ENGINEERING HYDROLOGY
(5th Semester Civil Engineering)
[Session-2014]

CIV-14

Teacher Incharge: Prof. Dr. Habib-ur-Rehman

Assignment No. 1

(Meteorology)

Q. No. 1: What is meant by 'Meteorology'?

Q. No. 2: Enlist the equipments used for the measurement of following Metrological Parameters / variables.

1) Atmospheric Pressure Barometer
2) Relative Humidity Psychrometer / Hairhygrograph
3) Air Temperature Thermometer
4) Wind Speed Anemometer
5) Wind Direction Dynes apparatus
6) Radiation Pyrheliometer
7) Sunshine Hours Sunshine recorder
8) Evaporation
9) Precipitation Raingauges

Q. No. 3: Discuss the Western Disturbances in producing rhe precipitation over Pakistan.

ENGINEERING HYDROLOGY

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Assignment No. 2

(Precipitation)

CIV-14

Part (A):

Go through Solved Example for Figure 3-11, page 72, of Text Book, "Hydrology for Engineers (3rd edition)" by Ray K. Linsley.

Part (B):

Solve following Numerical Problems of Text Book, "Hydrology for Engineers (3rd edition)" by Ray K. Linsley. 3-1, 3-3, 3-5, 3-6 (solve on excel sheet) & 3-8.

Part (C):

Solve the following numerical problems.

Q. No.1 For the data given in the table below, comment which method is suitable for computing the missing precipitation data at station D.

Station	A	B	C	D	E
Storm ppt. (mm)	115	90	132	?	84
Normal Annual ppt. (mm)	1016	970	1170	915	1070

Q. No.2 Find out the missing storm precipitation data for station D in the table given above by using Normal ratio method.

Q. No.3 Compute the average precipitation in mm over the area as shown in Figure-1 by Thiessen Polygon method. Station precipitations are given in the Table-1.

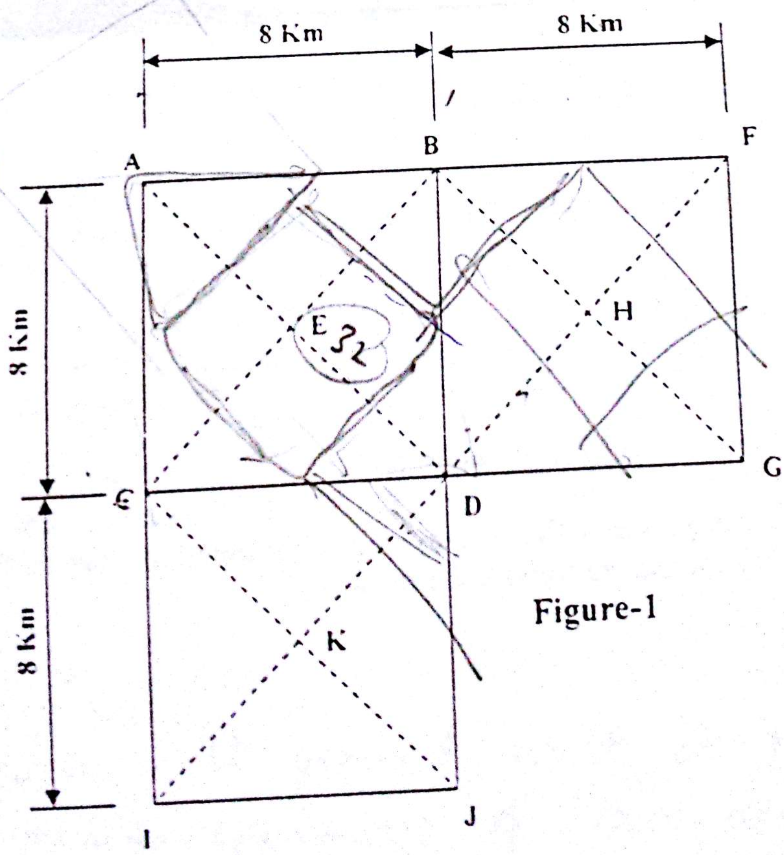

Figure-1

Table-1

Gauge Station	Annual ppt. (mm)
A	350
B	400
C	330
D	360
E	380
F	650
G	500
H	390
I	250
J	340
K	355

Q. No. 4: The data given below was obtained from Isohyetal map of a catchment.

Isohyet	Isohyetal Precipitation (cm)	Area enclosed between two Isohyets (km^2)
1	2.50	
2	5.00	300*
3	7.50	390
4	10.0	600
5	10.0	442
6	7.50	500*

Note : The Isohyets No.1 and 6 were out of the boundary of the catchment. The area between Isohyet No. 2 and boundary was estimated to be 300 km^2 and that of between Isohyet No. 5 and boundary was 500 km^2. Precipitations on these boundaries were interpolated as 4.0 and 9.0 cm respectively. Find the average precipitation for the catchment. * denotes the extreme areas.

Q. No. 5: Define 'Average Return Power' of a Radar writing its equation. Compute the rainfall rate in mm/hr at Lahore Meteorology Station using a Radar with a Z value of 400.000 mm^6/m^3. Take values of a and b as 300 and 2.6, respectively.

Q. No. 6: Compute average precipitation in mm depth over a catchment area by using Thiessen Polygon method. Station precipitations are given in the table below.

S. No.	Station	Precipitation (mm)	Area of Polygon (km^2)
1	A	800	250
2	B	700	200
3	C	675	241
4	D	860	232
5	E	815	280
6	F	700	270

Q. No. 7: For a drainage basin of 770 km^2. isohytes drawn for a given storm gives the following data:

Isohyets (cm)	15-12	12-9	9-6	6-3	3-1
Area enclosed (km^2)	92	128	120	175	85

The area enclosed between boundary having 17cm Precipitation and that of 15 cm isoheyt is 100 km^2 and boundary having 0.5cm Precipitation and 1 cm isohyet is 70 km^2. Sketch a neat diagram of the watershed showing the isohyets and find the average Precipitation over the drainage basin. Note that precipitation has increasing trend towards north.

Sec - D 14'-Civil Ma'am Vaiza Shiraz

Hydrology

Engineering Hydrology
Assignment - 3
(Precipitation)

1. Find out actual amount of precipitation over certain area if standard rain gauge is used for the measurement with given data:
   - Diameter of measuring cylinder = 50mm
   - Diameter of Measuring stick = 5mm
   - Measuring stick reading = 250mm
2. Assuming rain falling vertically, express the catch of a gauge inclined at 20° from the vertical in term of a percentage of the catch for the same gauge installed vertically.
3. For the data given in the table below, comment which method is suitable for computing the missing precipitation data at station D.

Station	A	B	C	D	E
Storm ppt. (mm)	115	90	132	?	84
Normal Annual ppt. (mm)	1016	970	1170	915	1070

4. Find out the missing storm precipitation data for station D in the table given above by using Normal ratio method.
5. Precipitation station X was inoperative for part of a month during which a storm occurred. The storm totals at three surrounding stations A, B and C were respectively 98, 80 and 110mm. the normal annual precipitation amount at stations X, A, B and C are respectively 880, 1008, 842 and 1080mm. estimate the storm precipitation for station X.
6. The annual precipitation at station X and the average annual precipitation at 15 surrounding stations are shown in the table below.
   - Determine the consistency of the record at station X.
   - In what year is a change in regime indicated?
   - Compute the mean annual precipitation for station X at its present site for the entire period, first, and secondly, with the data adjusted for the change in regime (USE EXCEL).

year	Annual Precipitation (mm)		year	Annual Precipitation (mm)	
	Station 'X'	Average of 15 surrounding stations		Station 'X'	Average of 15 surrounding stations
1979	34	35	1964	26	25
1978	27	25	1963	20	22
1977	28	26	1962	34	24
1976	30	35	1961	41	26
1975	34	33	1960	58	40
1974	37	34	1959	35	28
1973	23	28	1958	37	26
1972	30	29	1957	36	26
1971	25	26	1956	29	26
1970	39	35	1955	35	30
1969	32	33	1954	25	23
1968	29	33	1953	27	26
1967	28	23	1952	42	36
1966	35	28	1951	24	21
1965	36	34	1950	47	29

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7. Compute the average precipitation in mm over the area as shown in Figure-1 by Thiessen Polygon method. Station precipitations are given in the table below.

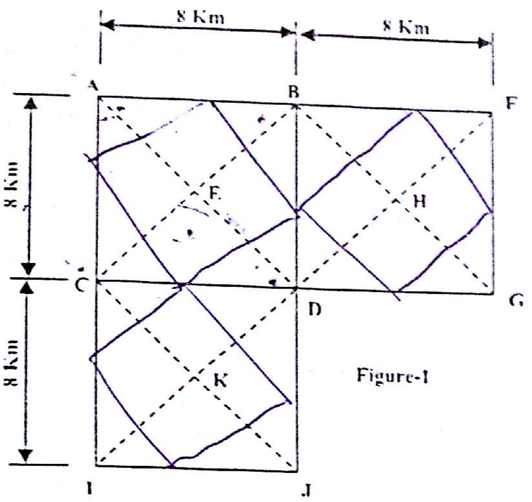

Figure-1

Gauge Station	Annual ppt. (mm)
A	350
B	400
C	330
D	360
E	380
F	650
G	500
H	390
I	250
J	340
K	355

Also compute average precipitation through Arithmetic Mean method and compare results by two methods.

8. The data given below was obtained from Isohyetal map of a catchment.

Isohyet	Isohyetal Precipitation (cm)	Area enclosed between two Isohyets (km^2)
1	2.50	
2	5.00	300*
3	7.50	390
4	10.0	600
5	10.0	442
6	7.50	500*

Note: The Isohyets No.1 and 6 were out of the boundary of the catchment. The area between Isohyets No. 2 and boundary was estimated to be 300 km^2 and that of between Isohyets No. 5 and boundary was 500 km^2. Precipitations on these boundaries were interpolated as 4.0 and 9.0 cm respectively. Find the average precipitation for the catchment. * denotes the extreme areas.

9. Compute average precipitation in mm depth over a catchment area by using Thiessen Polygon method. Station precipitations are given in the table below.

S. No.	Station	Precipitation (mm)	Area of Polygon (km^2)
1	A	73	930
2	B	85	710
3	C	112	1090
4	D	101	1680

Also compute average precipitation through Arithmetic Mean method and compare results by two methods.

10. For a drainage basin of 779 km^2, isohyets drawn for a given storm gives the following data:

Isohyets (cm)	15-12	12-9	9-6	6-3	3-1
Area enclosed (km^2)	92	128	120	175	85

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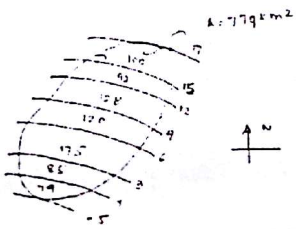
The area enclosed between boundary having 17cm Precipitation and that of 15 cm isohyets is 100 km^2 and boundary having 0.5cm Precipitation and 1 cm isohyets is 79 km^2. Sketch a neat diagram of the watershed showing the isohyets and find the average Precipitation over the drainage basin. Note that precipitation has increasing trend towards north.

Note: Assume suitable data, if missing.

Problem #	Answers
1	Actual amount of precipitation = 247.5 mm
2	% catch = 97%
3	Normal Ratio Method
4	P_D = 121.2 mm
5	P_x = 86.26 mm
6	a) Data is Inconsistent b) Change Year = 1966 c) Mean annual ppt. for station X before adjustment = 32.8 mm Mean annual ppt. for station X after adjustment = 28.7 mm
7	P_{avg} = 383.64 mm Diff. = 7.72 mm
8	P_{avg} = 7.42 mm
9	P_{avg} = 95.24 mm Diff. = 2.49 mm
10	P_{avg} = 7.83 mm 

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Assignment No. 4

(Floods & their Estimates)

6/6-14

Solve the following numerical problems.

Q. No. 1. The following table gives flood data for 12 years recorded at a site of a certain river.

year	Discharge	year	Discharge	year	Discharge
1989	2500	1993	3500	1997	2410
1990	3800	1994	3700	1998	5000
1991	4600	1995	4600	1999	4400
1992	3500	1996	4800	2000	3600

Find the recurrence intervals for the floods of various magnitudes by Hazen method and California method.

Q. No. 2. For the data given in Q. No. 1, find the return periods for the floods of various magnitudes by Gumbel's method.

Q. No. 3. The following table gives floods for 10 years recorded at a site of a certain river.

Year	Discharge	Year	Discharge	Year	Discharge
2000	2600	2004	3500	2007	8900
2001	3900	2005	3700	2008	5100
2002	7600	2006	4600	2009	5400
2003	6500				

Find the recurrence interval and flood frequency for the floods of various magnitudes by California method.

Q. No. 4. For the data given in Q. No. 1, find the return periods for the floods of various magnitudes by Weibull method.

Q. No. 5. For the data given in Q. No. 1, plot frequency distribution curve and find the magnitude of the flood for a return period of 20 years (use attached sheet).

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Engineering Hydrology

Assignment – 4

(Stream Flow)

1. A 25 g/l solution of a fluorescent tracer was discharged into a stream at a constant rate of 10 cm^3/sec. the background concentration of the dye in the stream water was found to be zero. At a downstream section sufficiently far away, the dye was found to reach an equilibrium concentration of 5 parts per billion. Estimate the stream discharge.

2. During a flood flow the depth of water in a 10m wide rectangular channel was found to be 3m and 2.9m at two sections 200m apart. Assuming Manning's coefficient to be 0.025, estimate the flood discharge through the channel at downstream gauge site.

3. The following data was collected during a stream gauging operation in a river. Compute the discharge.

Distance from the left bank (m)	Depth (m)	Velocity (m/sec) At 0.2d	Velocity (m/sec) At 0.8d
0	0	0	0
1.5	1.3	0.6	0.4
3	2.5	0.9	0.6
4.5	1.7	0.7	0.5
6	1	0.6	0.4
7.5	0.4	0.4	0.3
9	0	0	0

4. The following are the data obtained in a stream gauging operation. A current meter with a calibration equation V = (0.32 N + 0.032) m/sec was used to measure the velocity at 0.6 depth. Using the mid-section method, calculate the discharge in stream.

Distance from the right bank (m)	Depth (m)	No. of revolutions	Time (Sec)
0	0	0	0
2	0.5	80	180
4	1.10	83	120
6	1.95	131	120
9	2.25	139	120
12	1.85	121	120
15	1.75	114	120
18	1.65	109	120
20	1.50	92	120
22	1.25	85	120
23	0.75	70	150
24	0	0	0

5. A 500 g/l solution of sodium dichromate was used as a chemical tracer. It was dosed at constant rate of 4 l/sec and at a downstream section. The equilibrium concentration was measured as 4 ppm. Estimate the discharge in stream.

6. A 200 g/l solution of common salt was discharged into a stream at a constant rate of 25 l/sec. the background concentration of the salt in the stream water was found to be 10ppm. At a downstream section sufficiently far away, the salt was found to reach an equilibrium concentration of 45 ppm. Estimate the stream discharge.

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7. During a high flow, water surface elevation of a small stream were noted at two sections A and B, 10 km apart. Section A is upstream of section B. these elevations and other salient hydraulic parameters are given below. Estimate the discharge in stream.

Section	Water surface elevation (m)	A (m^2)	R (m)
A	104.771	73.293	2.733
B	104.500	93.375	3.089

8. A small stream has a trapezoidal section with the base width of 12m and side slopes of 2 hz: 1 vt in a reach of 8 km. during the floods high water levels record at the end of each reach are as below. Estimate the discharge in stream. Assume n = 0.030.

Section	Bed elevation (m)	Water surface elevation (m)
Upstream	100.20	102.70
Downstream	98.60	101.30

9. The following are the ordinates of stage rating curve. Determine the stage corresponding to zero discharge.

Stage (m)	20.80	21.42	21.95	23.37	23	23.52	23
Discharge (m^3/sec)	100	200	300	400	600	800	1000

10. The stage discharge data of a river are given below. Establish a stage- discharge relationship to predict the stage for a known discharge. Assume the stage value for zero discharge as 20.50 m. determine the stage of the river corresponding to a discharge of 2600 m^3/sec.

Stage (m)	Discharge (m^3/sec)	Stage (m)	Discharge (m^3/sec)
21.95	100	24.05	780
22.45	220	24.55	1010
22.80	295	24.85	1220
23	400	25.40	1300
23.40	490	25.15	1420
23.75	500	25.55	1550
23.65	640	25.90	1760

Note: Assume suitable data, if missing.
Use Excel, if required.

Problem #	Answers
1	Q = 50 m^3/sec
2	Q = 38.95 m^3/sec
3	Q = 6.429 m^3/sec
4	Q = 11.86 m^3/sec
5	Q = 500 m^3/sec
6	Q = 143 m^3/sec
7	Q = 44.25 m^3/sec
8	Q = 30.18 m^3/sec
9	a = 18.6 m
10	a) $(G-a) = 0.16334Q^{0.4656}$ b) Stage = 26.85 m

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Q.1 Data: ① SEISMC GROUP UET LHR

$C_0 = 25\ g/l$

$q = 10\ cm^3/s$ Continuous Injection

$C_1 = 0$

$C_2 = 5\ ppb$

$Q = ?$

$1\ l = 1000\ gm$

Sol:

$1g/m^3 = 1mg/l = 1ppm$

$1ppm = 1mg/l$

$1ppb = 1\mu g/l$

$1ppb = 1\times10^{-6}\ g/l$

$C_2 = 5\times10^{-6}\ g/l$

Using

$$Q = \frac{C_0 q}{C_2} = \frac{25\times10\times10^{-6}}{5\times10^{-6}}$$

~~$1m^3 = 100^3\ cm^3$~~

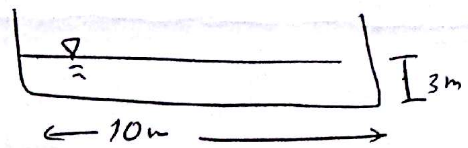
$1m^3 = 10^6\ cm^3$

$1cm^3 = 10^{-6}\ m^3$

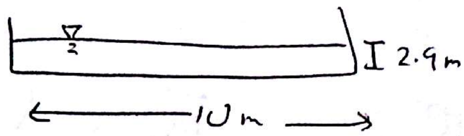
$Q = 50\ m^3/s$

Q=2

Upstream



Downstream



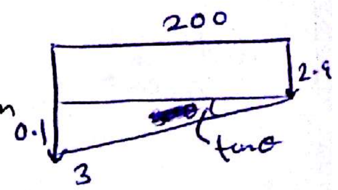
Using manning's eq

$$Q = \frac{1}{n} A R^{2/3} \sqrt{S}$$

n = manning's coefficient of roughness = 0.025

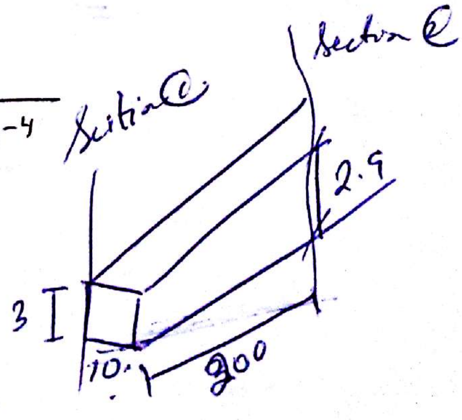
A = flow area $= 2.9\times10\ m^2$ ($d\times b$)

R = hydraulic section $= \frac{A}{P} = \frac{2.9\times10}{10+2.9\times2} = 1.835\ m$



S = channel slope

$= \frac{0.1}{200} = 5\times10^{-4}$

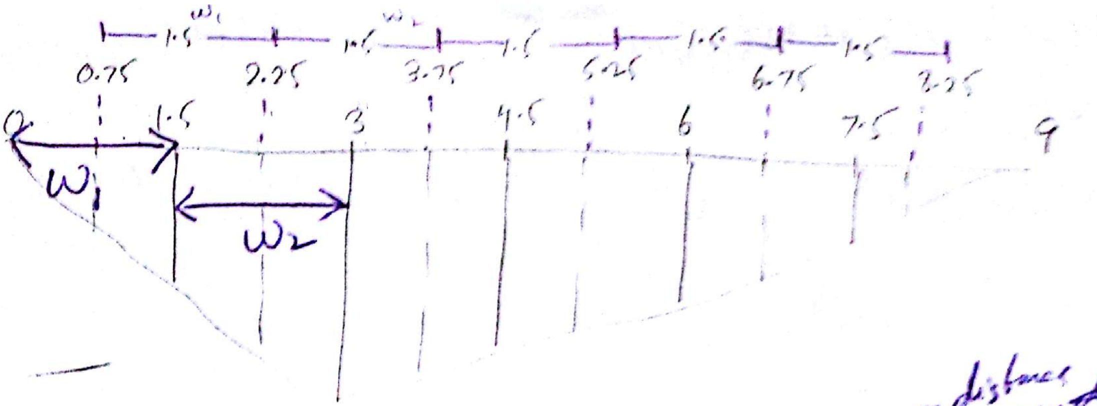


Hence

$$Q = \frac{1}{0.025}\times29\times(1.835)^{2/3}\sqrt{5\times10^{-4}}$$

$Q = 37.88\ m^3/s$

(3)



→ distance midpoint between ~~depth~~ lines

Distance from left bank (m)	Depth (m)	Velocity at 0.2d (m/s)	Velocity at 0.8d (m/s)	Mean velocity (m/s)	Width (m)	Area (m^2)	Q m^3/s
0	0	0	0	0	~~3~~		
1.5	1.3	0.6	0.4	0.5	~~1.5~~ 1.6875	2.19375 ~~1.95~~	1.0969 ~~0.975~~
3	2.5	0.9	0.6	0.75	1.5	3.75	2.8125
4.5	1.7	0.7	0.5	0.6	1.5	2.55	1.53
6	1	0.6	0.4	0.5	1.5	1.5	0.75
7.5	0.4	0.4	0.3	0.35	~~1.5~~ 1.6875	~~0.6~~ 0.675	~~0.21~~ 0.23625
9	0	0	0	0			

$\Sigma = \sout{6.2775}$

$6.426 \frac{m^3}{s}$

$Q = 6.2775 \, m^3/s$

for 1st & last sections

$$\overline{W}_1 = \frac{\left(W_1 + \frac{W_2}{2}\right)^2}{2W_1}$$

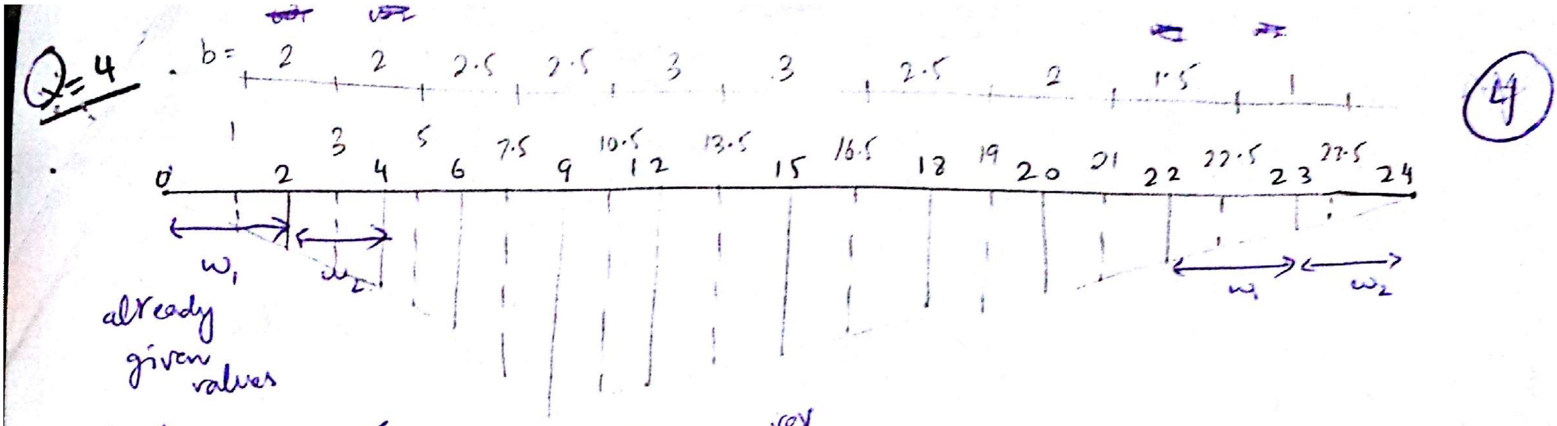
$$= \frac{\left(1.5 + \frac{1.5}{2}\right)^2}{2(1.5)}$$

$$= 1.6875$$

(According to book by Subramanya Engg Hydrology)

Q=4

(4)



Distance from right bank (m)	Depth (m)	No. of rev.	Time (s)	N (rev/s)	V m/s	Width m	Area m^2	Q = AV m^3/s
0	0	0	0	0	0	0		
2	0.5	80	180	0.444	0.17408	(2).25	1.125	~~0.1741~~ 0.19584
4	1.10	83	120	0.692	0.25344	2	2.2	0.5576
6	1.95	131	120	1.092	0.38144	2.5	4.875	1.8595
9	2.25	139	120	1.158	0.40756	2.5	5.625	2.265
12	1.85	121	120	1.01	0.3552	3	5.55	1.9684
15	1.75	114	120	0.95	0.336	3	5.25	1.764
18	1.65	109	120	0.908	0.32256	2.5	4.125	1.331
20	1.56	92	120	0.767	0.27744	2	3	0.832
22	1.25	85	120	0.708	0.25856	1.5	1.875	0.485
23	0.75	70	150	0.467	0.18144	(1).125	~~0.75~~ 0.84375	~~0.136~~ 0.15309
24	0	0	0	0	0	0		
						Σ		11.431

$Q = 11.431 \ m^3/s$

For 1st and last sections $\bar{w}_1 = \dfrac{(2 + 2/2)^2}{2 \times 2} = \dfrac{9}{4} = 2.25$

$\dfrac{(1 + 1/2)^2}{2 \times 1} = 1.125$

(5)

Data:

$C_0 = 500 g/l$

$q = 4 l/s = 4 \times 10^{-3} m^3/s$

$C_2 = 4 ppm = 4 mg/l$

$= 4 \times 10^{-3} g/l$

$1m^3 = 10^3 dm^3$

$1l = 1dm^3 = 10^{-3} m^3$

$1m^3 = 1000$ litre

Sol:

$C_1 \approx 0$

Constant rate injection:

$(1ppm = 1 \frac{mg}{l})$

$$Q = \frac{C_0 q}{C_2} = \frac{500 \times 4 \times 10^{-3}}{4 \times 10^{-3}}$$

$$\boxed{Q = 500 m^3/s}$$ ✓

(6)

Constant rate injection

Data:

$C_0 = 200 g/l$

$q = 25 l/s = 25 \times 10^{-3} m^3/s$

$C_1 = 10 ppm = 10 mg/l = 10 \times 10^{-3} g/l$

$C_2 = 45 ppm = 45 \times 10^{-3} g/l$

Sol:

$$Q = \frac{C_0 - C_2}{C_2 - C_1} \times q$$ ✓

$$= \frac{200 - 45 \times 10^{-3}}{45 \times 10^{-3} - 10 \times 10^{-3}} \times 25 \times 10^{-3}$$

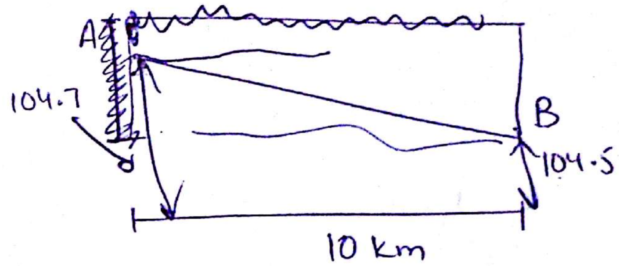
$$\boxed{Q = 142.825 m^3/s}$$

(7)

Section	water surface elevation (m)	A (m^2)	R (m)
A	104.771	73.293	2.733
B	104.500	93.375	3.089

$n = 0.02$

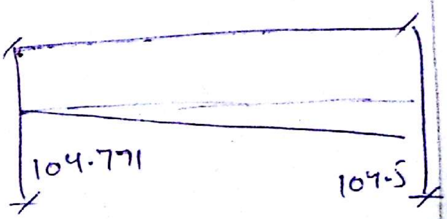
$Q = \frac{1}{n} A R^{2/3} \sqrt{S}$



$Q = K\sqrt{S}$

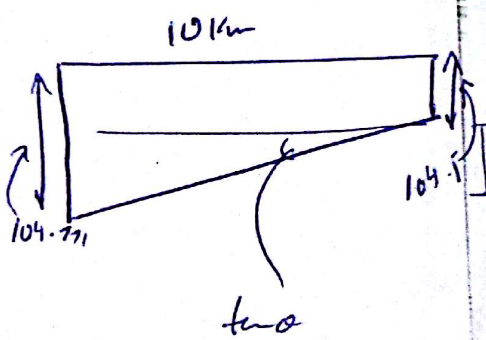
$K = \frac{1}{n} A R^{2/3}$

$K_A = \frac{1}{0.02} \times 73.293 \times (2.733)^{2/3} = 7163.5$ ✓



$K_B = \frac{1}{0.02} \times 93.375 \times (3.089)^{2/3} = 9902.5$ ✓

$\text{Avg } K = \sqrt{K_A K_B} = 8422.4$



$S = \frac{104.771 - 104.500}{10000} = \frac{0.271}{10\,000}$

$Q = K\sqrt{S}$

$= 8422.4 \sqrt{\frac{0.271}{10{,}000}}$

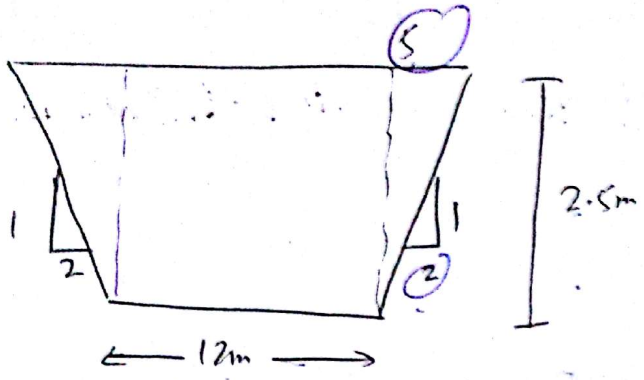
$Q =$

$\boxed{Q = 43.84 \; m^3/s}$ ✓

(8)

Q No 8

For upstream



upstream

$D = 102.7 - 100.2$

$= 2.5m$

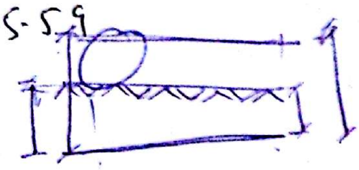
$A = (12 \times 2.5) + (\frac{1}{2} \times 2.5 \times 5) 2$

$A = 42.5 m^2$

$R = \frac{A}{P} = \frac{42.5}{23.18} = 1.8335 m$

$P_w = 12 + 2 \times 5.59$

$= 23.18m$

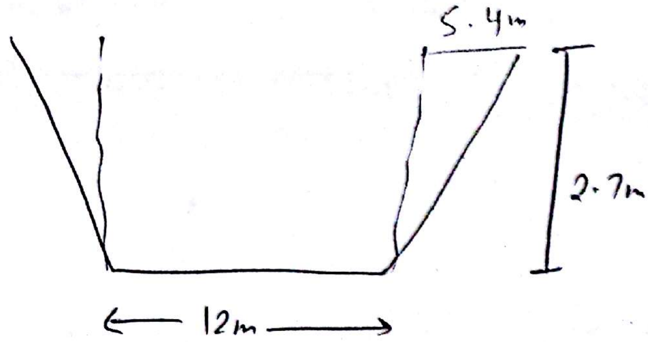


$K_v = \frac{1}{n} A R^{2/3} = \frac{1}{0.03} \times 42.5 \times (1.8335)^{2/3}$

Kupstream

$K_u = 2122.2$

For downstream



$D = 101.30 - 98.6 = 2.7m$

$A = 12 \times 2.7 + (\frac{1}{2} \times 2.7 \times 5.4) \times 2$

$A = 46.98 m^2$

$R = \frac{A}{P_w} = \frac{46.98}{12 + 6.037 \times 2} = 1.9514m$

$K_D = \frac{1}{0.03} \times 46.98 \times (1.9514)^{2/3} = 2445.4$

Kdownstream

$\Rightarrow K_{avg} = \sqrt{K_u K_D} = \sqrt{(2122.2)(2445.4)} = 2278$ ✓

$Q = \frac{1}{n} A R^{2/3} \sqrt{S}$ also $Q = K_{avg} \sqrt{S}$

S → slope of water surface elevation

$Q = 2278 \sqrt{\frac{102.7 - 101.3}{3000}}$

$Q = 30.14 \ m^3/s$