for the catchment

- Western Australia
- Cape region of South Africa
- Parts of central Chile

2. A watershed with a catchment area of $1mi^2$ converts about 60-percent of precipitation into streamflow, the remainder is lost. The watershed response equation is

$$k\frac{dQ}{dt} + Q(t) = P(t) \cdot A \cdot C \qquad (1)$$

where $Q(t)$ is the streamflow leaving the catchment, $P(t)$ is the precipitation entering the catchment, A is the catchment area, C is the precipitation to streamflow conversion fraction, and k is the basin characteristic time constant.

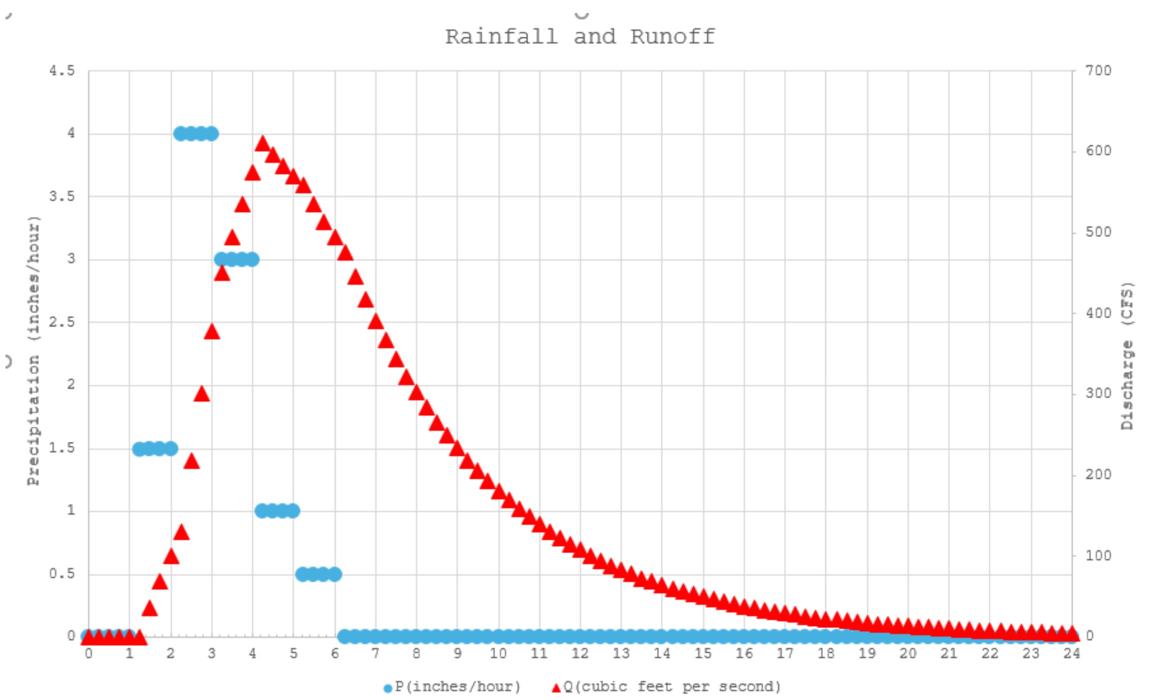

Figure 3: Rainfall-runoff plot for the catchment

Using the information in Figure **??** determine:

a) The maximum discharge rate in cubic feet per second.

b) The time when the maximum discharge occurs.

c) The value in hours of the of the basin time constant k.

d) The total volume in acre feet of precipitation entering the catchment (before any losses)

e) The total volume in acre feet of discharge leaving the catchment

3. Using an appropriate NRCS 24-hour rainfall distribution

   Determine:

   a) The cumulative rainfall depth (inches) for a 50-yr ARI storm in Lubbock, Texas.
   b) The rainfall intensity (inches/hour) for each half-hour increment of the storm.
   c) The maximum rainfall intensity (inches/hour) in any 30-minute interval.

4. The relation between infiltration capacity in mm/hour and the time (in hours) since the start of the experiment as measured with an infiltrometer is depicted in Figure ??.

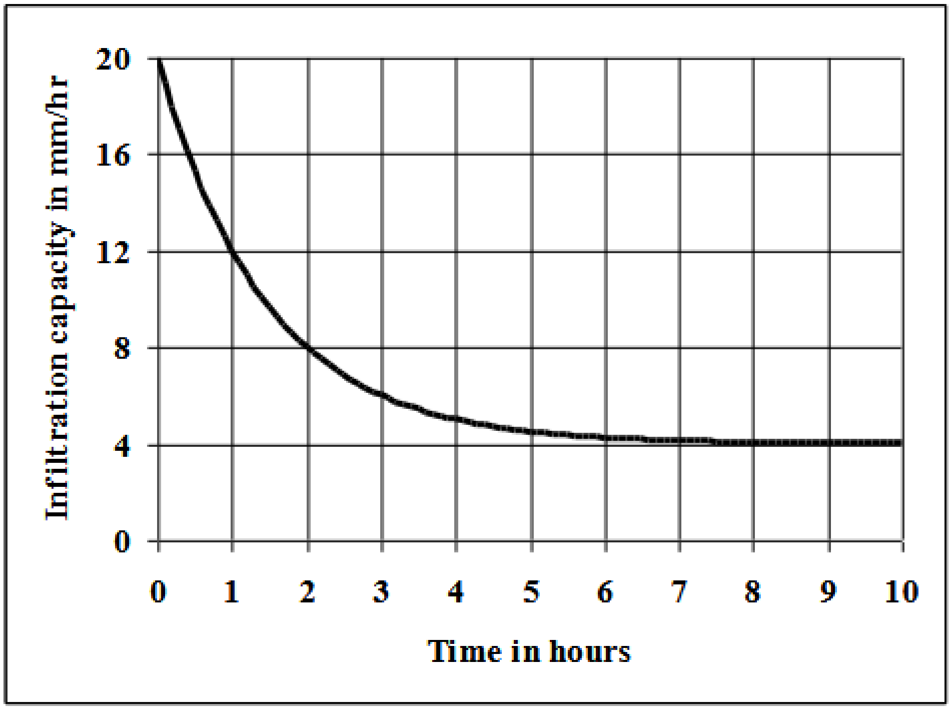

Figure 4: Infiltrometer data for some soil

The relationship is to be described with the Horton infiltration model

$$q(t) = f_c + (f_o - f_c)e^{-kt} \tag{2}$$

Determine:

a) The equilibrium infiltration rate, f_c, in mm/hr.

b) The initial (dry soil) infiltration rate, f_o, in mm/hr.

c) The soil constant k.

d) The total amount of water that will infiltrate into an initially dry soil during a rainstorm with a duration 60 minutes and a constant intensity of 20 mm/h.

e) The total amount of water that will infiltrate into an initially dry soil during a rainstorm with a duration 480 minutes and a constant intensity of 12 mm/h.