University Of Technology
Building and Construction Eng. Dept.
Final Exam – 2015/2016 (1)
Branch :Sanitary and Environmental
Class: 3rd
subject :Hydrology
Time : 3 Hours
Examiner: Lec. Ghydaa AL.Kindi
Date :13/6 / 2016

Answer 4 equation only:

Q1/A For the given information, use the second method to separate hydrograph in its components, and drive the unite hydrograph for a catchment area of 23800km^2?

Time (days)	1	2	3	4	5	6	7	8	9	10	11	12	13
Q (m^3/sec)	2	5	20	200	700	600	120	52	25	12	6	3	0

10degree

Q1/B define five only.

1- Glacial
2- Lapse rate
3- Sleet
4- Current meter
5- Reference Crop Evapotranspiration:
6- DUNE

Q1/C How many cases of Base flow Separation? **10 degree**

Q2/A Draw the storage capacity in a reservoir is nationally divided into three or four parts, distinguished by corresponding levels? **8degree**

Q2/B by Horton infiltration model catchment soil has the following Horton infiltration parameter f_0=100mm/hr, f_c=20mm/hr, k=2 min^{-1}

- plot the infiltration capacity curve with time of this catchment
- plot the accumulative infiltration for this catchment

10degree

Q2/C what's the factors that effect on infiltration? **7degree**

Q3/A Using the Penman method, to estimate ET, given the following data: temperature at water surface = 20°C, temperature of air = 30 °C, relative humidity =45%, wind velocity = 1.5 mph (36 mi/day). The month is July at latitude 30° north, r is given as 0.06, and S is found to be 0.6? **10degree**

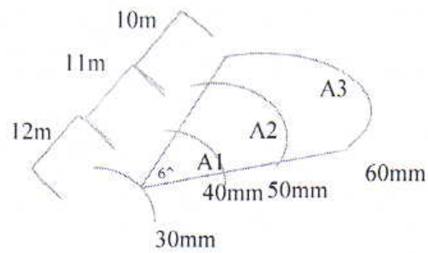
Q3/B Draw and explain the hydrograph component? **5degree**

Q3/C Find out the missing storm precipitation of station 'C' given in the following table:

Station	A	B	C	D	E
Storm precipitation (cm)	9.7	8.3	----	11.7	8.0
Normal Annual precipitation (cm)	100.3	109.5	93.5	125.7	117.5

10degree

Q4/A For fig .below find the average depth of p.p.t use isohyetal method?



10degree

Q4/B there are many type of recording rain gauges? **5degree**

Q4/C find the probable life of the reservoir with initial capacity of 30Mm^3 , if the average annual flow is 60 Mm^3, and the average annual sediment in flow is 200000 Ton , assumed the specific weight of the sediment equal 1.2 gm/cm^3 , assume that 80% of the initial capacity will full with sediment? **10degree**

Capacity -Inflow ratio (C/I)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Trap eff.	87	93	95	95.5	96	96.5	97	97	97	97.5

Q5/A How many cases worth of consideration infiltration? **8degree**

Q5/B A reservoir has the following areas enclosed by contours of various elevations. Determine?

1- Reservoirs capacity
2- Normal pool level

Elevation capacity relation, when the initial elevation is 220m and the final elevation is 300m. **10degree**

Elevation (m)	200	220	240	260	280	300
Area (km^2)	150	175	210	270	320	400

Q5/C explained the suspended load sediment? **7degree**

Good luck

NOTE;

$$\overline{P} = \frac{P_1 + P_2 + \ldots\ldots + P_i + \ldots\ldots P_n}{N} = \frac{1}{N}\sum_{i=1}^{N} P_i$$

$$N = \left(\frac{c_v}{\varepsilon}\right)^2$$

$$c_v = \frac{\sigma_m}{p} * 100$$

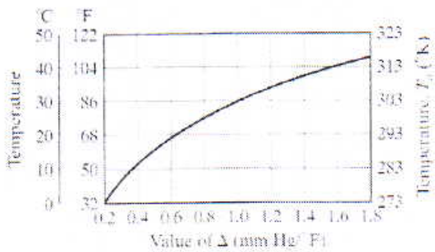
$$\sigma_m = \sqrt{\frac{\sum_{i=1}^{m}(pi - p)^2}{m - 1}}$$

$$v_t = \sqrt{\frac{4 * g * D}{3 * c_d} * \left(\frac{\rho_w}{\rho_a} - 1\right)}$$

$$ET = \frac{\Delta \times H + 0.27E}{\Delta + 0.27}$$

fp =fc +(f0 − fc)e−kt

$$F = f_c t + \frac{f_0 - f_c}{k}(1 - e^{-kt})$$



$$E_s = P + R_1 - R_2 + R_g - T_s - I - \Delta S_s$$

$$F(t) = \left[\frac{f_c}{k}\ln(f_0 - f_c) + \frac{f_0}{k}\right] - \frac{f_c}{k}\ln(f_p - f_c) - \frac{f_p}{k}$$

$$H = R(1 - r)(0.18 + 0.55\ S) - B(0.56 - 0.092\ e^{0}{}_{d}{}^{.5})(0.10 + 0.90\ S)$$

$$E = 0.35(e_a - e_d)\ (1 + 0.0098u_2)$$

TABLE 6.6 Tabulated Values of R. Mean Monthly Intensity of Solar Radiation on a Horizontal Surface.^{a} for Use in the Penman Equation

	Latitude (deg)	J	F	M	A	M	J	J	A	S	O	N	D
North	60	1.3	3.5	6.8	11.1	14.6	16.5	15.7	12.7	8.5	4.7	1.9	0.9
	50	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0
	40	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.5
	30	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
	20	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
	10	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
	0	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
South	10	15.8	15.7	15.1	13.8	12.4	11.6	11.9	13.0	14.4	15.3	15.7	15.8
	20	16.8	16.0	14.6	12.5	10.7	9.6	10.0	11.5	13.5	15.3	16.4	16.9
	30	17.3	15.8	13.6	10.8	8.7	7.4	7.8	9.6	12.1	14.8	16.7	17.6
	40	17.3	15.2	12.2	8.8	6.4	5.1	5.6	7.5	10.5	13.8	16.5	17.8
	50	17.1	14.1	10.5	6.6	4.1	2.8	3.3	5.2	8.5	12.5	16.0	17.8
	60	16.6	12.7	8.4	4.3	1.9	0.8	1.2	2.9	6.2	10.7	15.2	17.5

Answer the equation(1)

Q1/A For the given information, use the second method to separate hydrograph in its components. and drive the unite hydrograph for a catchment area of $23800km^2$?

Time (days)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Q (m^3/sec)	**2**	**5**	**20**	**200**	**700**	**600**	**120**	**52**	**25**	**12**	**6**	**3**	**0**

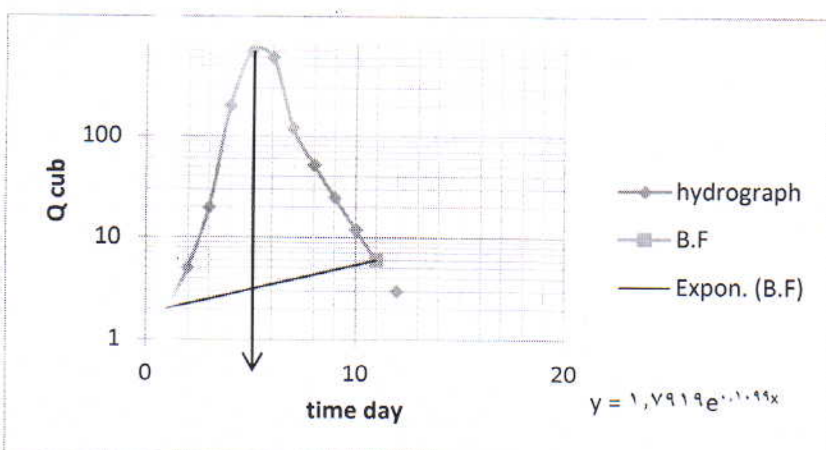
time	Q cubes	B.F	D.F=Q-BF	U.H=D.F/DEBTH
1	2	2.00	0.00	0
2	5	2.23	2.77	0.448049479
3	20	2.49	17.51	2.834429633
4	200	2.78	197.22	31.92792887
5	700	3.10	696.90	112.8210679
6	600	3.46	596.54	96.57359967
7	120	3.87	116.13	18.80081317
8	52	4.32	47.68	7.719501944
9	25	4.82	20.18	3.26726812
10	12	5.38	6.62	1.072076311
11	6	6.00	0.00	0
12	3	3.00	0.00	0
13	0	0.00	0.00	0
		43.46	1701.54	275.4647351

N Days=$0.8*23800^{0.2}$ =6.002Days

Volume of D.R=**1701.54***1*24*3600=147013056m^3

Depth=21698496/23800*1000*1000=0.00617702m=6.17702mm

CHECK =275.4647351*24*3600/23800*1000*1000=0.001000006m=1mm



1- Glacial

As glaciers move over their beds, they entrain and move material of all sizes. Glaciers can carry the largest sediment, and areas of glacial deposition often contain a large number of glacial erratics, many of which are several metres in diameter. Glaciers also pulverize rock into "glacial flour", which is so fine that it is often carried away by winds to create loess deposits thousands of kilometres afield. Sediment entrained in glaciers often moves approximately along the glacial flowlines, causing it to appear at the surface in the ablation zone.

1- Lapse rate :-

A vertical temp, gradient: the rate of change of temp, with height of atmosphere from ground surface.

3-Sleet مطر متجمد:-

Solid grains of ice formed by the freezing of large melted ice crystals falling through a layer of subfreezing air near the earth surface

3- **Current meter**: electronic pulses determine water velocity. Can be used in large bodies of water like oceans to measure the current.
4- **Reference Crop Evapotranspiration**: the rate of evapotranspiration from an area planted with a specific (reference) crop, where water availability is not a limiting factor

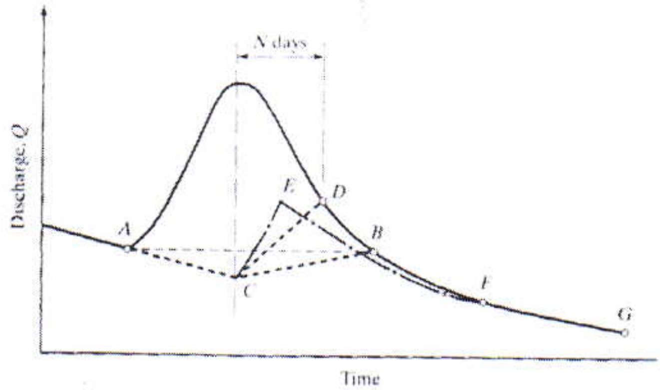
5- **DUNE:**-Movement of particales through the fluid of flow as suspended material.

Q6/C how many cases of Base flow Separation?

Baseflow Separation

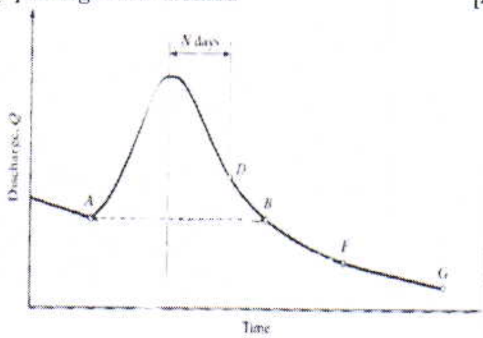
There are several graphical methods for baseflow separation (to find out direct runoff):

- [1] Draw a horizontal line (AB) from the point at which surface runoff begins (A) to the intersection on the recession part (B)
- [2] Project the initial recession curve downward from A to C, connect point D to point C by a straight line. Point D is A0.2 days after the peak (A is the drainage area in mi2)
- [3] Project the line AC along the slope to the left of A and then connect points C and B
- [4] Extend GF backward until reaching point E below the inflection point. Connect between E and C

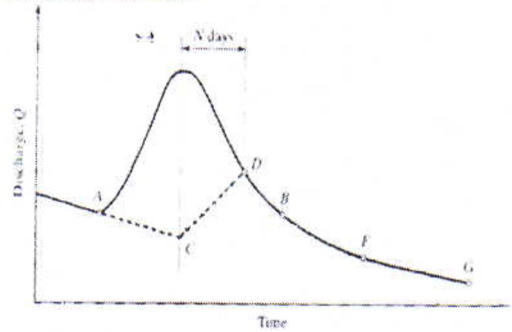


Baseflow Separation

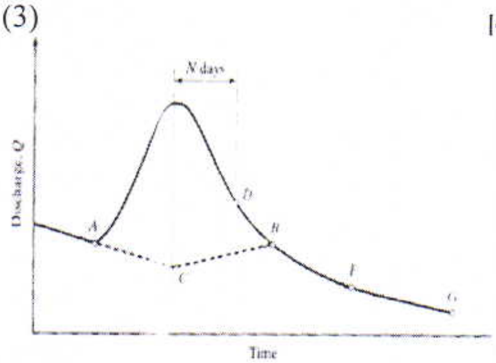
[1] Straight line method



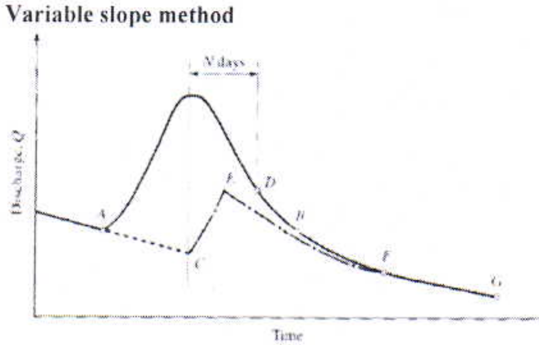
[2] Fixed base method



(3)



[4] Variable slope method



Q2/A Draw the storage capacity in a reservoir is nationally divided into three or four parts, distinguished by corresponding levels?

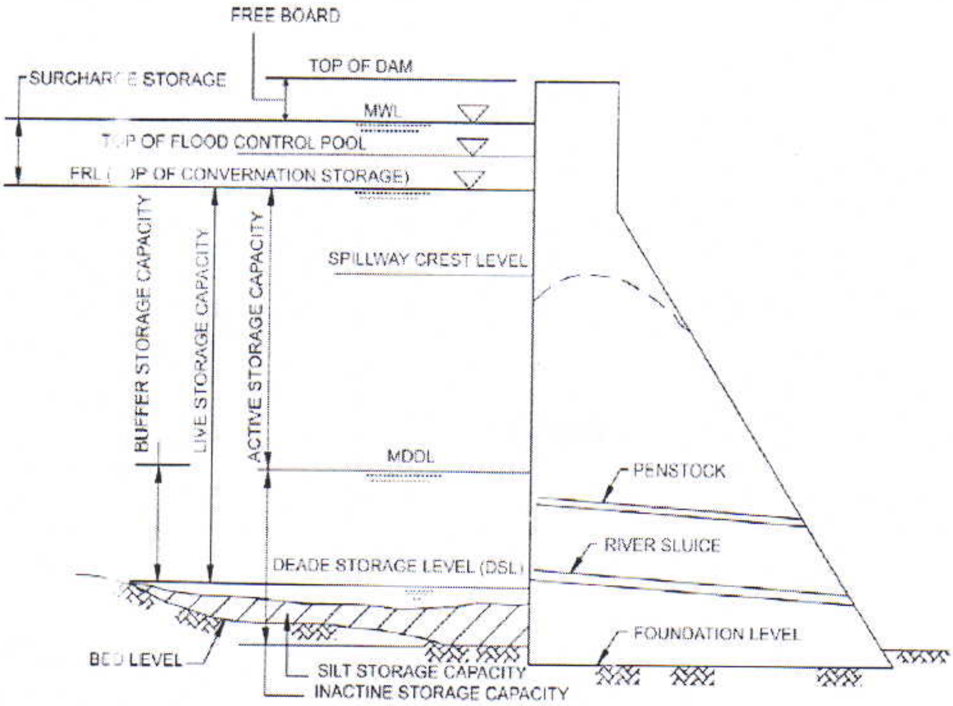
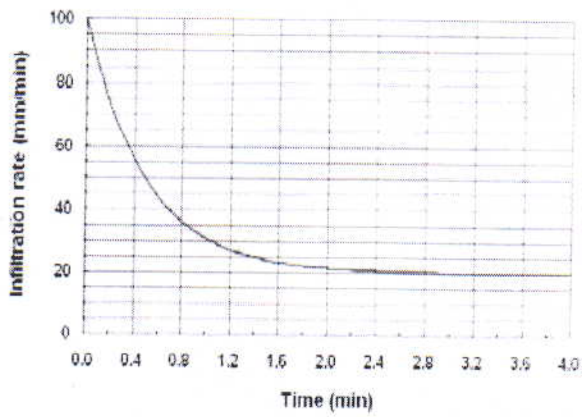


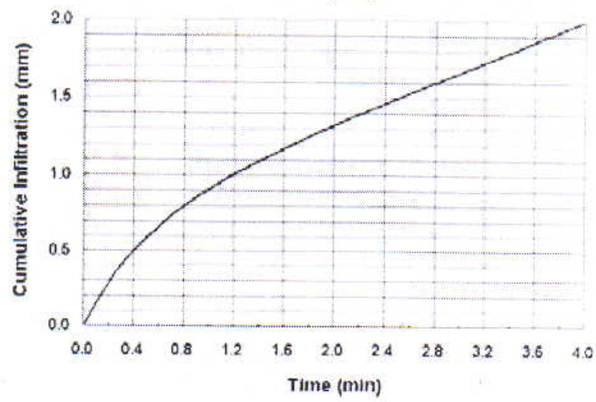
FIGURE 1. SCHEMATIC DIAGRAM SHOWING STORAGE ZONES (OF CAPACITY) NOMENCLATURE

Q2/B by Horton infiltration model catchment soil has the following Horton infiltration parameter f_0=100mm/hr, f_c=20mm/hr, k=2 min^{-1}

- plot the infiltration capacity curve with time of this catchment
- plot the accumulative infiltration for this catchment

t (min)	f_p (mm/hr)	F (mm)
0.0	100.00	0.00
0.2	73.63	0.29
0.4	55.95	0.50
0.6	44.10	0.67
0.8	36.15	0.80
1.0	30.83	0.91
1.2	27.26	1.01
1.4	24.86	1.09
1.6	23.26	1.17
1.8	22.19	1.25
2.0	21.47	1.32
2.2	20.98	1.39
2.4	20.66	1.46
2.6	20.44	1.53
2.8	20.30	1.60
3.0	20.20	1.67
3.2	20.13	1.73
3.4	20.09	1.80
3.6	20.06	1.87
3.8	20.04	1.93
4.0	20.03	2.00
4.2	20.02	2.07





Q2/C what's the factors that effect on infiltration

1- Soil structure: shapes of particles and the way the particles are packed

2- Permeability: high permeability allows water to easily infiltrate

3- Slope (topography): Less infiltration is expected with increasing the surface slope

4- Coarse-grained sandy or gravely soils have large spaces between each grain and allow water to infiltrate quickly. One may expect in heavy rainy days that no runoff will be generated!!

5- Similarly, a clayey soil will resist infiltration and the surface will become covered with water even in light rains

Q3/A Using the Penman method, to estimate ET, given the following data: temperature at water surface = 20°C, temperature of air = 30 °C, relative humidity =45%, wind velocity = 1.5 mph (36 mi/day). The month is July at latitude 30° north, r is given as 0.06, and S is found to be 0.6

- First of all, determine the evaporation. To do so, use the following equation:

  E= 0.35(ea- ed)(1 0.0098 u2)

- compute ea and ed. Use the following equation for ea which is the saturated vapor pressure at the temperature of air (33 °C)

$$e_{sat}(T) = e_0 = 6.11\ e^{\left(\frac{17.3T}{T+237.3}\right)}$$

- ea = 42.587 mbar = 32 mm Hg
- ed = Rh × ea = 37.8 × 0.45 = 17.04 mm Hg
- To find out E, substitute in the above equation to get:
- E = 0.35 × (32 – 17.04) (1 + 0.0098 × 36) = 7.08 mm/day
- Now, we need to find out the net amount of energy finally remaining at the surface (H) Use:

$$H = R(1-r)(0.18+0.55\ S) - B(0.56-0.092\ e_d^{0.5})(0.10+0.90\ S)$$

- From the previous table, R = 16.56 mm (mean monthly total radiation)
- r = 0.06 (the estimated percentage of reflecting

surface)

- S = 0.6 (the actual duration of bright sunshine to the maximum possible duration of bright sunshine)
- B = 16.2 (a temperature dependent coefficient)

<u>Thus</u> $H = R(1-r)(0.18+0.55\ S) - B(0.56-0.092\ e_d^{0.5})(0.10+0.90\ S)$

- $H = 16.56\times(1 - 0.06)\times(0.18+0.55\times0.6) - 16.2\times(0.56 - 0.092\times17.04^{0.5}) \times (0.10 + 0.90\times0.6) = 6.07$ mm/day

TABLE 6.6 Tabulated Values of R. Mean Monthly Intensity of Solar Radiation on a Horizontal Surface.[a] for Use in the Penman Equation

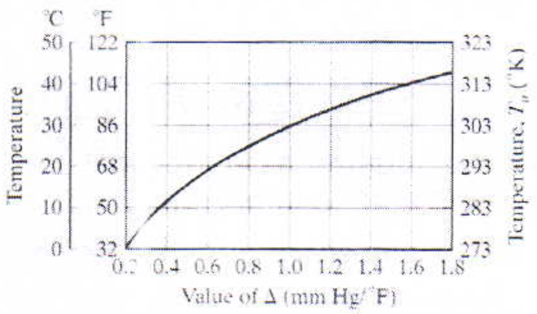
	Latitude (deg)	J	F	M	A	M	J	J	A	S	O	N	D
North	60	1.3	3.5	6.8	11.1	14.6	16.5	15.7	12.7	8.5	4.7	1.9	0.9
	50	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0
	40	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.5
	30	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
	20	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
	10	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
	0	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
South	10	15.8	15.7	15.1	13.8	12.4	11.6	11.9	13.0	14.4	15.3	15.7	15.8
	20	16.8	16.0	14.6	12.5	10.7	9.6	10.0	11.5	13.5	15.3	16.4	16.9
	30	17.3	15.8	13.6	10.8	8.7	7.4	7.8	9.6	12.1	14.8	16.7	17.6
	40	17.3	15.2	12.2	8.8	6.4	5.1	5.6	7.5	10.5	13.8	16.5	17.8
	50	17.1	14.1	10.5	6.6	4.1	2.8	3.3	5.2	8.5	12.5	16.0	17.8
	60	16.6	12.7	8.4	4.3	1.9	0.8	1.2	2.9	6.2	10.7	15.2	17.5

- Finally, we have to compute ET using the following equation:

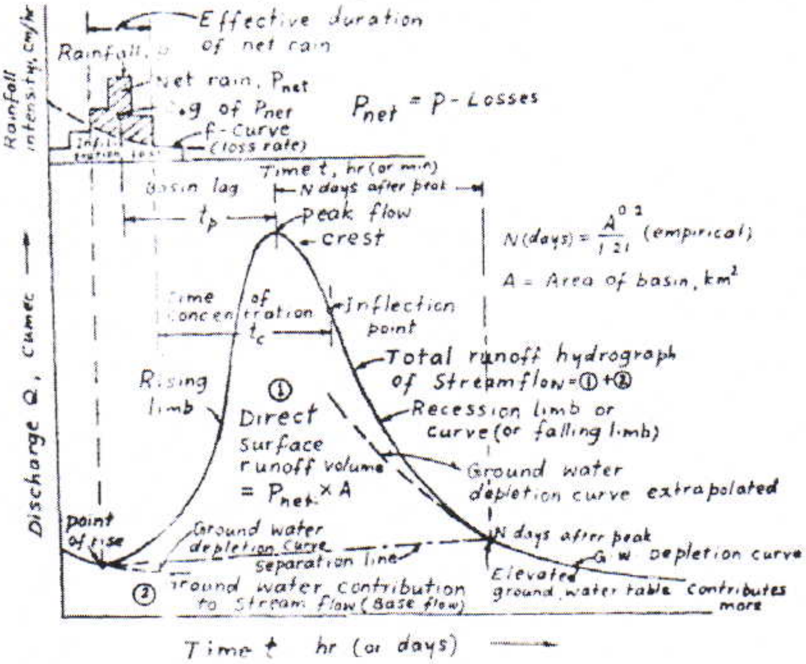
$$ET = \frac{\Delta \times H + 0.27E}{\Delta + 0.27}$$

- Thus, we need to figure out the value of Δ. From the preceding figure and at air temperature of 30 °C we find that Δ = 1.0
- Substituting in the above equation [(1.0×6.07 +0.27×9.82)]/(1.0+0.27) gives a value of ET of 8.157mm/day

$$ET = \frac{\Delta \times H + 0.27E}{\Delta + 0.27}$$



Q3/B draw and explain hydrograph component



Q3/C Find out the missing storm precipitation of station 'C' given in the following table:

Station	**A**	**B**	**C**	**D**	**E**
Storm precipitation (cm)	9.7	8.3	----	11.7	8.0
Normal Annual precipitation (cm)	100.3	109.5	93.5	125.7	117.5

Solution

In this example the storm precipitation and normal annual precipitations at stations A, B, D and E are given and missing precipitation at station 'C' is to be calculated whose normal annual precipitation is known. We will determine first that whether arithmetic mean or normal ratio method is to be applied.

10% of Nc = 93.5 x 10/100 = 9.35

After the addition of 10% of Nc in Nc, we get 93.5 + 9.35 = 102.85

And by subtracting 10% we get a value of 84.15

So Na, Nb, Nd or Ne values are to be checked for the range 102.85 to 84.15.

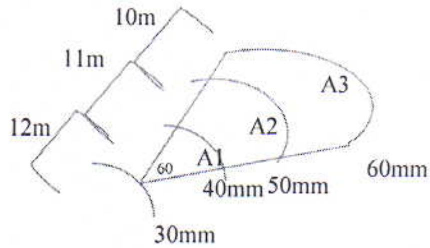
If any value of Na, Nb, Nd or Ne lies beyond this range, then normal ratio method would be used. It is clear from data in table above that Nb, Nd and Ne values are out of this range so the normal ratio method is applicable here, according to which

$$P_x = \frac{1}{n}\sum_{i=1}^{i=n}\frac{N_x}{N_i}P_i$$

Pc = (1/4)(93.5 x 9.7/100.3 + 93.5 x 8.3/109.5 + 93.5 x 11.7/125.7 + 93.5 x 8.0/117.5) = 7.8 cm

Q4/A ***For fig .below find the average depth of p.p.t use isohyetal method***

Solution/



$$A1 = r^2 * \frac{\theta(rad)}{2} \rightarrow 12^2 * \frac{\pi}{3*2} = 75.398m^2$$

$$A2 = r^2 * \frac{\theta(rad)}{2} \rightarrow 23^2 * \frac{\pi}{3*2} - A1 = 201.586m^2$$

$$A3 = r^2 * \frac{\theta(rad)}{2} \rightarrow 33^2 * \frac{\pi}{3*2} - A2 - A1 = 293.215m^2$$

Point	P (mm)	Pi (mm)	Ai km2	pi*Ai
A1	40-30	35	75.3982	2638.937
A2	50-40	45	201.58555	9071.34975
A3	60-50	55	293.215	16126.825
			570.19875	27837.11175

P.P.T=(27837.11175/570.19875)= 48.82mm

Q1/B DEFINE FIVE ONLY ;

Q4/B There are many types of recording rain gauges:-

1) Tipping bucket rain gauge.قياس مصيدة دلو المطر
2) Weighing bucket rain gaugeوزن دلو مقياس المطر .
3) Siphon rain gaugeسيفون مقياس المطر .
4) Radar measurementقياس الرادار .
5) Satellite measurementقياس الأقمار الصناعية .

Q4/C find the probable life of the reservoir with initial capacity of $30Mm^3$, if the average annual flow is 60 Mm^3, and the average annual sediment in flow is 200000 Ton , assumed the specific weight of the sediment equal 1.2 gm/cm^3 , assume that 80% of the initial capacity will full with sediment?

Capacity -Inflow ratio (C/I)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Trap eff.	87	93	95	95.5	96	96.5	97	97	97	97.5

Solution /

The weight of the sediments =200000 ton

$20000*1000*1000=2*10^{11}$ gm

Vol. of sediment $= \frac{2*10^{11}}{1.2*10^6} = \frac{1}{6} * 10^{6} m^3$

Capacity of reservoir	C/I	Trap eff.	Average trap eff.	Vol. of sediment
30	0.5	0.96	0	0
24	0.4	0.955	0.9575	$\frac{1}{6}*10^6*0.9575$
18	0.3	0.95	0.9525	$\frac{1}{6}*10^6*0.9525$
12	0.2	0.93	0.94	$\frac{1}{6}*10^6*0.94$
6	0.1	0.87	0.9	$\frac{1}{6}*10^6*0.90$

$\frac{30}{?} = \frac{100}{80}$

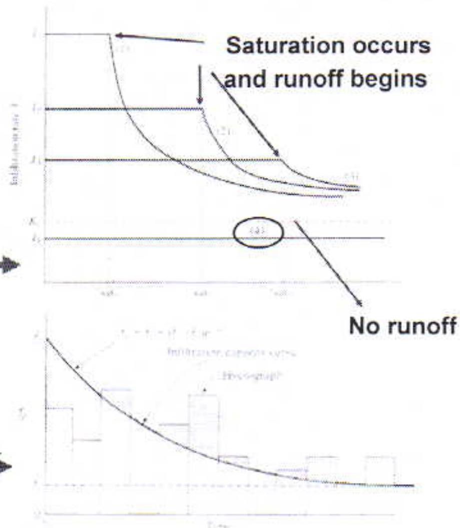
Capacity vol.	No. of years
6	$6*10^6/\frac{1}{6}*10^6*0.9575 = 37.6$
6	37.8
6	38.3
6	40
$\sum$	153.7 years

Q5/A How many cases worth of consideration infiltration consideration: There are three cases worth of

[1] Rainfall rate ≤ Saturated hydraulic conductivity (case 4)

[2] Rainfall rate > Saturated hydraulic conductivity but Rainfall rate ≤ Infiltration capacity (case 1,2, and 3)

[3] Rainfall rate > Infiltration capacity



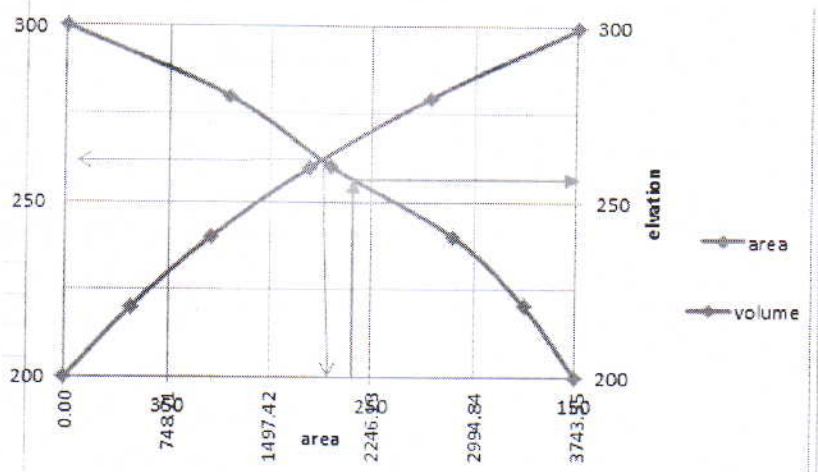
Q5/B A reservoir has the following areas enclosed by contours of various elevations. Determine?

1- Reservoirs capacity
2- Normal pool level

Elevation capacity relation, when the initial elevation is 220m and the final elevation is 300m. 10degree

Elevation (m)	200	220	240	260	280	300
Area (km^2)	150	175	210	270	320	400

H	A	veration Volume	Volume
200	150	0.00	0.00
220	175	487.02	487.02
240	210	576.70	1063.72
260	270	718.12	1781.84
280	320	883.94	2665.78
300	400	1077.77	3743.55



$$A_2 = \sqrt{A1 * A3} = \sqrt{175 * 400} = 264.57 km^2$$

$$a = \frac{H1*H3-H2^2}{H1+H3-2*H2} = \frac{220*300-264.57^2}{220+264.57-2*300} = 34.629$$

$A=K(H-a)^b$

$A= K(H-34.629)^b$

$Ln\ A = \ln k + \ln(H-34.629)^b$

$LnA = \ln k + b \ln (H-34.629)$

$Y= z+b*x$

$Yx= zx+ bx^2$

H	A	Y=ln(A)	X=ln(H-a)	X^2	X*y
200	150	5.010	5.109	26.101	25.545
220	175	5.164	5.222	27.248	26.966
240	210	5.347	5.324	28.344	28.467
260	270	5.598	5.4177	29.37	30.328
280	320	5.768	5.502	30.25	31.735
300	400	5.99	5.5811	31.149	33.431
		32.877	32.147	172.462	176.472

32.147= z + 32.147b…………………(1)

Z=(32.147-32.147b)

176.472= 32.147*z+172.462b

176.472=32.147*(32.147-32.147b)+ 172.462b

176.472= 1033.429-1033.429b +172.462b

176.472-1033.429=-860.967b

-856.957= -860.967b

b =0.995

z = 32.147-32.147*0.995

z =0.1497

Q5/C explained the suspended load sediment?

Movement of particle through the fluid of the flow as suspended material

1- Ripple or comptation
2- Ripple with dune
3- Dune
4- Flat surface
5- Sandy wave
6- antinode