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FACULTY OF HEALTH SCIENCES
DEGREE IN ENVIRONMENTAL HEALTH SCIENCES
(FINAL EXAMINATION)

TITLE OF PAPER : HYDROLOGY

COURSE CODE : EHS 545

TIME : 3HOURS

TOTAL MARKS : 100

INSTRUCTIONS:

- ANSWER ANY FOUR QUESTIONS
- QUESTION 1 (I) IS MULTIPLE CHOICE
- ALL QUESTIONS ARE WORTH 25 MARKS EACH
- NO FORM OF PAPER SHOULD BE BROUGHT IN OR OUT OF THE EXAMINATION ROOM
- BEGIN THE ANSWER TO EACH QUESTION IN A SEPARATE SHEET OF PAPER.

DO NO OPEN THIS EXAMINATION PAPER UNTIL PERMISSION HAS BEEN GRANTED BY THE INVIGILATOR.

QUESTION 1

I.

Multiple choice: Write True or False against each letter corresponding to the following statements as they apply to hydrology.

(a) Infiltration capacity is the minimum rate at which water may enter the upper soil horizons.

(b) Double mass analysis tests the consistency of the record at a station by comparing its accumulated precipitation with the concurrent accumulated values of precipitation for a group of surround stations.

(c) Depth-Area duration curves determine the minimum amount of precipitation within various durations over areas of various sizes.

(d) The simplest method for determining reservoir capacity from stream flow data is by means of a mass curve.

(e) In non-frontal precipitation, low pressure occurs in an area and air flows from the surrounding areas lifts the air in low pressure area until it reaches heights where it condenses and precipitates falling as rainfall.

(f) Orographic rainfall is caused by the lifting of air mass due to pressure difference causing warm air to rise and upon reaching high levels it precipitates as rainfall.

(g) In warm air-front precipitation, warm air is forced upwards more rapidly.

(h) Precipitation is measured on the basis of the vertical depth of water that would accumulate on a level surface if the precipitation remains where it falls.

(16 Marks)

II.

(a) What is the information required in pumping tests?

(6 marks)

(b) Name three things that determine the amount of runoff.

(3 marks)

QUESTION 2

(a) A well with a diameter of 0.6m is constructed in a confined aquifer. The sand aquifer has a uniform thickness of 15m overlain by an impermeable layer with a depth of 35m. A pumping test was conducted to determine the coefficient of permeability of the aquifer. The initial piezometric surface was 15.0m below the ground-surface datum of the test well and observation wells. After water was pumped at a rate of 13.0 l/s for several days, water levels in the wells stabilized with the following drawdown: 6.4m in the test well, 3.7m in the observation well at a distance of 30m. From these test data, calculate the permeability of the aquifer. Then, using this K value, estimate the well discharge with the drawdown in the well lowered to the top of the confined aquifer. See Figure 1.

(9 marks)

(b) Using the data provided, calculate the storage capacity required. The water demand (D) is 0.405 x $10^6 m^3$/month and the available water flows at a flow rate, Q, of $10^6 m^3$/month. Use the arithmetic method.

Arithmetic Method and Storage

Month	**Q ($10^6 m^3$)**	**D ($10^6 m^3$)**
January	0.18	0.405
February	1.02	0.405
March	1.32	0.405
April	0.51	0.405
May	0.87	0.405
June	0.67	0.405
July	0.19	0.405
August	0.08	0.405
September	0.07	0.405
October	0.04	0.405
November	0.10	0.405
December	0.26	0.405
January	0.20	0.405
February	1.10	0.405
March	1.01	0.405

(16 marks)

QUESTION 3

(a) A clear lake has a surface area of 708,000m^2. For the month of March, this lake had an inflow of 1.5 m^3/s and an outflow of 1.35 m^3/s. A storage change of +708,000m^3 was recorded. If the total depth of rainfall recorded at the local rain gauge was 225 mm for the month, estimate the evaporation loss from the lake. State any assumptions that you make in your calculations.

(13 marks)

(b) During the water-year 1994/95, a catchment's area of 2500km^2 received 1300mm of precipitation. The average discharge at the catchment's outlet was 30m^3/s. Estimate the amount of water lost due to the combined effects of evaporation, transpiration and percolation to ground water. Compute the volumetric run off coefficient for the catchment in the water-year.

(9 marks)

(c) State Darcy's law on ground water flow.

(3 marks)

QUESTION 4

(a) Describe the Thiessen method and the Isohyetal method of estimating precipitation.

(12 marks)

(b) Describe the hydrologic cycle

(13 marks)

QUESTION 5

(a) An evaporation pan is maintained near a small lake in order to determine daily evaporation. The water level in the pan is observed every day, and water is added if the water level falls below about 17.5 cm. Estimate the daily pan evaporation for the 14-day period for which readings are summarized in the following table.

Day	Rainfall, mm during the day	Water level, mm during the day
1.	4.1	199.0
2.	3.8	198.0
3.	4.2	196.7
4.	1.3	196.2
5.	0.2	193.9
6.	0	189.3
7.	0.5	185.5
8.	0.2	182.7
9.	0	180.9
10.	0	179.4
11.	0	176.6

12.	0.2	197.7
13.	0	196.4
14.	0.5	194.9

NB: The pan was filled to a depth of 200mm at the beginning of both day 1 and day 12.

(6 marks)

(b) Stream flow Records Listing the Lowest Mean Discharge for Seven Consecutive Days for Each year from 1961 to 1982.

The average annual discharge for this period was 178 m^3/s.

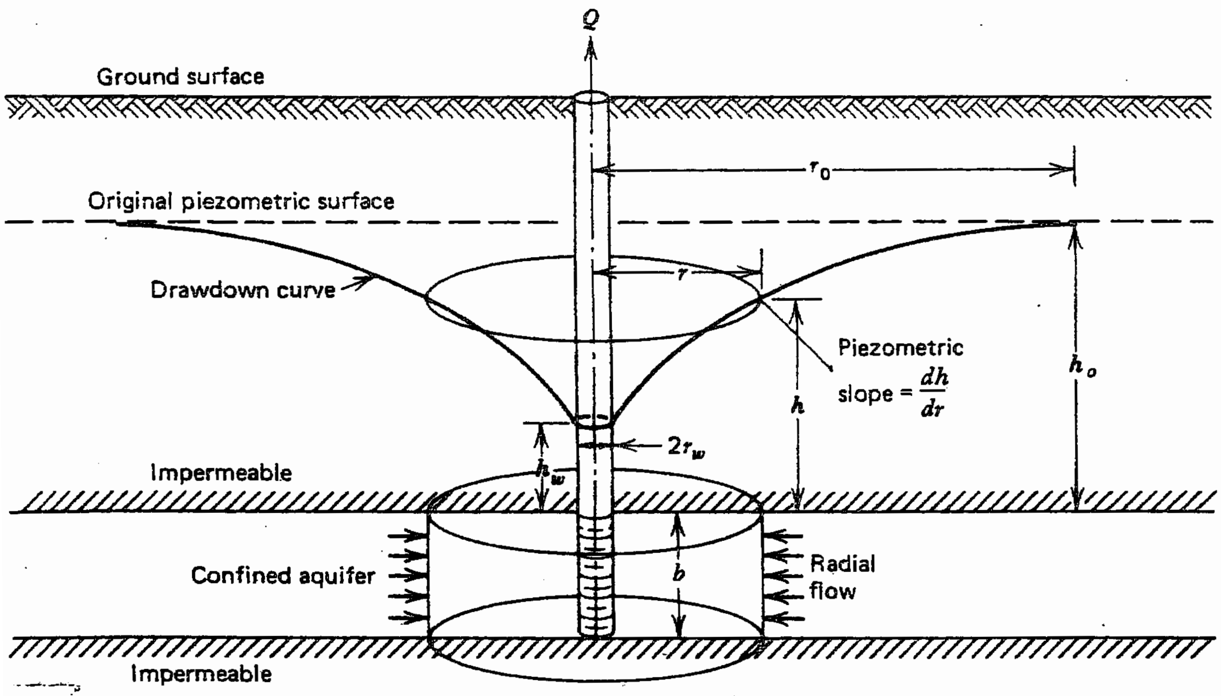
Year	Lowest Mean Flow in Cubic Meter per Second for 7 Consecutive days
1961	19.6
1962	28.6
1963	18.1
1964	34.3
1965	29.3
1966	35.7
1967	35.0
1968	27.0
1969	35.0
1970	36.9
1971	90.3
1972	50.6
1973	35.3
1974	59.4
1975	26.3
1976	30.1
1977	29.4
1978	29.7
1979	30.4
1980	49.6
1981	36.6
1982	59.1

[16 marks]

QUESTION 5

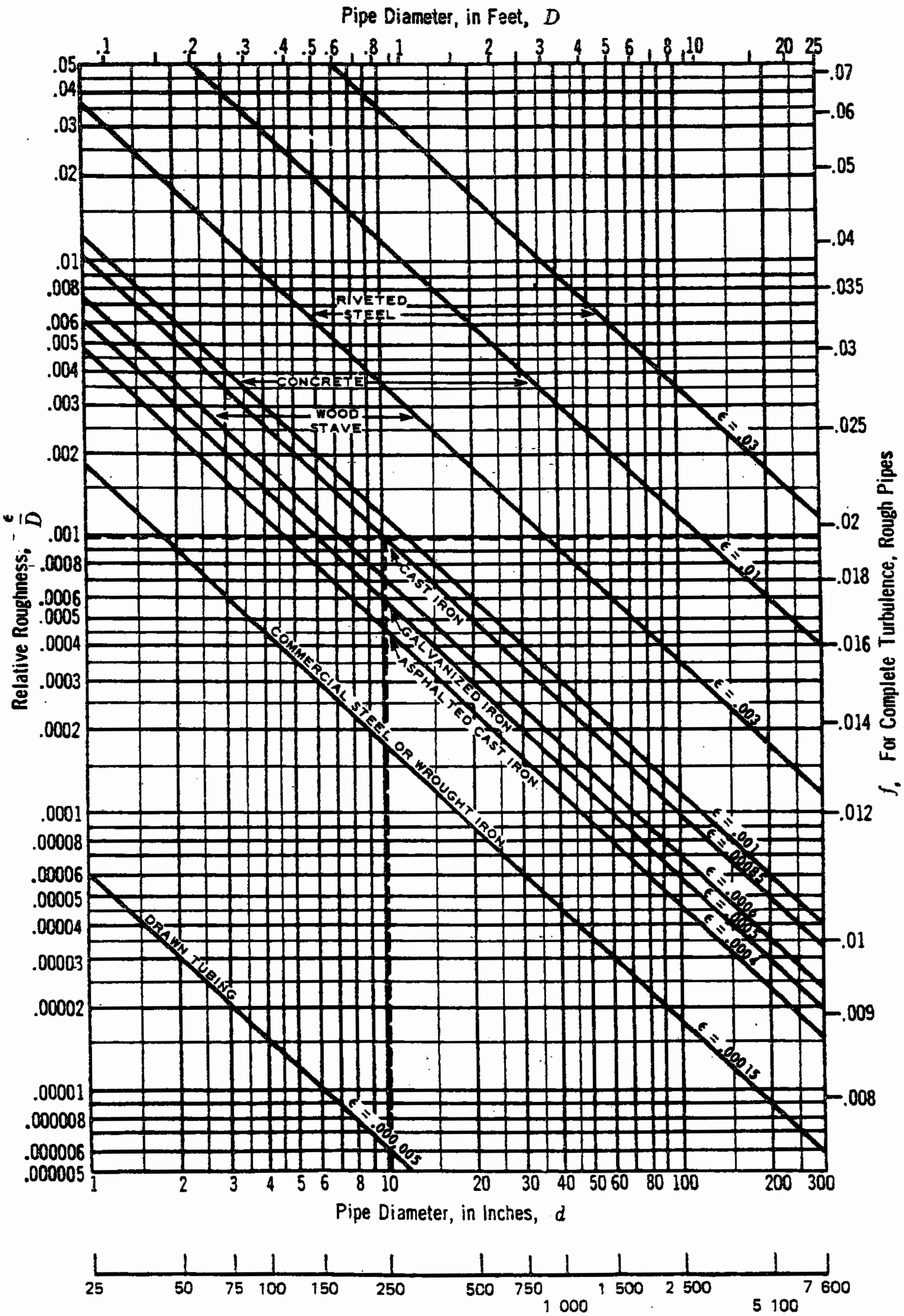
A trade waste treatment plant works on a batch system taking a discharge of up to 1000 m^3 from a 2000 m^3 capacity tank at regular hourly intervals. The tank receives waste from a number of units of process plant, each of which discharges 500 m^3 when it empties. The number of units emptied in any one hour is random and independent. There is a 25 per cent probability of only one unit being emptied in an hour, a 50 per cent probability of two units being emptied in an hour, and a 25 per cent per cent of three units being emptied in an hour. If the tank is full when a unit is to be emptied, the waste is discharged untreated to the nearby river instead. Estimate the probability of such an occurrence.

(25 marks



Q
Ground surface
r_0
Original piezometric surface
Drawdown curve
r
Piezometric
slope = $\frac{dh}{dr}$
h_o
h
$2r_w$
h_w
Impermeable
Confined aquifer
Radial
flow
b
Impermeable

Figure 1.


Pipe Diameter, in Feet, D
.1
.2
.3
.4
.5
.6
.8
1
2
3
4
5
6
8
10
20
25
Relative Roughness, ε/D
.05
.04
.03
.02
.01
.008
.006
.005
.004
.003
.002
.001
.0008
.0006
.0005
.0004
.0003
.0002
.0001
.00008
.00006
.00005
.00004
.00003
.00002
.00001
.000008
.000006
.000005
f, For Complete Turbulence, Rough Pipes
.07
.06
.05
.04
.035
.03
.025
.02
.018
.016
.014
.012
.01
.009
.008
RIVETED STEEL
CONCRETE
WOOD STAVE
CAST IRON
GALVANIZED IRON
ASPHALTED CAST IRON
COMMERCIAL STEEL OR WROUGHT IRON
DRAWN TUBING
ε = .03
ε = .01
ε = .003
ε = .001
ε = .00085
ε = .0006
ε = .0005
ε = .0004
ε = .00015
ε = .000 005
Pipe Diameter, in Inches, d
1
2
3
4
5
6
8
10
20
30
40
50
60
80
100
200
300
25
50
75
100
150
250
500
750
1 000
1 500
2 500
5 100
7 600

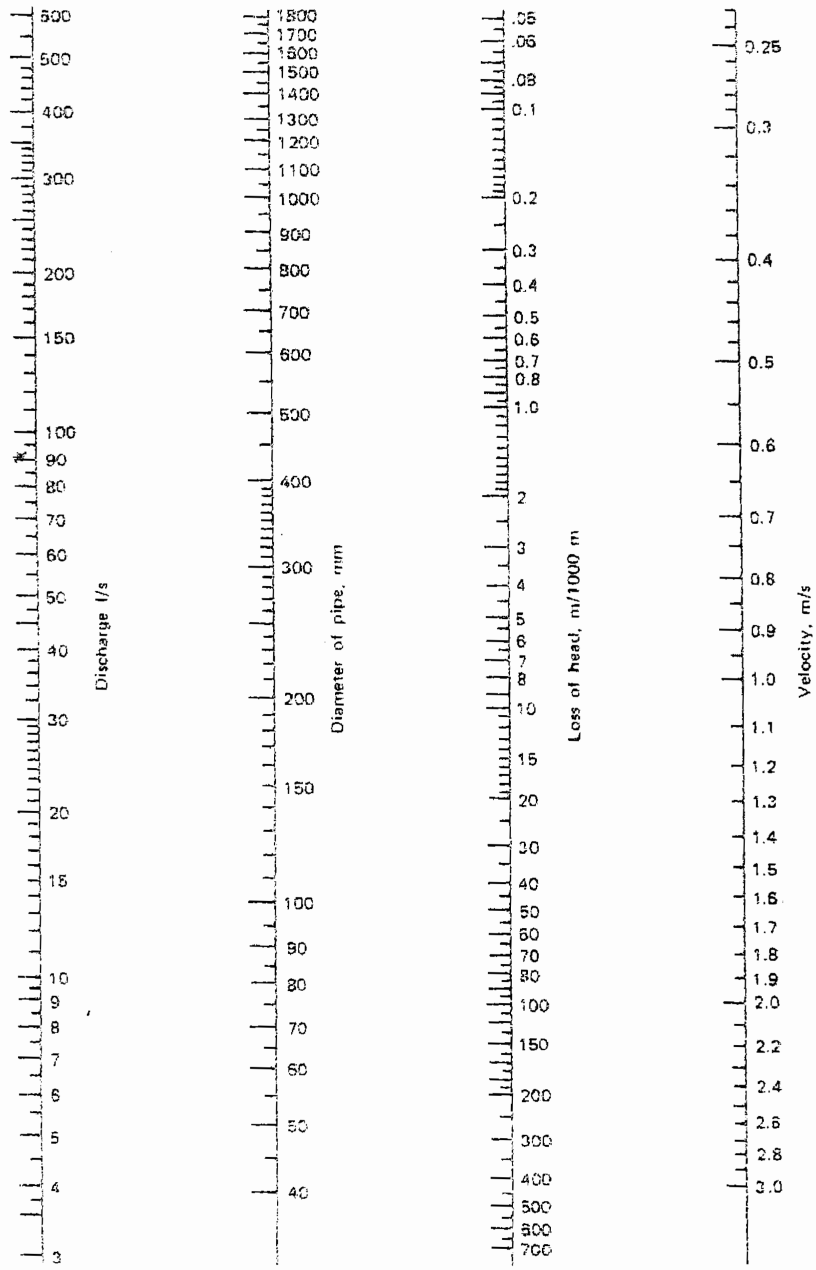

Discharge l/s
600 500 400 300 200 150 100 90 80 70 60 50 40 30 20 15 10 9 8 7 6 5 4 3
Diameter of pipe, mm
1800 1700 1600 1500 1400 1300 1200 1100 1000 900 800 700 600 500 400 300 200 150 100 90 80 70 60 50 40
Loss of head, m/1000 m
.05 .06 .08 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 1.0 2 3 4 5 6 7 8 10 15 20 30 40 50 60 70 80 100 150 200 300 400 500 600 700
Velocity, m/s
0.25 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0 2.2 2.4 2.6 2.8 3.0

FIGURE 9

FORMULARS

1. $Cd = 0.61$ and $T = \int dt = \frac{ZA\,(H_1^{1/2} - H_2^{1/2})}{Cda\sqrt{2g}}$

2. $Q = 2/3\ Cd\ \sqrt{2g}\quad b(H_1^{3/2} - H_2^{3/2})$

3. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

4. $F_S = V_S/\sqrt{g Y_S}$

5. $(Y + V/2g) - (Y + V/2g)$

6. $\rho g y^2/2 + \rho q(V_1 - V_2) - \rho g Y_2^2/ F_X = 0$

7. $Y_G = Y_s \sqrt{1+2F_s^2}\ (1 - Y_S/ Y_2)$

8. $Q = AV$

9. $Q = A/n\ R^{2/3}\ S_0^{1/2}$

10. $Y_i = Y_S/2\ (\sqrt{1+8\beta f_S^2} - 1)$

11. $F_S = V_S/\sqrt{g Y_S}$

12. $p_1/\rho g + v_1^2/2g = p_2/\rho g + v_2^2/2g + 0.03\ (p_1/\rho g - p_2/\rho g)$

13. $Q = 1.84BH^{3/2}\ [(1+ \alpha\ v^2/2g\ H)^{3/2} - (\alpha\ v^2/2g\ H)^{3/2}]$

14. $k=[(1+ \alpha\ v^2/2g\ H)^{3/2} - (\alpha\ v^2/2g\ H)^{3/2}]$

15. $h= (v^2/2g)(1+ A_1/A_2)^2 = v^2/2g\ (A_1/A_2 - 1)^2$

16. $W = \sum_{i=1} \frac{p^{2rms(1)} S_i}{\rho C}$, where $\rho C = 420$ RAYLS.

17. $S.I.L = 10 \log_{10} (I) + 120$

18. $L_p = 10 \log (p_1/p_0)^2$ or
    $(p_1/p_0)^2 = 10^{Lp/10}$

19. $L_p(total) = 10 \log (p_{total}/p_0)^2$

20. $I = W/A$

21. $L_W = 10 \log W/W_0$

22. $h = \dfrac{2\sigma \cos\theta}{R\rho g}$

23. $\dfrac{p_1}{\rho g} + \dfrac{v_1^2}{2g} = \dfrac{p_2}{\rho g} + \dfrac{v_2^2}{2g}$

24. $W = \rho g Q h_p$,

25. Turbine output = $\eta_t \rho g Q h_p$,

26. $k=[(1+ \alpha v^2/2g H)^{3/2} - (\alpha v^2/2g H)^{3/2}]$

27. $h= (v^2/2g)(1+ A_1/A_2)^2 = v^2/2g (A_1/A_2 - 1)^2$

28. $Q = a_1 v_1 = a_1 v_2$

29. $h_L = (1/C_c-1)^2 V_1^2/2g$

30. $A = (b + Ny)y$

31. $P = b + 2y\sqrt{(1+N^2)}$

32. $\Delta Q = \dfrac{-\Sigma h}{2 \Sigma h/Q}$