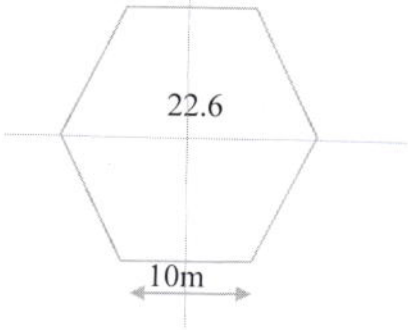
University Of Technology
Building and Construction Eng. Dept.
Final Exam – First Attempt – 2014/2015

Branch :	**1** Sanitary	**Class:**
subject :	Hydrology	**Time : 3 Hours**
Examiner :		**Date : /6 / 2015**

Answer / equation only.

Q1/A the depths of p.p.t for a hexagon catchment are :(25, 27, 36, 52.1, 39.7, 40.5, 22.6)find depth by theissen polygon?

Point	Pi (mm)
S1	22.6
S2	25
S3	27
S4	36
S5	52.1
s6	39.7
s7	40



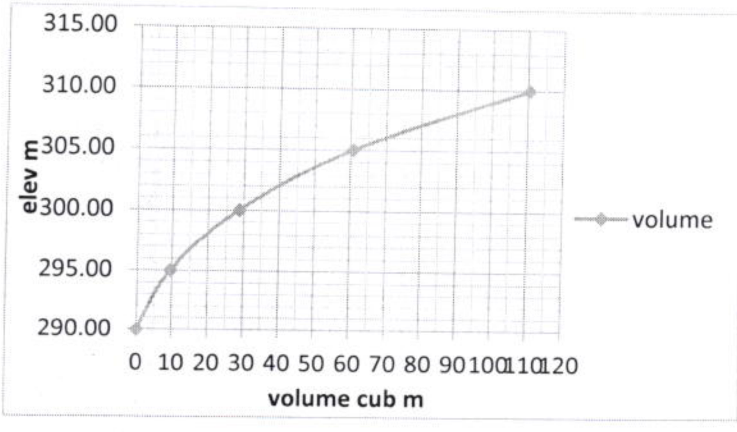
Q1/B what is the effect of Rainfall and Direct Runoff?

Q2/A For the given information, use the third method to separate the hydrograph in to its components, and derive the 6 hr unit hydrograph from the 4hr unit hydrograph.

Time (hr)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
Q (m^3/sec)	0	10	30	60	86	135	161	172	165	142	123	104	88	73	56	43	30	19

Q2/B what is infiltration and what are these factors?

Q3/A find the volume -elevation relation (factor) for the following information H_1=295m, H_2=305m?



Q3/B what are purposes of reservoir?

Q4/A uses curve method to derive 2hr U.H from the ordinates of 4hr U.H?

time hr	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
U:H	0	8	20	43	80	110	130	146	150	142	130	112	90	70	52	38	27	20

Q4/B define only five?

1- Trap efficiency
2- Antinode
3- Lapse rate
4- Glaze
5- Hydrology application
6- Sleet

Q5/A a catchment has eight rain gauge station the annual rain fall is given in the list below, what should be the minimum number of the rain gauges in the catchment for estimating the mean rain fall with an error less 9%?

Rain gauge	Annual rain fall (mm)
A	70.8
B	77.6
C	92
D	150.8
E	110.4
f	100.8
G	132.3
H	88.5

Q5/B What're cases of runoff:

Q6/A calculate the terminal velocity at (0.6mm) dia, of rain drop falling in air at standard atmosphere (101.3kpa &20°c)? $\rho_a = 1.2kg/m^3$

Drop diameter (mm)	C_d
0.2	1.2
0.4	1.66
0.6	1.07
0.8	0.815
1	0.671

Q6/B what are meters that used in measurement flow?

Q7/A find out the sensitivity of the infiltration capacity curve to different decay coefficients (k) assuming that f =2.9 in/h and fc=0.5in/hr? Assume k=0.15.0.3, 0.45hr^{-1}

Q7/B what are the factors affecting evaporation and what are the method for estimating evaporation

Q8/A Using the Penman method, estimate ET, given the following data: temperature at water surface = 22°C, temperature of air = 33 °C, relative humidity =45%, wind velocity = 1.5 mph (36 mi/day). The month is July at latitude 33° north, r is given as 0.07, and S is found to be 0.7?

Q8/B Classified the Streams with scam?

NOTE

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

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

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

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

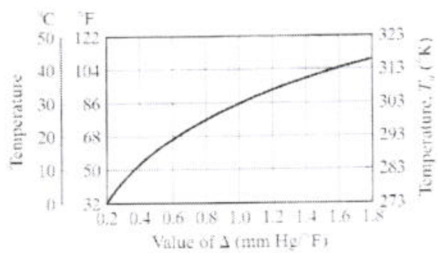
fp =fc +(f0 −fc)e−kt

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

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

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

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



$$A = r^2 * \frac{\theta(rad)}{2}$$

E 0.35(ea - ed)(1+ 0.0098 U_2)

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

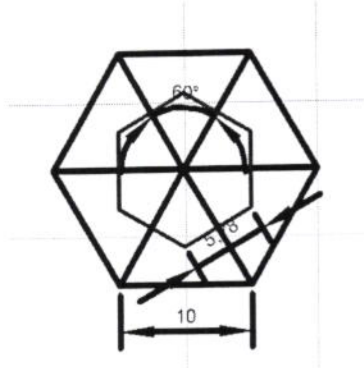
TABLE 6.6 Tabulated Values of *R*. Mean Monthly Intensity of Solar Radiation on a Horizontal Surface,[a] for Use in the Penman Equation

	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

GOOD LUCK

Answer the equation

HW(OUT)the depths of p.p.t for a hexagon catchment are :(25,27,36,52.1,39.7,40.5,22.6)find depth by theissen polygon?



H=5/tan(30)= 8.66m

*Atri=0.5*10*8.66=43.3m²*

*Atotal=6*Atrin =259.8m²*

$D = \sqrt{5^2 + 8.66^2} = 10m$

*H1=5m, b=2*tan(30)*5=5.78m*

*A1=6*0.5*5*5.78=86.7m²*

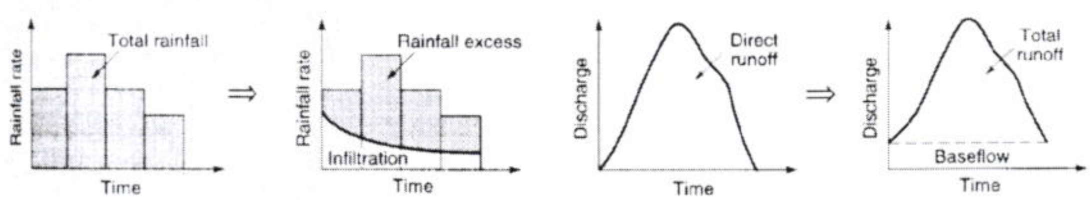
A2=A3=A4=A5=A6=A7= (259.8-86.7)/6 =28.85m²

Point	Pi (mm)	Ai km2	pi*(Ai/At)
S1	22.6	86.7	7.5420323
S2	25	28.85	2.776174
S3	27	28.85	2.9982679
S4	36	28.85	3.9976905
S5	52.1	28.85	5.7855466
s6	39.7	28.85	4.4085643
s7	40	28.85	4.4418784
		259.8	**31.950154**

Q1/B what is the effect of Rainfall and Direct Runoff?

-
- When rainfall event occurs, a portion of the hyetograph produces significant response

The portion of input producing the response is called effective water input (more commonly is called effective precipitation or excess precipitation)
The portion of total output constituting the response is called event flow (or storm runoff, direct runoff, or quickflow)
The volume of eventflow equals the volume of effective water input

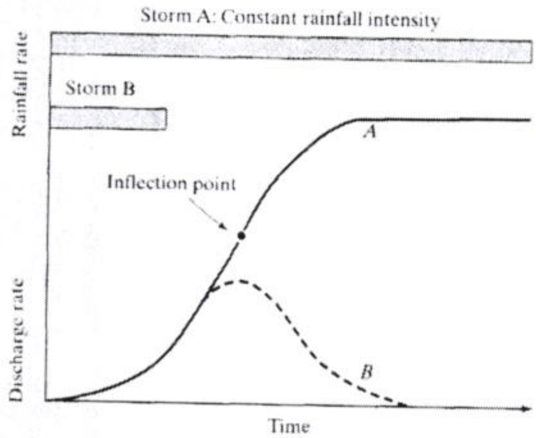


Storm Hydrograph Under Constant Rainfall Intensity

- If the rainfall maintains a constant intensity for a long enough period of time, a state of equilibrium discharge is reached
- The inflection point on curve A often indicates the time at which storage in the watershed begins to fill

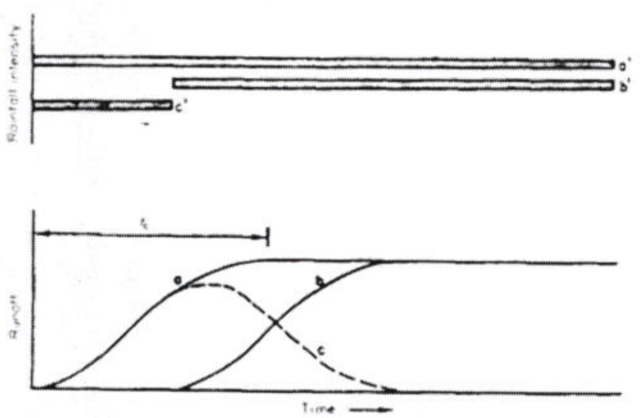
- As rainfall continues, maximum storage capacity is attained and equilibrium is reached (rainfall input equals runoff output)

Once peak flow has been reached, the DRH begins to descend and the source of supply is coming from water accumulated within the watershed such as channel storage



Storm Hydrograph Under Constant Rainfall
Intensity and different durations

- The same depth of rainfall delivered over two different durations will produce different runoff rates
- The influence of duration on the hydrograph of runoff can be seen from the figure, where a uniform-intensity storm causes the hydrograph of "a"
- Such storms may be defined as covering the whole catchment area, over which the depth of rainfall is reasonably constant
- After a certain time, tc, the time of concentration, the rate of runoff becomes constant
- "a" and "b" are the result of rainfalls a' and b' respectively. Their subtraction leaves the short-period rain c' and its resulting hydrograph "c", which is the typical shape of most natural hydrographs

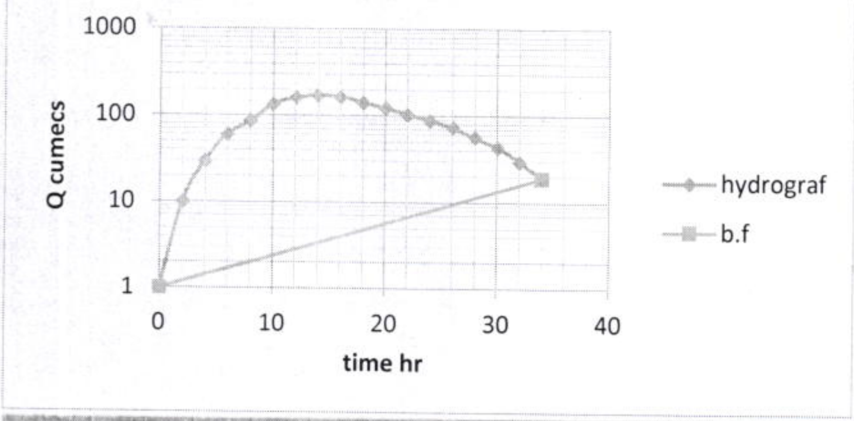


Q2/A For the given information, use the third method to separate the hydrograph in to its components, and derive the 6 hr unit hydrograph from the 4hr unit hydrograph.

Time (hr)	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
Q (m^3/sec)	0	10	30	60	86	135	161	172	165	142	123	104	88	73	56	43	30	19

Depth = 1383.82*2*3600/7777*1000000 =0.00128m [1.2815mm]

Depth of U.H = 1080.14*2*3600/7777*1000000 = 0.001000001m[1mm]



time hr	Q cumecs	b.f	d.r.f	U.H 4hr	s curve 4hr	lag 6hr	abs	U.H 6hr
0	1	١,٠٠	0.00	0.00	0.00	0.00	0.00	0.00
2	10	١,١٩	8.81	6.88	6.88	0.00	6.88	4.59
4	30	١,٤١	28.59	22.31	22.31	0.00	22.31	14.88
6	60	١,٦٨	58.32	45.52	52.40	0.00	52.40	34.93
8	86	٢,٠٠	84.00	65.57	87.88	6.88	81.00	54.00
10	135	٢,٣٨	132.62	103.52	155.92	22.31	133.61	89.07
12	161	٢,٨٣	158.17	123.46	211.34	52.40	158.94	105.96
14	172	٣,٣٦	168.64	131.63	287.55	87.88	199.67	133.11
16	165	٤,٠٠	161.00	125.67	337.01	155.92	181.09	120.73
18	142	٤,٧٥	137.25	107.13	394.68	211.34	183.34	122.22
20	123	٥,٦٥	117.35	91.60	428.61	287.55	141.06	94.04
22	104	٦,٧٢	97.28	75.93	470.61	337.01	133.60	89.06
24	88	٧,٩٩	80.01	62.45	491.06	394.68	96.38	64.25
26	73	٩,٥٠	63.50	49.56	520.17	428.61	91.56	61.04
28	56	١١,٣٠	44.70	34.89	525.95	470.61	55.34	36.89
30	43	١٣,٤٤	29.56	23.08	543.25	491.06	52.19	34.79
32	30	١٥,٩٨	14.02	10.95	536.89	520.17	16.72	11.15
34	19	١٩,٠٠	0.00	0.00	543.25	525.95	17.30	11.53
	1498	114.18	1383.82	1080.14				

Q2/B what is infiltration and what are these factors?

What is Infiltration?

1- Infiltration is the process by Ground Surface which water (precipitation or irrigation) on the ground surface enters the soil

2- When water moves downward then this is percolation

3- Infiltration rate f(t) is a measure of the rate at which a particular soil is able to absorb rainfall or irrigation

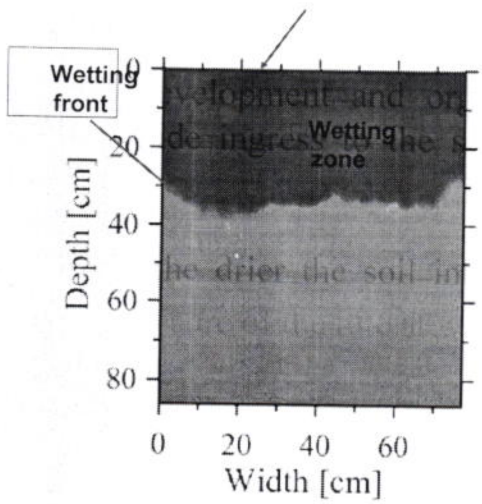
4- It is measured in inches per hour or millimeters per hour

Soil Factors that Controls Infiltration

1- Vegetation cover, root development and organic content: this promotes infiltration since roots provide ingress to the soil, organic matter creates a sponge-like surface

2- Initial moisture content: the drier the soil initially, the larger will be the infiltration

3- Soil texture: characterizes the size and number of the passages through which water must flow



Soil

Factors that Controls Infiltration

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

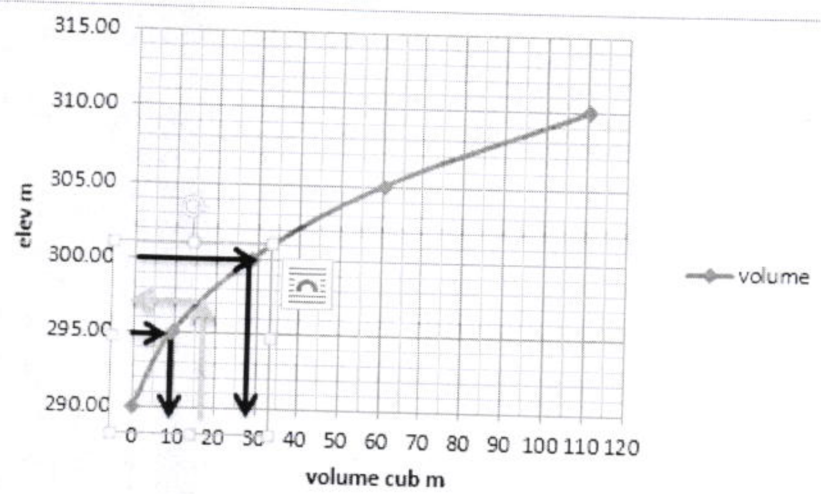
2- Permeability: high permeability allows water to easily infiltrate

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 find the volume -elevation relation for the following information H_1=295m ,H_2=305m?



$$v_2 = \sqrt{v_1 * v_3} \gg v_2 = \sqrt{9.424988 * 28.66108} \gg v_2 = 16.4356m^3$$

From fig above found H_2=297m from the v_2=16.4356m^2

$$a = \frac{H_1 * H_3 - H_2^2}{H_1 + H_3 - 2 * H_2} \gg \frac{295*300-299^2}{295+300-2*299} = 291m$$

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

$v=k(H-285)^b$ Takeln for two side of eq

Ln v = ln k + ln $(H-285)^b$ → ln v=ln k+b ln (H-291)

Y =ln A , x = ln(H-285) , z = ln k

Y= nz +b*x ---→ (1)

Multiply eq above by x to found eq (2)-----→ xy = k*x +b*x^2

solve two eq to find b and k

H	A	varation volume	volume	y=ln(v)	x=ln(H-291)	x^2	Xy
290.000	1.100	0.000	0.000	0.000	0.000	0.000	0.000
295.000	2.800	9.425	9.425	2.243	1.386	1.922	3.110
300.000	5.000	19.236	28.661	3.356	2.197	4.828	7.373
305.000	7.900	31.975	60.636	4.105	2.639	6.965	10.833
310.000	12.200	49.862	110.498	4.705	2.944	8.670	13.854
				14.409	9.167	22.384	35.169

Now

Eq (1)---→ 14.409=5z+9.167b

Eq (2) --→ 36.169=9.167*z+22.384b solve

Z=(14.409-9.167b)/5 ----→ 36.169=9.167*((14.409-9.167b)/5)+22.384b

B=1. 7485 ---→ b=1. 7485

Z=-0.3238 ----→ k =0.7233782

$v=0.7233782\ (H-285)^{1.7485}$

Q3/B what is purposes of reservoir?

- Storage and control for water irrigation
- storage and diversion of water for domestic uses
- water supply for industries
- development of Hydropower

5- increasing water depth for navigation

6- Storage Space for flood Control

7- Reclamation of low land

Q4/A uses curve method to derive 2hr U.H from the ordinates of 4hr U.H?

time hr	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
U:H	0	8	20	43	80	110	130	146	150	142	130	112	90	70	52	38	27	20

Q15\use s curve method to derive 2hr U.H from the ordinates of 4hr U.H?

Time hr	U.H	4hr s curve	lag 2hr	abs =4hr - lag 2hr	2 hr U.H = abs *4/2
0	0	0	0	0	0
2	8	8	0	8	16
4	20	20	8	12	24
6	43	51	20	31	62
8	80	100	51	49	98
10	110	161	100	61	122
12	130	230	161	69	138
14	146	307	230	77	154
16	150	380	307	73	146
18	142	449	380	69	138
20	130	510	449	61	122
22	112	561	510	51	102
24	90	600	561	39	78
26	70	631	600	31	62
28	52	652	631	21	42
30	38	669	652	17	34
32	27	679	669	10	20
34	20	689	679	10	20

Trap Efficiency ([illegible]) كفاءة القنص

IS the ratio between the total Sediment in the reservoir to the total Sediment comes by the ~~reservoir~~ flow

6- Anti node

1- Lapse rate :-

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

a) Glaze :-

Is the ice coaling generally clear and smooth, but usually containing some air packets formed or exposed surface by the freezing of super cooled water deposited by rain or drizzle.

2- Hydrology application is in :-

1. Design and operation of water reservoir projects.
2. To estimate the magnitudes of flow floods at different of floods of year.
3. To decide reservoir capacity, spillway discharge.
4. To decide dimension of hydraulic structure.

3- Sleet :-

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

Q5/A a catchment has eight rain gauge station the annual rain fall is given in the list below, what should be the minimum number of the rain gauges in the catchment for estimating the mean rain fall with an error less 9%?

Rain gauge	Annual rain fall (mm)
A	70.8
B	77.6
C	92
D	150.8
E	110.4
f	100.8
G	132.3
H	88.5

Rain gauge	Annual rain fall (mm)	$(pi-p)^2$
A	70.8	1030.4
B	77.6	640.09
C	92	118.81
D	150.8	2294.41
E	110.4	56.25
f	100.8	4.41
G	132.3	864.36
H	88.5	207.36
	∑ annual rain=903.2	$\sum(pi-p)^2$=5216.1

$$p=\frac{\sum \text{annual rain}}{number\ gauge}\rightarrow\frac{903.2}{8}=112.9$$

$$\sigma_m=\sqrt{\frac{\sum_{i=1}^{m}(pi-p)^2}{m-1}}\rightarrow\sqrt{\frac{\sum_{i=1}^{8}5216.1}{7}}=27.298$$

$$c_v=\frac{\sigma_m}{p}*100\rightarrow\frac{27.298}{112.9}*100=24.18$$

$$N=(\frac{c_v}{\varepsilon})^2\rightarrow(\frac{24.18}{7})^2=11.93\approx 12$$

Q5/B What's Cases of runoff:

1. **Infiltration excess overland flow**
2. **Saturation excess overland flow**
3. **Antecedent soil moisture**
4. **Subsurface return flow**

Q6/A calculate the terminal velocity at (0.6mm) dia, of rain drop falling in air at standard atmosphere (101.3kpa &20°c)?

Solution/

Cd=1.07 from table, at 20oc $\rho_w=998kg/m^3$ & $\rho_a=1.2kg/m^3$

$$v_t=\sqrt{\frac{4*g*D}{3*c_d}*(\frac{\rho_w}{\rho_a}-1)}\rightarrow\sqrt{\frac{4*9.81*0.6}{3*1.07}*(\frac{998}{1.2}-1)}=78.05\ m/sec$$

Q6/B what are meters using in measure flow?

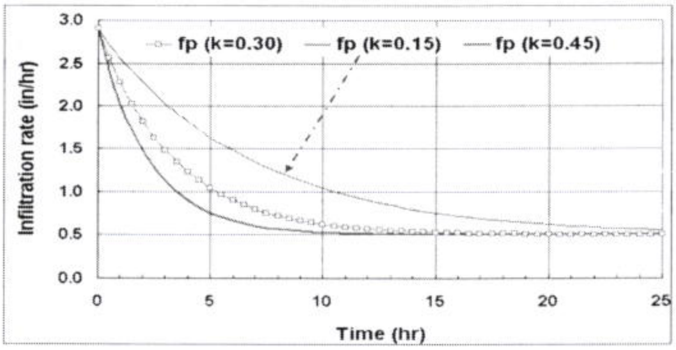
1. **Pygmy meter**: a wheel is rotated by water flow and the rate of the rotation signifies the water velocity. It is primarily used in measuring discharge.
2. **Vortex meter**: velocity is proportional to the downstream frequency of the vortex flow and is read on a digital readout. It is used for measuring flow in pipes.

3- **Flow probe**: the flow turns a propeller that sends the water velocity data to a digital readout display in ft/s or m/s
4- **Current meter**: electronic pulses determine water velocity. Can be used in large bodies of water like oceans to measure the current.

Q7/A

Horton Infiltration Model – Example [2]

- Find out the sensitivity of the infiltration capacity curve to different decay coefficients (k) assuming that f_0 = 2.9 in/h and f_c = 0.5 in/h



- Assume k values = 0.15, 0.30, and 0.45 hour^{-1}

Q7/B Factors Affecting Evaporation

1- Wind
2- Salor radiation
3- Relative Humidity
4- Temperature

Method for estimating evaporation

1- Water budge method
2- Energy budge method
3- Mass transfer methods
4- The use of pans

Q8/A Using the Penman method, estimate ET, given the following data: temperature at water surface = 22°C, temperature of air = 33 °C, relative humidity =45%, wind velocity = 1.5 mph (36 mi/day). The month is June at latitude 33° north, r is given as 0.07, and S is found to be 0.7

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

$E\ 0.35(ea - ed)(1 + 0.0098\ U_2)$

- 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 = 50.5 mb = 37.8 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 × (37.8 – 17.04) (1 + 0.0098 × 36) = 9.82 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 = 16.26 mm (mean monthly total radiation)
- r = 0.07 (the estimated percentage of reflecting surface)
- S = 0.7 (the actual duration of bright sunshine to the maximum possible duration of bright sunshine)
- B = 17.69 (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 = 16.26×(1 – 0.07)×(0.18+0.55×0.7) – 17.69×(0.56 – 0.092×17.040.5)×(0.10 + 0.90×0.7) = 6.216 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 33 °C we find that $\Delta = 1.2$
- Substituting in the above equation $[(1.2\times6.216 + 0.27\times9.82)]/(1.2+0.27)$ gives a value of ET of 6.8779mm/day

Q8/B Classified the Streams with scam?

1- Intermittent: GWT is above stream stage so surface runoff and groundwater contribution. In dry periods, GWT drops below the stream bed and the stream dries up
2- Perennial: GWT never drops below the stream stage even in most sever droughts. Perennial streams flow throughout the year