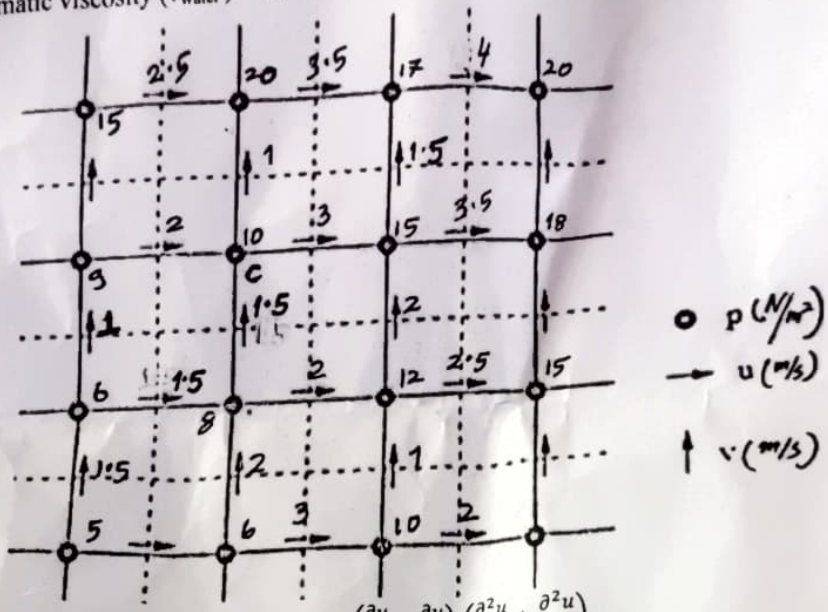
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Bhadra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MEWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Simulation Laboratory

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *<u>All</u> questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. Find the first estimation of $\tilde{u}_c^n$ (provisional velocity) using following staggered grid while solving Navier-stokes equation using Marker-cell method. Take ρ_{water} = 1000 kg/m^3 and Kinematic viscosity (ν_{water}) = 10^{-6} m^2/s. Take, $\Delta x = \Delta y$ = 10 m and Δt = 5 sec.



2. Develop finite difference molecules for $\left(\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y}\right)\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right)$.
3. Relationship between Rainfall Intensity (I), mm/h and Duration (t), min is $I = k\,(t + a)^{-b}$. For the following set of observed data of I and t find the value of parameters k and b, if a = 10.

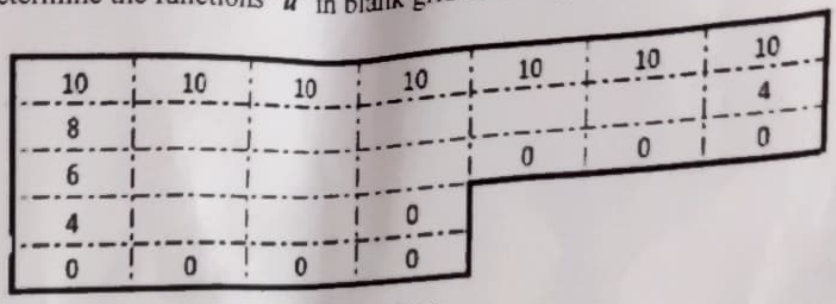
Rainfall Intensity (I), mm/h	Duration (t), min
80	15
70	30
60	45

Update the value of parameters using recursive procedure if new information I = 55 mm/h for t = 90 min is available.

4. Write down the source code for Recursive LST with sub-programs for matrix transpose, matrix inversion and matrix multiplication.
5. Write and explain each statement of source code which plots the axis (with title) with ticks (with label) in appropriate intervals and values given below covering the whole area of the screen using Window coordinates.

Time	Stage m	Time	Stage m
12 MN	212.85	2 PM	215.45
2 AM	212.80	4 PM	214.95
4 AM	213.60	6 PM	214.35
6 AM	214.75	8 PM	213.75
8 AM	218.4	10 PM	213.25
10 AM	217.4	12 MN	213.0
12 Noon	216.1		

6. Using numerical approximation of $\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}$, write down the equation in matrix form which determine the functions "u" in blank grid in the figure below.



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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2081 Bhadra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - System Mathematics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define Operation Research in Water Resources Engineering. List any three objectives of Operation Research. [3]

   b) Solve the following LP problem using simplex method. [9]

$$\begin{aligned} \text{Max } Z &= 0.5x_1 + 6x_2 + 5x_3 \\ \text{st } & 4x_1 + 6x_2 + 3x_3 \le 24 \\ & x_1 + 1.5x_2 + 3x_3 \le 12 \\ & 3x_1 + x_2 + x_3 \ge 5 \\ & x_1, x_2, x_3 \ge 0 \end{aligned}$$

2. a) Define Fibonacci Numbers. Explain its relation to the Dynamic Programming. [3]

   b) A city w/s project has to be expand for the storage system from existing 100 units capacity to 200 units capacity, in next 25 years of each 5 years revision in expansion. The discounted present worth for additional capacities are as follows: [9]

Time	Required Additional Capacity
End of 5th Year	20
End of 10th Year	40
End of 15th Year	60
End of 20th Year	80
End of 25th Year	100

Additional Capacity		0	20	40	60	80	100
t, Periods (years)							
1	1-5	0	140	170	220	270	320
2	6-10	0	100	130	150	170	230
3	11-15	0	80	100	120	130	
4	16-20	0	40	50	70		
5	21-25	0	20	40			

   Solve the capacity expansion problem using Dynamic programming.

3. Solve the following NLP problems.

   a) Maximize $f(X) = -10x_1^2 - 8x_2^2 + 13x_1x_2 - 3x_1 + 8x_2 + 10$
   s.t.: $4x_1 + 3x_2 = 40$;
   $5x_1 + 7x_2 \ge 72$;

   b) Optimize $f(X) = -3x_1^2 - 5x_2^2 + 8x_1 + 11x_2$ [6]
   s.t.: $3x_1 + 4x_2 \le 31$;
   $-4x_1 - 5x_2 \ge -41$;

4. Using Gomory's Cutting Plane Method solve the following ILP problem. [6]

$$\begin{aligned} \text{Max } f(X) &= 5x_1 + 11x_2 \\ \text{s.t.: } & x_1 + 3x_2 \le 14; \\ & 3x_1 - 2x_2 \le 9; \\ & 4x_1 + 3x_2 \ge 28; \\ & x_1, x_2 \ge 0 \text{ and, } x_1 \text{ and } x_2 \text{ are integers} \end{aligned}$$

   [12]

5. Write short notes on: (Any Three) [3×4]
   a) Network analysis using Dynamic Programming
   b) Dual Simplex Method to solve LPP
   c) Mathematical definition of Global minimum and Global Maximum
   d) Branch and Bound Method of solving ILPP

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Examination Control Division
2081 Bhadra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Hydrological Analysis

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Are physical science and system approaches 'mutually-exclusive' or 'complementary' to each other? Please justify your answer with appropriate reasoning and examples. [5]

   b) You are asked to perform hydrological analysis to a hydropower project at an ungagged location in a catchment that has one hydrological station at other location. How do you perform that analysis with scientifically convincing way? Please elaborate steps as well as key outputs. [7]

2. a) How two general approaches for overland flow estimation differ from each other? Please elaborate with appropriate illustrations. [5]

   b) For a soil with infiltration capacity at time t as f(t), initial infiltration rate as 'f_0' and final (constant) infiltration rate as 'f_c', please derive an expression for estimating Horton's constant 'k'. [7]

3. a) How can we differentiate between small catchment and medium-sized catchment? What methods are used to estimate responses from small and medium-sized catchments? [3+2]

   b) Please derive a 3h UH from a 2h UH given in the following Table using appropriate method. [7]

Time (h)	0	1	2	3	4	5	6	7	8
2-hr UH ordinates (m^3/s)	0	25	50	75	150	125	50	25	0

4. a) What are different types of response functions in a linear system? How a linear system is comparable with unity hydrograph? [2+3]

   b) Route the following hydrograph (using Muskingum method) through a river reach with K=6 hrs and X=0.15. Take the outflow discharge at the start of the inflow as 6 m^3/s. Also estimate attenuation and lag of peak. [7]

Time (h)	0	3	6	9	12	15	18
Inflow (m^3/s)	6	13	23	19	12	9	6

5. a) Discuss diffusion wave equation for channel routing and its applicability. [5]

   b) A catchment with 100 km^2 area has 4-h time of concentration. Area derived from time-area histogram and 6-hr storm at 1-hr interval is shown in the Table below. Calculate outflow hydrograph. [7]

Time (h)	0-1	1-2	2-3	3-4	4-5	5-6
Effective rainfall (cm/h)	0.5	1.0	2.0	1.5	1.0	0.5
Area (km^2)	10	30	20	40	-	-

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Examination Control Division
2081 Bhadra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Advanced Hydraulics

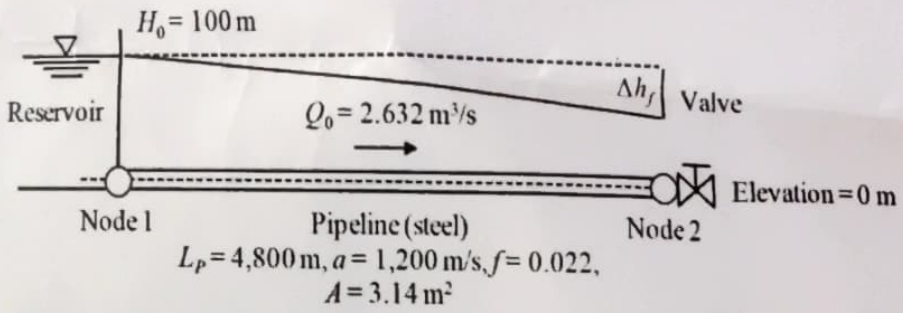
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Apply the first order Kinematic Wave Routing method (Finite difference Scheme) to predict the outflow hydrographs at 25 Km downstream. The inflow hydrograph is given below. The channel is 100 m wide, $S_0 = 0.003$ and $n = 0.02$. Use wide rectangular channel assumption. Take dt = 30 mins, dx = 5 km

   Plot tentatively the inflow and outflow hydrograph together on the same figure. Are these likely to be realistic? Why or why not? [8]

Time (hrs)	0	1	2	3	4	5	6	7	8
Q (m^3/s)	1000	1200	3000	5500	5500	3000	1200	1000	1000

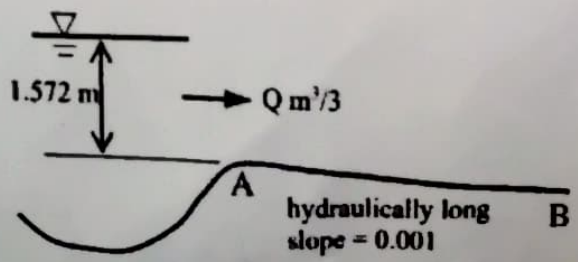
2. Calculate the pressure head at Node 1 and Node 2 in due to sudden closure of valve which resulted in the decrease of discharge to 10% of original at the valve in next possible time step using method of Characteristics. Assume suitable value if necessary. [8]



3. Explain types of grids in CFD with pros and cons. Sediment deposition is computed numerically in a sand trap. The water flow is uniform with a velocity U=4 m/s and a water depth H=5m. The fall velocity of the sediments is w = 0.2 m/s. The orthogonal grid cells has sizes dx=1m and dy=0.1m in the horizontal and vertical directions, respectively. The Manning-Strickler's value is M=1/n=25. Compute the values of the a_{nb} coefficients for the SOU scheme. [2+8]

4. a) Derive an expression for Saint Venant momentum equation forwarded by Manz (1985). [6]

   b) A lake discharges into a 10 m wide rectangular channel with manning's n = 0.014 a shown. Show that the discharge in the channel is 30 m^3/s. [6]

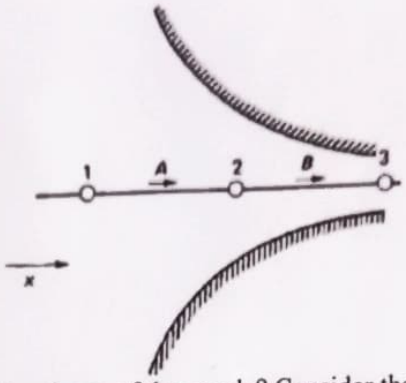


5. The one-dimensional flow through the nozzle is described by Continuity Equation.

$$\frac{\partial(uA)}{\partial x} = 0$$

X- Momentum Equation

$$\frac{\partial(\rho uA.u)}{\partial x} = -A\frac{\partial p}{\partial x}$$



Where A is the cross-sectional area of the nozzle? Consider the following data:

ρ =1000 kg/m^3, A_A= 5 m^2, A_B= 4 m^2, P1 = 300 kPa, P3= 100 kPa. Show discretization equation for velocity and pressure and use the SIMPLE algorithm to compute velocity and pressure at the nodes (u_A, u_B, P_2). Assume negligible momentum of fluid upstream of point 1. [8]

6. a) Derive an expression for unknown depth and velocity using diffusive finite difference scheme. [6]

b) Water flows at a depth of 3 m and a velocity of 1.5 m/s in a rectangular channel into a large lake. The level of water in the lake is initially the same as that in the channel but suddenly starts falling resulting in an increase in velocity at the junction with the lake at a rate of 0.5 m/s per hour for a period of three hours.

i) Determine how long it takes for the velocity in the channel at a distance of 2 km from the lake to increase to 2.5m/s. Assume frictionless horizontal channel. [4]

ii) If the depth at the junction with the lake start falling at the rate of 0.3 m per hour, find how long it takes for the water level in the channel to fall by 0.6 m at a section 3 km upstream of the junction? [4]

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Examination Control Division
2081 Bhadra

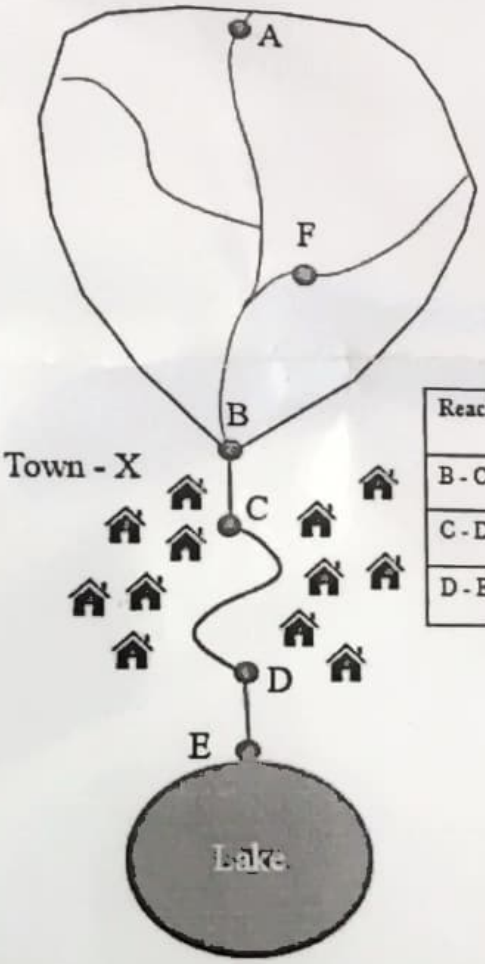
Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Sedimentation and River Engineering

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. You are working as a river engineer in a river basin management authority of a river system with a catchment area of about 1000 km^2 which is draining into a lake. The schematic diagram of this river system is shown in figure below. Upstream of the lake, the river flows through a Town-X, the largest settlement in the catchment, in a meandering planform (between point C and D) and is fully alluvial. The average characteristics of this river reach is also provided in the schematic figure.

   What are the distinct reaches, generally, in a river systems? Explain with their characteristics. How would river characteristics: bed slope, bed material size, discharge, average channel width and flow velocity, change along point A to E? [4]



Reach	Length (km)	Width (m)	Slope (%)
B - C	1	50	0.5
C - D	3	50	0.5
D - E	1	50	0.5

Figure: A schematic representation of the river system as reference to Q1 – Q6

2. The river basin authority requests you to estimate the fine sediment supply from the catchment into the lake. Which formula would you use for the estimation? Explain each factors in the formula. [4

3. The authority also wants to build a sediment trap upstream of the lake to minimize bed load deposits in the lake. Obviously, the first task is to estimate the bedload transport rate in the river during a high flow season. The river reach from point B to point E can be assumed as transporting reach with a rectangular cross-section. The authority also carried out a bulk sediment sampling at the reach, which is provided in the table below. The average river flow during high flow season, which is about 3 months, is 100 m^3/s. Compute the volume of bed load transporting along the river reach during the high flow season, assuming D_{50} as the representative particle size for the bed deposits. Some of the sediment transport formula are provided in the supplementary information. Explain your choice of sediment transport formulae for this problem. [8]

Table: Bulk sediment samples carried at the river reach (from point B to point E)

Sieve Size (mm)	Weight Retained (Kg)	Sieve Size (mm)	Weight Retained (Kg)
125	196.3	8	25.6
100	140.2	4.5	15.7
75	61	2.36	30.1
50	130	1.6	8
45	11	0.5	47.4
31.5	38	0.3	36.5
22.5	31	0.18	13.8
16	18.6	0.063	8.3
12.5	17.4	Fine	170

4. What type of bars would you expect along the meandering river reach flowing through the Town-X? How would you classify these bars? What is the main factor influencing the bar formation? [3]

5. The authority is also conducting a feasibility study of a Run-of-River (ROR) hydropower project in a tributary at location F that has a gross head of 500 m. The authority requests you to advise him/ her in planning for the suspended sediment sampling of the project. [8]

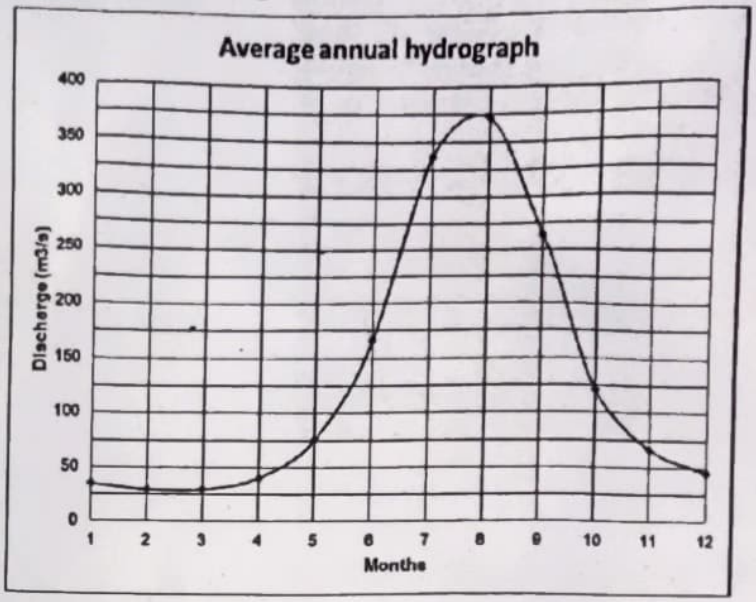
   i) What are the main parameters that you would recommend to obtain from the suspended sediment sampling and why?
   ii) The river at the headworks location is about 20 m wide and has a bed slope of 15%. Which sediment sampling method would you apply?
   iii) Considering the seasonal variation in river discharge, describe the suspended sediment sampling frequency that you would suggest for a yearlong sediment sampling program.
   iv) Define Isokinetic sampling. Why is it important in suspended sediment sampling?

6. Town-X is rapidly expanding due to the recent immigration from the villages in the river basin. The planners of town are planning to construct a straight river channel between point C and D, which would be 50 m wide and 1.5 km long, to accommodate more houses in the flood plain. What would be the short-term and long-term morphological response of the river in the reach? Explain with appropriate sketches. What would be your recommendation for the town planners? You may assume rectangular river cross-sections, long-term mean discharge of 50 m^3/s and a constant water level in the lake throughout the year. The non-linearity of sediment transport can be assumed as 4. [15]

7. What are the different paradigms of designing a reservoir? Which one would you chose while designing reservoir projects in Himalayan region? Explain with appropriate reasons. [3]

8. What are the sediment handling strategies in RoR hydropower projects? What are the key considerations for bed load handling at the headworks of the RoR projects? [5]

9. You are operating a RoR plant in a river with seasonal flow shown in figure below. The suspended sediment concentration variation shows the similar trend as that of the river flow. The turbine experiences wear and tear while operating during the high flow season and thus have to be maintained annually. Explain the turbine maintenance strategy which you would adopt to maximize the generation. [5]



10. Draw a typical sedimentation pattern in a reservoir. What are the differences between flushing and drawdown flushing? [5]

Supplementary Materials:

Particle Fall velocity can be estimated using the following relationship

$Ws = 0.097 \times D_s^{0.5178}$

Ws = Particle fall velocity (m/s)

Ds = Particle size (mm)

Sediment Transport Formula

Formula 1: $q_{sb} = 13.3\sqrt{\Delta g D_{50}^3}\sqrt{(\theta - 0.047)^3}$

Formula 2: $q_s = \frac{1}{12C^3\Delta^2 D_{50}\sqrt{g}}u^5$

q_s = Sediment transport per unit width ($m^3/s/m$)

θ = Shields number (-)

D_{50} = Median diameter of sediment (m)

Δ = relative specific density of sediment (-)

C = Chezy roughness ($m^{1/2}/s$)

u = flow velocity (m/s)

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Jestha

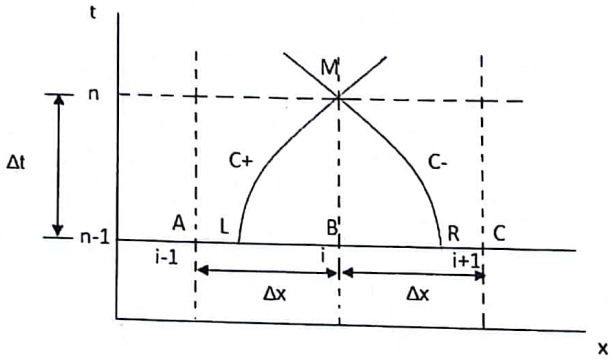
Exam	**Regular / Back**				
Level	M.Sc.	Full Marks	:	20
Programme	Hydropower	Pass Marks	:	10
Year/Part	I/I	Time	:	1.5 hrs

Internal Assessment -02

Subject: Applied Hydraulics

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempts **All** questions*
- ✓ *The figures in the margin indicate **Full Marks***
- ✓ *Assume suitable data if necessary*

1. Using fixed grid scheme, calculate velocity and flow depth at point M applying MOC as shown in figure below for 1D unsteady open channel flow.



Relevant data are as follows:
Trapezoidal channel with side slopes 1:2 (V:H)
Width of channel= 3 m and bed slope = 0.0001
V_A= 3 m/s, V_B= 2.8 m/s , V_C= 2.7 m/s
y_A= 2 m, y_B=1.9 m , y_C=1.8 m
Δx=1000 m Δt=30 sec
Take manning's n = 0.03

2. Write the assumption made for deriving governing equation of Simple Surge Tank and Derive the Governing Equation for Simple Surge Tank. 5

3. Calculate the transient pressure at reservoir, 100 m, 200 m and 300 m (at the end of a pipe of) from reservoir using Lax scheme up to j+1 time step. The reservoir has a constant head of 168 m. The diameter of pipe is 0.2 m, f=0.025 and a=1200 m/s. 0.0055 10

Level	M.Sc.	Full Marks	:	20
Programme	Hydropower	Pass Marks	:	10
Year/Part	I/I	Time	: 1 hrs	

Assessment – 2079 Baisakh **Set - B**

Subject: Applied Hydraulics

- ✓ *Candidates are required to give their answers in their own words as far as practicable.*
- ✓ *Attempts **All** questions*
- ✓ *The figures in the margin indicate **Full Marks***
- ✓ *Assume suitable data if necessary*
- ✓ *All questions carry equal marks*

1. The wicket gates of a turbine connected to the end of a 600 m long steel penstock pipe have been closed in 1.0 sec due to the disconnection of the power plant with the grid. Describe with necessary sketches the sequences of events (Pressure head, discharge, material behavior) for a full cycle. You may assume a reservoir at the upstream end of the penstock.

2. Calculate transient pressure at distance of each every 150m in a 600 m long penstock pipe for j+1 time step using Alternative I Mac CorMark Scheme.

   Given,

   f = 0.025
   a = 1200 m/s
   Q = 0.72 m^3/s
   Ho = 300+ Roll Number (m)
   D = 0.2 m

3. Compute and plot surface profile 1 km upstream of the fall in trapezoidal channel with free over fall downstream having following data by (a). Euler Method (b). Modified Euler Method.

   Δx =50 m, 150 m, 300 m, 500 m and 1000 m

   Bottom width 30 m

   Side slope 2H to 1 V

   n = 0.013

   Q = 45 m^3/s

   S_o = 0.00015

4. Compute the free surge and the period of a simple surge tank following sudden rejection if the initial steady flow is 1200 m^3/sec. The length of tunnel is 1700 m and the c/s area of the tunnel and of the tank is 200 m^2 and 600 m^2 respectively.

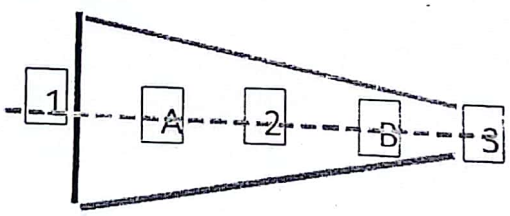
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Jestha

Exam.	Back		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Advanced Hydraulics

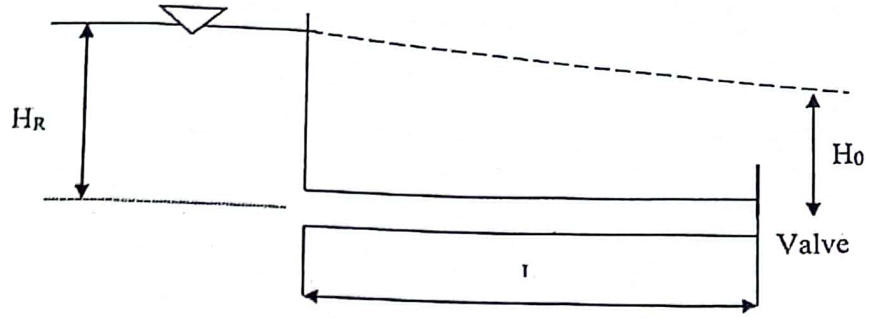
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Derive the following Saint-Venant continuity equation for rectangular channel section: $\frac{\partial y}{\partial t} + y\frac{\partial v}{\partial x} + v\frac{\partial y}{\partial x} - \frac{q_i}{b} = 0$, where q_i is bulk lateral inflow and other symbols have their usual meanings. [8]
2. Derive the simple wave problem equation for a long channel carrying uniform flow having disturbance at the upstream end. Describe how this equation is useful for the dam break problem with dry downstream channel bed. [8]
3. How does the following concepts affect the quality of a grid: orthogonality, expansion ratio and aspect ratio? Sediment deposition is computed numerically in a settling basin. The water flow is uniform with a velocity U=5 m/s and a water depth H=5m. The fall velocity of the sediments is w = 0.10 m/s. The orthogonal grid cells has sizes dx=1m and dy=0.1m in the horizontal and vertical directions, respectively. The Manning-Strickler's value is M=1/n=40. Compute the values of the a_{nb} coefficients for the SOU scheme. [2+8]
4. One dimensional flow in a nozzle shown in figure below can be described by
   $\frac{d(\rho UA)}{dx} = 0$ and $\frac{d(\rho UA)U}{dx} = -A\frac{dP}{dx}$
   Where U is velocity, P pressure and A cross-sectional area.



   Given conditions are $\rho = 1$ everywhere, $A_A = 3$, $A_B = 2$, $P_1 = 100$, $P_3 = 0$. Assume that the fluid upstream of point 1 has negligible momentum. Obtain U_A, U_B, P_2 using SIMPLE Algorithm. Employ appropriate Under-relaxation. [10]
5. A 5-m wide rectangular concrete-lined canal takes off from a lake having a constant water level of 2 m above the channel bottom at the entrance. The channel is long, has a bottom slope of 0.004, and n = 0.013. If the head losses at the entrance are negligible, determine the discharge in the canal. [8]

6. The figure above shows the simple pipe line system with a valve at downstream. For instantaneous closure of valve and for the following data, calculate the pressure head values (Using method of characteristics) at the mid-point length of pipe for 0.1 second. Given, L =500 m, celerity = 1300m/s, Diameter of pipe= 0.4 m, friction factor, f= 0.018, HR = 100m, Ho = 50m. [8]



7. A 200 km long rectangular channel (B= 5 m) has a reservoir at the upstream end and a gate at the downstream end. Initially the flow condition in the canal are uniform at V = 0.35 m/s and y = 1.05 m. The water surface level in the reservoir begins to rise at a rate of 0.2m/h for 6 h. Calculate the flow condition in the canal at t = 2h. Assume $S_0 = S_f = 0$. Use Leapfrog Scheme and take appropriate Δx and Δt. [8]

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Tribhuvan University
Institute of Engineering
Pulchowk Campus
Mid-Term Examination, May 2022

Level: Master
Program: Water Resources Engineering
Subject: **Hydrologic Analysis**

Full Marks: 40
Time: 1hr 15 min
Year/Part: I/I

Please answer the following questions in own words as far as practicable. Scores to each question are provided in bracket.

Q1. What are different approaches for hydrologic analysis? Discuss their complementarities. [6+4]

Q2. How do you think that infiltration is a key component of a watershed model? The Horton's infiltration equation for a basin is given by $f = 10 + 30e^{-0.8t}$ where f is in mm/hr and t is in hours. What are the values of f0, fc and k? If a storm occurs on the basin with an intensity of more than 40mm/h, determine the depth of infiltration for the first 1 hour and the average infiltration rate for the first 2 hours. [3+7]

Q3. Describe the conditions of applicability of different approaches for changing duration of Unit Hydrograph (UH). Derive a 3-hr unit UH from a 2-hr UH given below. [3+7]

Time (h)	0	1	2	3	4	5	6	7	8	9
2-hr UH ordinates (m^3/s)	0	50	100	150	300	250	100	50	0	0

Q4. What is **convolution integral**? Discuss, with appropriate illustration, how linear system model/concept is comparable with unit hydrograph concept. [3+7]

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Minor Test
MSC WRE. Advanced Hydraulics
FM: 100 PM: 50
Time: 60 mins

1. By applying the continuity and momentum equation, Derive, for rectangular channel, the celerity of the wave equation $c = \sqrt{gy}$, where y = depth of flow. (20)

2. Water flows at a depth of 2.5 m and a velocity of 1.5 m/s in a rectangular channel into a large lake. The level of water in the lake is initially the same as that in the channel but suddenly starts falling resulting in an increase in velocity at the junction with the lake at a rate of 0.6 m/s per hour for a period of three hours.

   a) Determine how long it takes for the velocity in the channel at a distance of 1.5 km from the lake to increase to 2.7 m/s. Assume frictionless horizontal channel.
   b) If the depth at the junction with the lake start falling at the rate of 0.3 m per hour, find how long it takes for the water level in the channel to fall by 0.6 m at a section 3 km upstream of the junction? (20 x 2=40)

3. Consider a rectangular channel 30 m wide with bed slope of 0.015 and manning's n = 0.035. In a numerical routing scheme, $\Delta x = 1500\ m\ and\ \Delta t = 10\ min$. Given the following rates:

Point	$i, j+1$	i, j	$i+1, j$
Q (m^3/s)	29.5	22.6	20.0

Determine Q_{i+1}^{j+1} using a finite difference scheme for a non-linear kinematic wave model.

Assume wide rectangular channel in development of kinematic wave model. (40)

M. Sc. Water Resources Engineering Program

Minor Test

Subject : Simulation Lab

FM: 20 Time: 2hr

1. Write a program to find $A^T \times B^T \times B \times A$

A

$$\begin{bmatrix} 3 \\ -4 \\ 2 \\ 5 \end{bmatrix} \qquad \begin{bmatrix} 3 & 5 & 7 & 4 \end{bmatrix}$$

Sub routine

2. A 6-h storm with a total of 5 cm of effective rainfall covers the entire watershed and is distributed in time as follows:

Time (h)	0	1	2	3	4	5	6
Effective rain (cm)	0.1	0.8	1.6	1.2	0.9		0.4

Direct runoff (Q) due to this rainfall have been observed as follows:

Q,m^3/s	0	10	100	360	840	1670	2500	2700	2410	1740	1000	460	170	40	0
t, h	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14

(a) Derive UH using LST.

(b) In the same screen, (i) Plot UH with title at left top corner covering ½ of the screen. All lines in RED color. Axis titles in GREEN Times New Roman font of 20 height. (ii) Plot composite hydrograph at right bottom corner covering ¼ of the screen. All lines in Red color. Axis titles in white Arial font of 20 height.

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Simulation Laboratory

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ ***All** questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Develop finite difference molecules for

$$\left(\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

b) Using numerical approximation of $\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}$, write down the equation in matrix form which determine the functions "u" in blank grid in the figure below.

10	10	10	10
8			8
6			6
4			4
2			2
0	0	0	0

2. a) Following effective rainfall produce direct run-off and ceases (becomes 0) at 23:00.

Time (h)	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Effective rain (cm)	1	2	3	4	5	6	

Prepare a coefficient Matrix of effective rainfall required for the estimation of non-zero ordinates of UH using LST.

b) Write a program to plot above hyetograph in window coordinate

3. Water table (H) and Rainfall (R) are related as $H = \alpha+\beta R$.

H	R
11	3
8	2

Since the number of unknown and number of equations available here are equal, α and β can also be calculated uniquely without using least square technique. Estimate the new value of α and β manually using previously estimated values if new set of value H = 6 and R = 1 become available, using recursive (updating) least square procedure. Check the results by estimating using LST using three sets of known variables as well. You are required to show all calculation details.

4. Solve using the steps to convert following differential equation into a difference equations for N = 4

$$\frac{du}{dx}+u=2x^2+x \qquad 0\le x\le 1 \quad u(0)=3$$

5. Write codes with proper explanation for the following:
   a) Random number generation between (10 and 100).
   b) Calculation of variance recursively.
   c) Smoothening of graphs using artificial viscosity.

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INSTITUTE OF ENGINEERING
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2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Advanced Hydraulics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) A rectangular channel of width 60 m and length 7.2 km has a constant bottom slope of 1:100. Assuming a value of manning's coefficient of 0.035, an initial condition of uniform flow along the channel at rate of 57 m^3/s and the inflow hydrograph given in the table below, calculate the discharge at 4.5 km downstream after 60 minutes using Kinematic wave approximations. Take dt = 6min and dx = 900 m. [6]

Inflow hydrograph	t(min)	0	12	24	36	48	60	72	84	96	108	120
	Q(m^3/s)	57	57	85	113	142	170	142	113	85	57	57

b) Consider the following Saint Venant equations for prismatic channel having no lateral inflow and outflow:

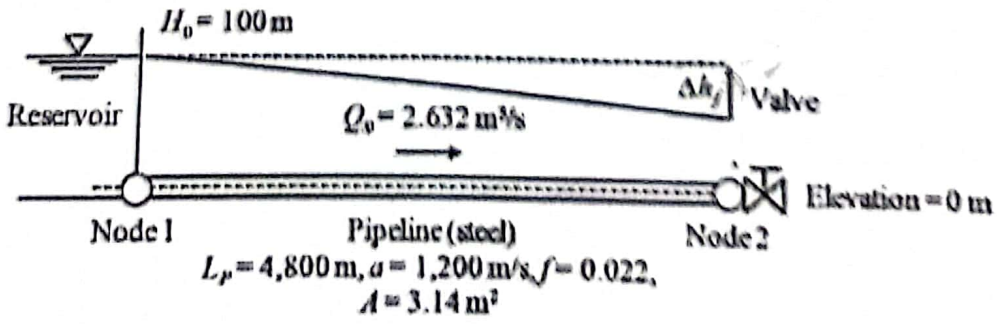
$$\frac{\partial y}{\partial t} + D_h \frac{\partial V}{\partial x} + V\frac{\partial y}{\partial x} = 0$$

$$\frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} + g\frac{\partial y}{\partial x} = 0$$

Transform the above governing equations into equations in λ – form for Lamda explicit scheme. Write also the finite difference schemes used for the predictor and corrector part of Lamda Scheme. [4+2]

2. a) A side-channel spillway channel is 100 m long and is rectangular in cross-section with B = 5 m, n= 0.020, β=1.30 and S_0= 0.15. If the lateral inflow rate is 1.75 $m^3/s/m$ length, find the critical depth and its location. [4]

b) Calculate the pressure head at Node 1 and Node 2 in due to sudden closure of valve in next possible time step using method of Characteristics. Assume suitable value if necessary. [8]



3. a) Sediment deposition is computed numerically in a sand trap. The water flow is uniform with a velocity U=3 m/s and a water depth H=4m. The fall velocity of the sediments is w = 0.15 m/s. The orthogonal grid cells has sizes dx=1m and dy=0.1m in

the horizontal and vertical directions, respectively. The Manning-Strickler's value is M=1/n=30. Compute the values of the a_{nb} coefficients for the SOU scheme. [8]

b) The analysis of flow measurement in a river reach gave:

	Station 1	Station 2
Location x (km)	10.8	12.1
Water depth (m)	0.55	0.45
Flow velocity(m/s)	0.45(+)	0.50(+)

At t = 1 h. Assuming a kinematic wave (S_o=S_f), plot the characteristics issuing from the measurement stations assuming straight lines. Calculate the location, time and flow properties at the intersection of the characteristics. [4]

4. a) The discharge and c/s area of the river at various sections d/s from the gated structure of hydropower due to some shock are given by the equations: (where x is distance from the gated structure)

$A = (-2 \times 10^{-5})x^2 + 0.0207x + 20.4, (m^2)$
$Q = (6 \times 10^{-5})x^2 - 0.0519x + 18.18, (m^3/s)$
The depth area relationship is also given by,
$y = -0.0632A + 3.4603$ (m)
Considering $\Delta x = 150\ m$, Average Top width for all section = 100m, S_0 = 0.001, n = 0.013

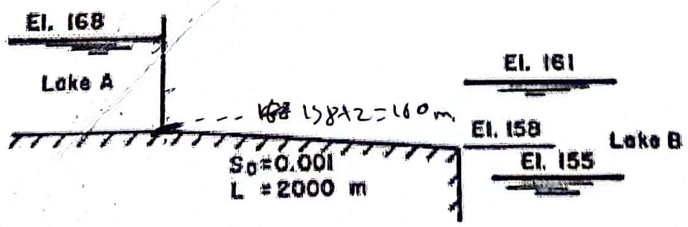
Implement Leap Frog Scheme to the Full dynamic Saint Venant Equations to determine the discharge for the wide rectangular channel at next maximum possible time step at a distance of 450 m. [8]

b) A complex natural river is to be modelled with a finite volume CFD model. What types of grids are available? What are the advantages and disadvantages with the different types? Which type would you prefer for the modelling? [4]

. a) What is SIMPLE algorithm? How will you solve Navier stokes equation using this algorithm? [6]

b) Lakes A and B are connected by a 10 m wide rectangular channel as shown in figure. If n for the flow surface is 0.013. Calculate discharge in the channel if the water level in lake B is at

EL. 155 and EL 161. [3×2]



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Tutorial: Sedimentation and River Engineering

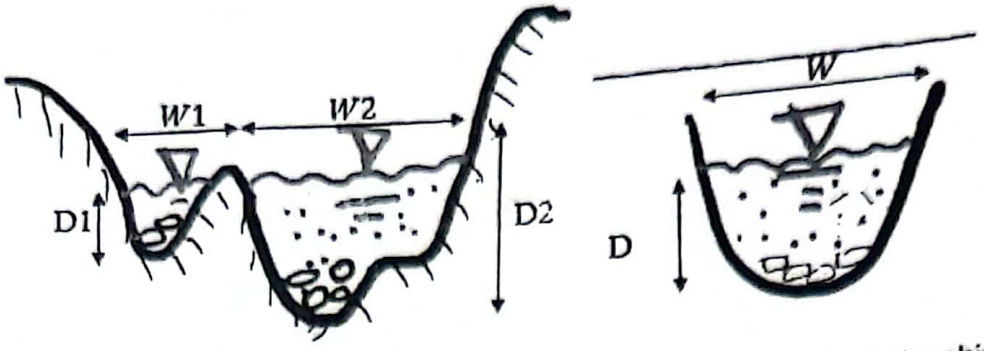
21 March 2022

Reach-1
Width = 100m
Slope = 1%
Length = 5Km

Reach-2
Width = 150m
Slope = 0.5%
Length = 10Km.

A Town-X is located along a bank of a river which originates from the Churia region of eastern Nepal. In the recent years the massive road construction and de-forestration has lead to high sediment yield from the catchment. Significant amount of sediment deposition has occurred in the river bed, in the recent years, which has threatened the infrastructure along the river flood plain. The mayor of the Town-X has requested you to suggest some immediate interventions which can lower the hazard in the coming monsoon. What type of mitigation measures would you adopt and provide explanation with quantitative assessment.

The river can be divided into two reaches and the Town-X is located in the flood pain of Reach-2. The river is braided along both reaches. The width to depth relationship in braided channels is more complex than the single thread channels.



The relation between the width and depth is given by the following relationship:

$W = K \times D^{\alpha}$

$K = 1.366 \times W_c^{0.834}$

$\alpha = 0.2196 \times P^{0.5182}$

$P = \gamma QS$

Where,

W = Wetted width of river (m); W_c = Total channel width (m); D = Depth of water (m); K = Constant (-); α = Constant (-); P = Stream power (N); γ = Specific weight of water (N); Q = Discharge (m^3/s); S = Slope (-)

A bulk sediment sampling was conducted at Reach-1 and the data obtained from the field is as follows:

Sieve Size (mm)	Weight Retained (Kg)
125	196.3
100	140.2
75	61.0
50	84.8
45	11.0
31.5	38.0
22.5	31.0
16	18.6
12.5	17.4
8	25.6
4.5	15.7
2.36	30.1
1.6	8.0
0.5	47.4
0.3	36.5
0.18	13.8
0.063	8.3
Fine	170.0

→ Difference between flushing and sluicing

→ Lecture 8 : Slide #86

→ Lecture 8 : Operation of PROR Reservoirs #Tutorial

The river is ephemeral in nature and the average flood of 200 m^3/s is witnessed every year for the average period of 15 days. For the rest of the period the discharge in the river is not sufficient to mobilize the armoured river bed (i.e. a coarse top layer of the river bed).

You may assume Mannings = 0.04 for both reaches and form drag can be neglected. Equivalent cross-sectional area can be assumed as rectangular, Discharge is constant for both reaches.

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Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Sedimentation and River Engineering (*Elective*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt <u>All</u> questions.*
- ✓ *The figures in the margin indicate <u>Full Marks</u>.*
- ✓ *Assume suitable data if necessary.*

1. What are the physical functions of rivers? Define different reaches/zones observed in a river systems with suitable examples. [4]
2. What are the different sources of sediment production in a catchment? Define sediment delivery ratio. What are the factors that affect the sediment delivery ratio? [4]
3. You carried out a pit sampling in a bar of a river to determine the sediment characteristics of the deposits. The following data is obtained from the sample. Compute the standard deviation, geometric mean and median diameter of the sample. Comment on the characteristics of the sediment deposits. [8]

Sieve Size (mm)	Weight retained (kg)
125	110.9
100	64.8
75	11.6
50	42.4
45	17.5
31.5	11
22.5	16
16	12
12.5	12
8	17.44
4.5	9.50
2.36	19.44
1.6	5.75
0.5	38.63
0.3	22.69
0.18	7.06
0.063	3.98
Fine	2.19

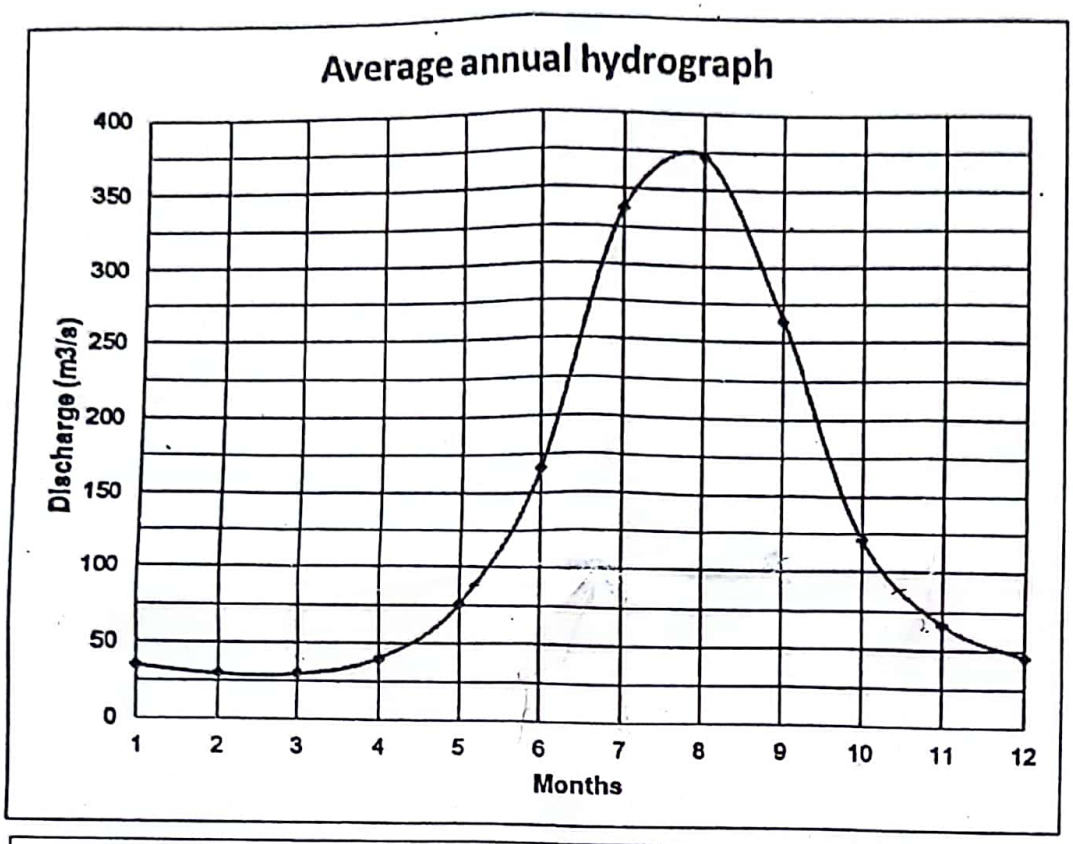
4. An automatic suspended sediment sampler is installed near the headworks area of a project which carries out sampling at an hourly frequency. The data collected during a flood event on 20th August 2020 is shown in Table below. Calculate the total suspended sediment load which occurred during the flood using different applicable methods. [8]

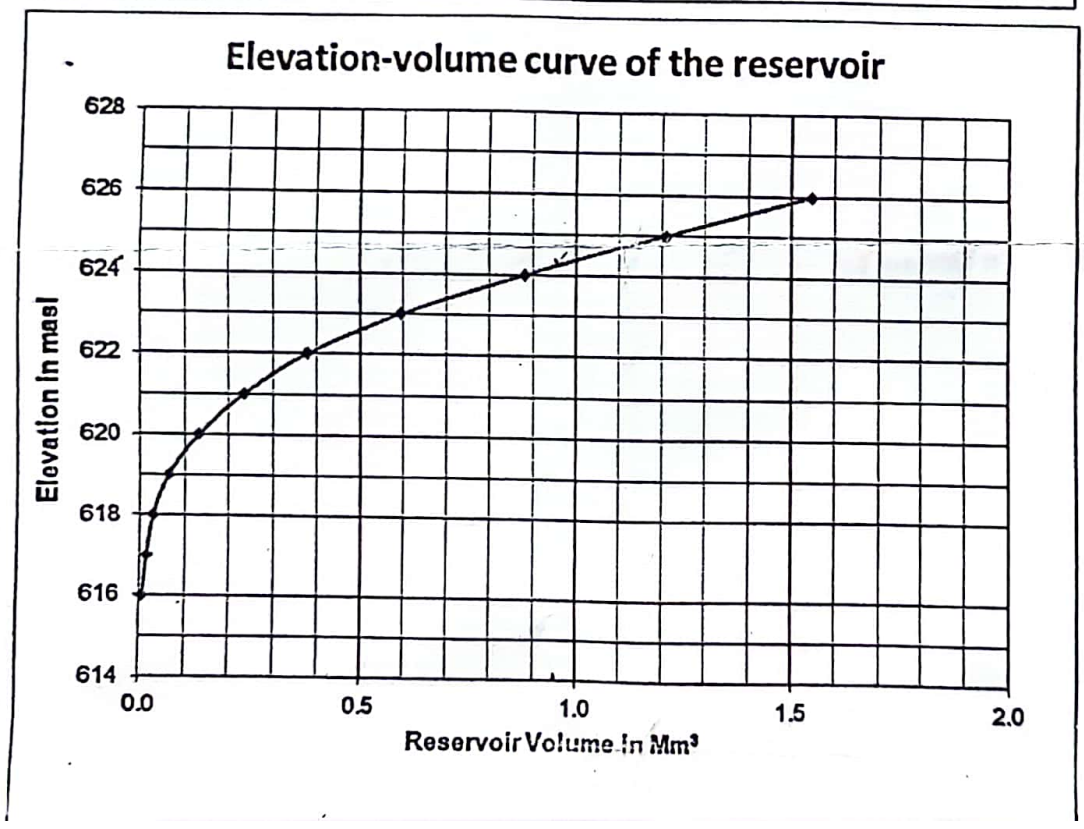
Table: Suspended sediment concentration and discharge recorded during the sampling period.

Date - Time	Suspended Sediment Concentration (PPM)	Discharge (m^3/s)
20/8/2020 - 8:00	15.72	14.0
20/8/2020 - 9:00	24.08	14.9
20/8/2020 - 10.00	34.01	19.0
20/8/2020 - 11:00	34.86	23.0
20/8/2020 - 12:00	199.89	35.3
20/8/2020 - 13:00	2056.87	80.7
20/8/2020 - 14:00	919.54	102.3
20/8/2020 - 15:00	2542.52	98.0
20/8/2020 - 16:00	873.48	81.4
20/8/2020 - 17:00	494.39	70.7
20/8/2020 - 18:00	103.91	65.4
20/8/2020 - 19:00	128.13	61.6
20/8/2020 - 20:00	108.00	52.7
20/8/2020 - 21:00	56.06	45.7
20/8/2020 - 22:00	32.47	38.4

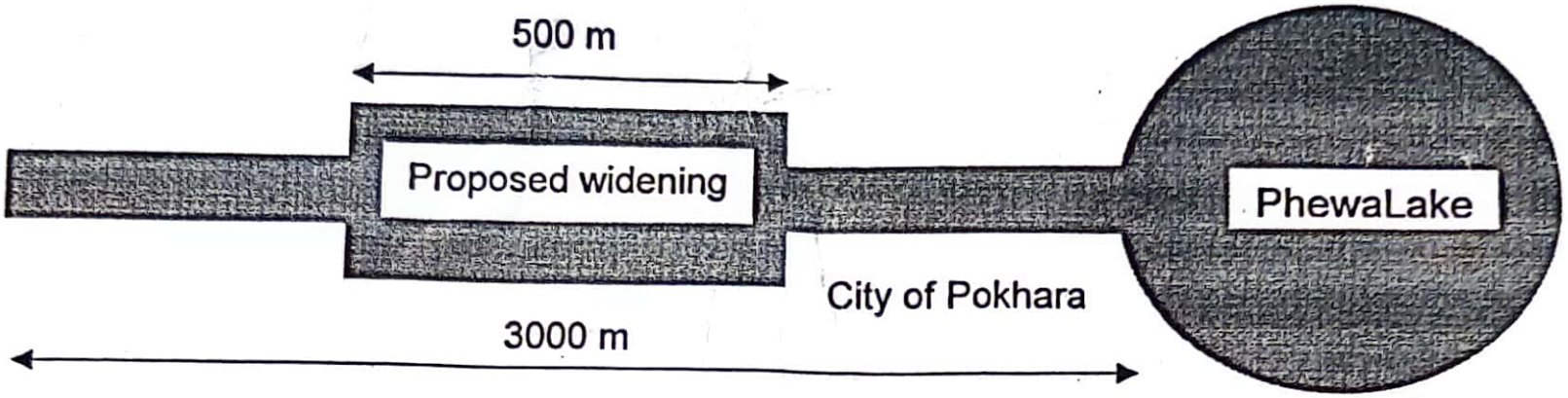
5. Define river bars. How are they classified? Why are river bars important for the water resources infrastructure project development? [4]

6. You are assigned to design a headworks of a peaking run-of-river hydropower project in the middle hills of Nepal. The project has an installed capacity of 75 MW and net head of 100 m and has to be operated to meet the 6 hours of daily peaking demand (3 hours in the morning and 3 hours in the evening). The estimated long-term annual hydrograph at the headworks and the elevation volume curve of the reservoir is provided in the figures below. Determine the capacity inflow ratio of a reservoir. Which design paradigm would you follow and why? Explain the annual reservoir operation that you would recommend for this project. You may assume an overall mechanical efficiency of 85% and neglect the effect of reservoir levels in the net head, for power calculations. After the project is implemented, the owner of the project again recruits you as the operation and maintenance expert. Now you need to perform the repair and maintenance of the turbines. What would be your maintenance strategy to maximize the annual revenue? [16]


Average annual hydrograph
Discharge (m3/s)
400
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
11
12
Months


Elevation-volume curve of the reservoir
Elevation in masl
628
626
624
622
620
618
616
614
0.0
0.5
1.0
1.5
2.0
Reservoir Volume In Mm³

7. A 3000 m long river reach passes through the city of Pokhara and drains into Phewa Lake. The river along this reach is channelized by flood walls along both banks. The river has an average annual discharge of 30 m^3/s, reach average width of 30 m and longitudinal slope of 0.5%. The city council of Pokhara is planning to increase the width of 500 m reach in the middle to 60 m and develop a city park in the same area. The council recruits you as a river morphologist and requests you to make the assessment of the project. What would be short-term and morphological response of the river in the reach? Explain with appropriate sketches. What would be your recommendation to the city council? You may assume a constant water level in Phewa Lake throughout the year. [16]



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M. Sc. Water Resources Engineering Program

Minor Test

Subject: Water Induced Hazard

1. Prove that

$$Q_{Debris\ flow} = \frac{C^*}{(C^*-\overline{C})} Q_{water} \qquad (5)$$

2. Starting from the basic momentum equation for motion of water, derive following steady momentum equation.

$$(1-Fr^2)\ \frac{\partial h}{\partial x} + \frac{\partial z_b}{\partial x} = Fr^2 \frac{h}{B} \frac{\partial B}{\partial x} - i_e \qquad (5)$$

3. What tensile strength of 500 roots/m^2 of diameter 2 mm will make factor of safety of stability of hillslope with following characteristics equals 2 in extreme worst situation?

C' = 5.3 kN/m^2; φ' = 34.7^0; γ =18.0+2.0(h_w/h_z) kN/m^3, γ_w = 9.8kN/m3; β=35^0; h_z=0.9m; Take surcharge vegetation = 3.8 KN/m^2 and wind load = 0.1 KN/m^2 (5)

Given:

Q(m3/s)	15	L (m)	300	B (m)	50		
n	0.03	λ	0.4	τ^*_c	0.02	Δx (m)	10
S.G	2.65	d_{50} (m)	0.0005	S_0	0.00819		

h (0,0) = 0.4 for t $\geq$ 0 and Z_b (0,0) = 50 m for t $\geq$ 0

Find:

q_b (2,2), q_b (3,2) τ_c (2,2), τ_c (3,2), Z_b (2,2), Z_b (3,2) for Δt = 1 hr (10)

4. A debris flow in a long rectangular channel 4 m width has mean velocity 6 m/s. What is the velocity at mid depth if $\Theta = 10^0$, mean dia of sediment = 0.2 m, C^* = 0.6, C_{mean} = 0.55. Take angle of collision as 90^0. (5)

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2080 Chaitra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Water Induced Hazards

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Explain in details with the necessary sequential steps for developing a simple landslide warning model based on rainfall amount and intensity for a territory using hillslope (kinematic storage) and infinite slope model. [12]

2. 0.2 m wide and 30 m long channel had bed material with a mean diameter of 0.32 mm. From the uniform-flow measurements, the following values were computed: $a = 1.45 \times 10^{-3}$; $b = 5.0$; Manning $n = 0.022$; and the porosity of the sediment bed layer, = 0.4. For, the initial water discharge, $q_o = 0.020$ m^2/s; the uniform flow depth, $h_o = 0.05$ m; the initial bed slope, $S_o = 0.00356$; Implement the upstream boundary representing constant discharge by specifying $q\ (0, t) = q_o$ for $t \geq 0$. Assume a fictitious node upstream of node 1 and specify sediment discharge at that node equal to $3 \times q_s$. For Δx = 1m and CFL = 0.9, find the change in bed elevation after Δt at 1 and 2 m d/s. [12]

3. With appropriate data sets draw approximate stereographic projections for situation (i) Rock toppling and (ii) wedge failure. [3+3]

4. A channel is divided into 5 equal segments (Δx = 10m) with 6 nodal points. The flow in channel is steady and sub-critical. Porosity of the sediment bed layer, = 0.4. What will be the sediment discharge at the outlet of the channel (node 6) with respect to sediment discharge at the inlet of the channel (node1) if net change in bed level of the channel degradation is 2 m in two hours period? [5]

5. Explain with a plot how gauge to gauge forecasting tool is developed with additional information of change in stage of the base station. Describe how this methodology is used in multi-tributary model. [5+5]

6. Derive the expression for stress due to interparticle collision during debris flow. [5]

7. Prove that there will be erosion of the bed during debris flow event when $\bar{c} < c_\infty$. [5]

8. [5]

Given		Find
h (13:00, 25 m u/s) = 6 m		velocity (13:00, 25 m u/s) =?
h (13:00, 25 m d/s) = 4 m		velocity (13:00, 25 m d/s) =?
h (13:00, 75 m u/s) = 6.5 m		
h (13:00, 75 m d/s) =3.5 m		
M (12:00, 50m d/s) =27 m^2/s		
M (12:00, location A) = 25 m^2/s		
M (12:00, 50m u/s) =20 m^2/s		

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Minor Test: Hydraulic Structures, Time: 90 mins

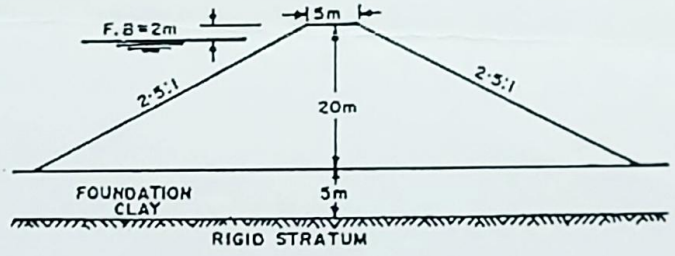
1. How low height dam is defined and designed? Explain the stress distribution at the base of concrete gravity dam for both Reservoir empty and Reservoir full case with neat sketches.

2. A homogenous earth dam section shown in figure has the following data:

a) Properties of materials of the dam
i) Dry density: 1800 kg/m^3
ii) Saturated Density: 2200 Kg/m^3
iii) Average angle of friction = 30^0
iv) Average Cohesion: 1600 kg/m^2

b) Properties of foundation of materials
i) Average unit weight: 1700 kg/m^3
ii) Average cohesion: 5400 kg/m^2
iii) Average angle of internal friction: 7^0

Find the seepage through the dam section and Check the section for the following:
i) Sloughing of the upstream slope during sudden drawdown
ii) Stability of foundation against shear



3. Check the stability of surge tank system having the dimensions given below. The specified factor of safety is 50 percent. The main data of the installation are as follows:
   Length of pressure tunnel : 700m
   Diameter of pressure tunnel: 3.5 m
   Velocity coefficient of pressure tunnel: 90
   Cross-sectional area of the upstream surge tank: 50 m^2
   Length of tailwater tunnel: 400m
   Diameter of the tailwater tunnel: 4.5 m
   velocity coefficient of tailwater tunnel: 70
   Cross sectional area of downstream surge tank: 120 m^2
   Design Discharge: 40 m^3/s
   Net head: 200m
   (Correct the system with appropriate hydraulic considerations, if found unstable)

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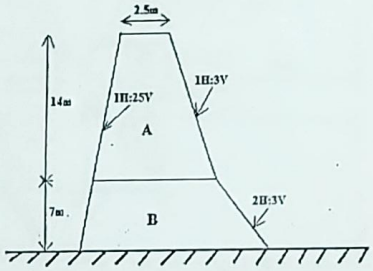
Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Hydraulic Structures

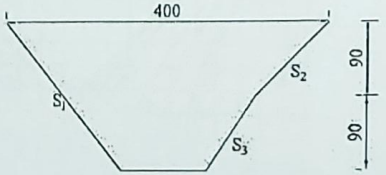
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary Charts are attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. a) A concrete Gravity dam in the western region of Nepal is in the following shape and size. Estimate Force induced due to earthquake per unit length of dam using Seismic Coefficient Method. Take Unit weight of dam material = 25 kN/m^3. Use Recommendation of IS1893-1984. [8]



b) Design a Francis turbine for following site condition data: Q = 10 m^3/s, H = 220m. Assume suitable parameters for your design. [7]

2. a) Using simplified arch theory, design a constant radius arch dam 180m high in a canyon having the cross section shown below. The upstream face is vertical. The thickness at the crest required to have 5 m. Take $\sigma_{allowable} = 4\,Mpa$, $\gamma_{concrete} = 24\frac{kN}{m^3}$, $\gamma = 10\frac{kN}{m^3}$ and $\theta = 130^o$. $S_1 = 1V:0.8H, S_2 = 1V:1.2H, S_3 = 1V:1.1H$ [7]



b) A hydropower system with the following design parameters is subjected to instantaneous closure from full load condition. Considering a time step as 60 sec compute the resulting surge levels including the maximum only in a simple surge tank. Use finite difference method. Make suitable assumptions if necessary. [8]

Design Discharge = 20 m^3/s
Diameter of tunnel = 4.5 m
Length of headrace tunnel = 3500 m
Weighted Manning's coeff. = 0.017
Diameter of Surge Tank = 10.0 m
Hydrostatic Level = 860.00 m

3. a) Discuss with illustrations the major issues in planning and design of hydraulic Structures in a Himalayan river. [5]

b) What are the major drivers of climate risk associated to water projects? [5]

c) Discuss with illustrations the mitigation measures to minimize impacts due to Flood and Multi hazards in Water projects in Himalayan rivers. [5]

4. a) Using the following data, Design a variable thickness upstream impervious blanket for an earth dam so that the seepage is reduced by at least 50%. [5]

Coefficient of permeability of blanket material = 3 x 10^{-8} m/s
Coefficient of permeability of foundation soil =8 x 10^{-6} m/s
Depth of foundation = 20 m
Total Water Head= 30 m
Base width of the core of dam = 70 m
Height of dam = 35 m

b) The figure below shows a multipurpose project (hydropower and irrigation) in one of the river. The concrete dam of height 64 m and 949 m long was constructed with central ogee spillway in 570 m length. The spillway consists of 23 spans of 20 m width equipped with radial gates. Extracting information from the provided figure,

i) Calculate specific discharge per unit width through the spillway corresponding to HFL. Assume suitable pier and abutment coefficient. [2]

ii) The dam is founded on competent rock (gneissic formation). From the preliminary geotechnical investigations, it is expected that there is good rock downstream of the dam as well. Given the preliminary geotechnical and topographical conditions, a solid bucket is designed as a terminal structure for energy dissipation. USBR method was applied during design. Check the provided invert elevation and bucket radius is acceptable or not according to IS7265-2010 for design of solid bucket type dissipator. (Relevant charts are attached) [8]

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Relevant Charts for the question 4a)

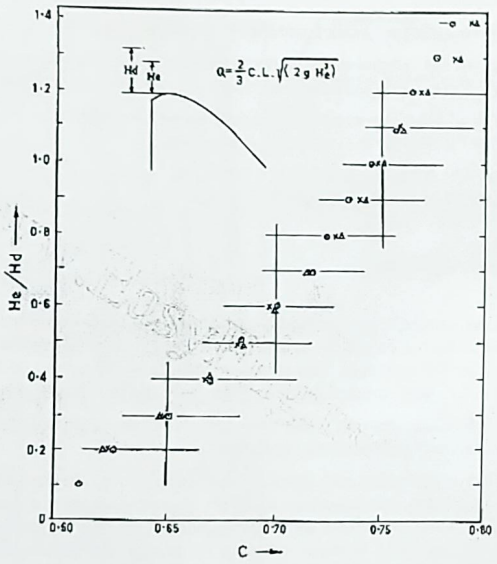


Figure 5 Discharge coefficient for design head for vertical upstream face: ⊕USBR, × WES(Original), △ WES(Elliptical).

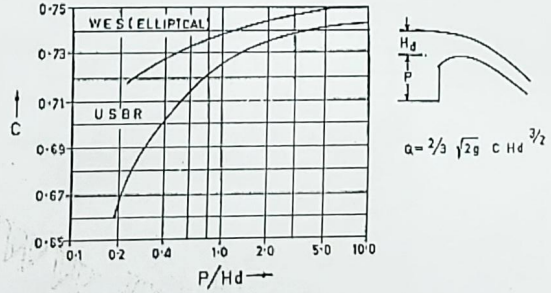
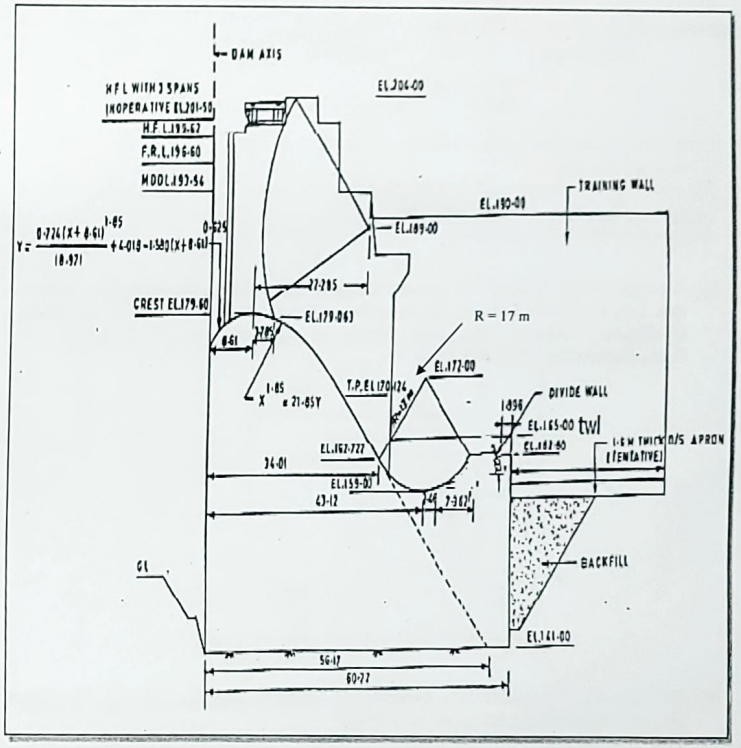


Figure 6 Effect of approach depth on coefficient of discharge.



Tribhuvan University
Institute of Engineering
Pulchowk Campus
Internal Assessment, 25th March, 2024

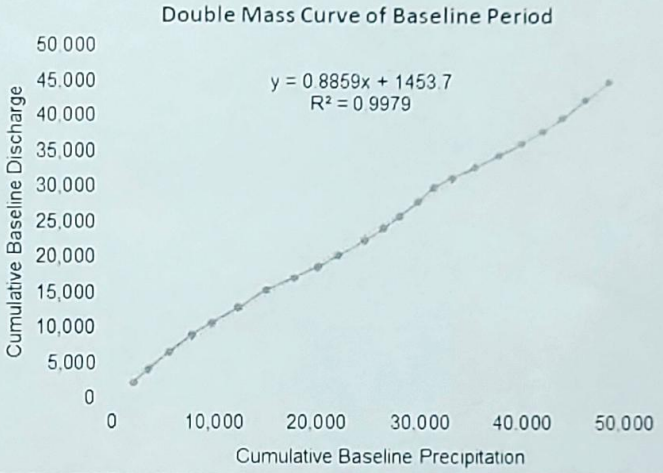
Level: Master
Program: Water Resources Engineering
Subject: **Climate Change & Water Security**

Full Marks: 100
Time: 1.5 hours
Year/Part: I/II

Please answer the following questions in own words as far as practicable. Scores to each question are provided in bracket.

Q1. There are varieties of global climate models (GCMs) or regional climate models (RCMs) available for projecting future climate. How do you select suitable one(s) for your application to a specific study area? Can we rely on one or need to use multiple GCMs/RCMs and why? [15+10]

Q2: Average annual time series of precipitation (P, mm) and discharge (Q, m^3/s) for a period is divided into baseline and variation periods. A double mass curve for the baseline period is shown in the Figure. Mean observed discharge of the entire baseline period is 1,962.7 m^3/s and precipitation and discharge for variation period (8 years) are shown in the following Table. Year 0 refers to the last year of the baseline period. Estimate relative contributions (%) of climate (rainfall) variability and anthropogenic activities to the total changes in river discharge. [25]



Year	0	1	2	3	4	5	6	7	8
P (mm)	2436.3	1926.8	1603.4	2514.9	1891.2	2317.5	2129.7	2001.6	1751.3
Q (mm)	2713.7	1462.2	1144.0	1250.1	1032.2	1406.7	1794.6	1724.9	2014.6

Q3. "Risk-based decision-making involves trade-offs among actors, between different risks and costs, and through time". Please elaborate the statement with appropriate examples linking them with various water security pathways. [25]

Q4. Discuss national and international frameworks for responding to climate change. [25]

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	**Regular**		
Level	M.Sc.	**Full Marks**	60
Programme	MSWRE	**Pass Marks**	30
Year / Part	I / II	**Time**	3 hrs.

Subject: - Climate Change and Water Security (*Elective*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Elaborate interaction between hydrosphere and atmosphere. Please elaborate interlinkages among carbon cycle, energy cycle and water cycle with appropriate illustrations. [5+7]

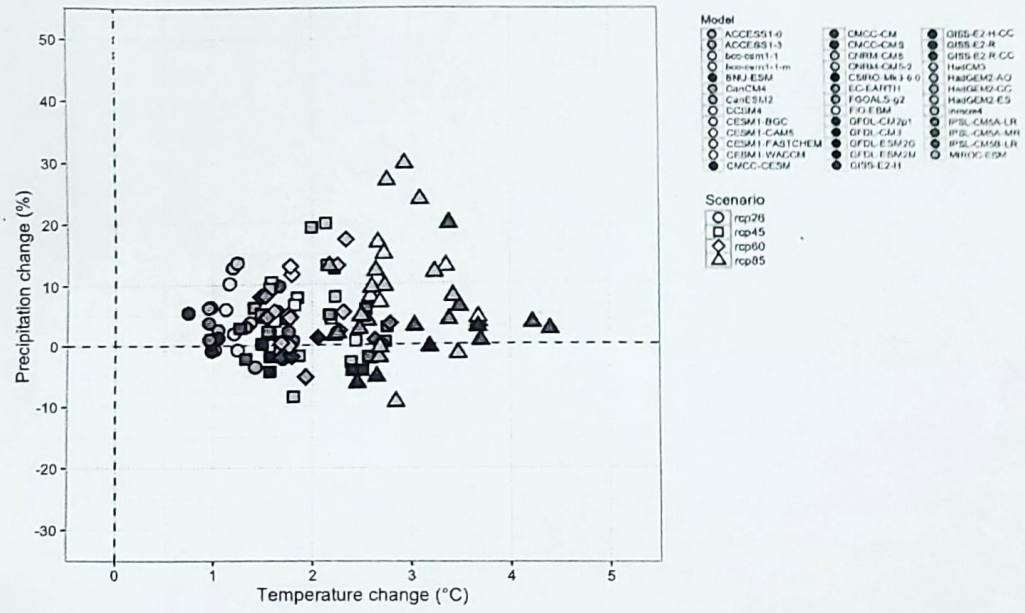
2. Average annual time series of precipitation (P, mm) and discharge (Q, mm) for a period is divided into baseline and variation periods. A double mass curve for the baseline period has a regression equation of $y = 0.8x+1200$ ($R^2 = 0.96$), where y is cumulative baseline discharge and x is cumulative baseline precipitation. Mean observed discharge of the entire baseline period is 1,890mm and precipitation and discharge for variation period (7 years) are shown in the following Table. Year 0 refers to the end of baseline period. Estimate relative contributions (%) of climate (rainfall) variability and anthropogenic activities to the total changes in river discharge. Provide your thoughts on better ways of attribution to climate change. [8+4]

Year	0	1	2	3	4	5	6	7
P (mm)	2200	2010	2300	1640	1400	2270	2060	1810
Q (mm)	1800	1300	1100	1050	970	1210	1580	1740

3. How climate change affects water security? How nexus approach helps towards achieving water security? Discuss international frameworks for responding to climate change. [4+4+4]

4. Following table shows precipitation (P) data for the period of 2026-2040 (15 years planning horizon) based on ARMA model. The Figure shows projected changes in climate from various General Circulation Models (GCMs) for the study region. Based on this information, please answer the following questions;

Year	P (mm)	Year	P (mm)	Year	P (mm)
2026	4	2031	58	2036	119
2027	0	2032	87	2037	107
2028	83	2033	26	2038	28
2029	164	2034	62	2039	0
2030	363	2035	163	2040	87



i) List the precipitation and temperature change factors you could use if your goal is to create a stress test that approximately encompassed the projections. [2]

ii) If you are using 50 stochastic realizations, how many model runs would you need using the change factors in question (i)? [1]

iii) If flooding is an issue, which extreme scenario(s) would be concerning? [2]

iv) If water supply is an issue, which extreme scenario(s) would be concerning? [1]

v) Develop a scenario of precipitation (one maximum case only) based on the change factor selected in question (i) and using data from table. [6]

5. Write short notes on: (Any Three) [3×4]

a) Framework for inclusivity analysis in climate resilient initiatives
b) Radiative forcing
c) Uncertainty in climate change impact assessment
d) Adaptation strategies to climate change
e) National responses to climate change

***

Tribhuvan University

Institute of Engineering (IoE)

M. Sc. in Water Resources Engineering Program

Date: 19 March 2024

Internal Examination

Subject: Glacier and Glacio-hydrological Modeling
Year/Level: II
Time: 1 hour

Course:
Semester: I
F. M.: 30

1. Define in one sentence (Mark 1 x 5 = 5):

a) Cryosphere b) Glacial lake c) Snow water equivalent
d) Glacier moraine e) Ice sheet

2. How glacier mass balance will estimate in the field? (10)

3. Write short notes on any THREE from below (Marks 5 x 3 = 15):

a) Types of glacier
b) Define a hydrological model and discuss various model types.
c) Heat budget calculation on a snow and ice surface
d) How does ICHYMOD differ from traditional temperature index models in computing snow and glacier melt?

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Glacier and Glacio-hydrological Modelling

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** question.*
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Group A

Answer the following questions: (Any Three) [3×10]

1. Describe methods of measuring accumulation and ablation of a glacier in the field.
2. Explain in detail how snow is transformed into ice in a glacier. List densities of different types of snow and firn.
3. How do glaciers and glacial lakes reflect climate change?
4. In the context of Nepal, which benefit of the Glacio-hydrological model stands out as the most impactful? (2 mams?)

Group B

5. Differentiate the following: (Any Three) [3×5]
   a) Glacier and permafrost
   b) Valley glacier and ice sheet
   c) Heat budget and statistical methods for estimating glacier ablation
   d) Polar glacier and sub-polar glacier

Group C

6. Write short notes on: (Any Three) [3×5]
   a) Causes of the earth's glaciation
   b) Importance of glacier and glacio-hydrological modeling studies in Nepal
   c) Importance of remote sensing data in glacier and glacial hazard studies
   d) Adaptation and mitigation techniques used in glacial hazards

***

M. Sc. Water Resources Engineering Program

Minor Test

Subject: Water Induced Hazard

1. Prove that

$$Q_{Debris\ flow} = \frac{C^*}{(C^*-\overline{C})} Q_{water} \qquad (5)$$

2. Starting from the basic momentum equation for motion of water, derive following steady momentum equation.

$$(1-Fr^2)\ \frac{\partial h}{\partial x} + \frac{\partial z_b}{\partial x} = Fr^2 \frac{h}{B} \frac{\partial B}{\partial x} - i_e \qquad (5)$$

3. What tensile strength of 500 roots/m^2 of diameter 2 mm will make factor of safety of stability of hillslope with following characteristics equals 2 in extreme worst situation?

C' = 5.3 kN/m^2; φ' = 34.7^0; γ =18.0+2.0(h_w/h_z) kN/m^3, γ_w = 9.8kN/m3; β=35^0; h_z=0.9m; Take surcharge vegetation = 3.8 KN/m^2 and wind load = 0.1 KN/m^2 (5)

Given:

Q(m3/s)	15	L (m)	300	B (m)	50		
n	0.03	λ	0.4	τ^*_c	0.02	Δx (m)	10
S.G	2.65	d_{50} (m)	0.0005	S_0	0.00819		

h (0,0) = 0.4 for t $\geq$ 0 and Z_b (0,0) = 50 m for t $\geq$ 0

Find:

q_b (2,2), q_b (3,2) τ_c (2,2), τ_c (3,2), Z_b (2,2), Z_b (3,2) for Δt = 1 hr (10)

4. A debris flow in a long rectangular channel 4 m width has mean velocity 6 m/s. What is the velocity at mid depth if $\Theta = 10^0$, mean dia of sediment = 0.2 m, C^* = 0.6, C_{mean} = 0.55. Take angle of collision as 90^0. (5)

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Water Induced Hazards

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Explain in details with the necessary sequential steps for developing a simple landslide warning model based on rainfall amount and intensity for a territory using hillslope (kinematic storage) and infinite slope model. [12]

2. 0.2 m wide and 30 m long channel had bed material with a mean diameter of 0.32 mm. From the uniform-flow measurements, the following values were computed: $a = 1.45 \times 10^{-3}$; $b = 5.0$; Manning $n = 0.022$; and the porosity of the sediment bed layer, = 0.4. For, the initial water discharge, $q_o = 0.020$ m^2/s; the uniform flow depth, $h_o = 0.05$ m; the initial bed slope, $S_o = 0.00356$; Implement the upstream boundary representing constant discharge by specifying $q\ (0, t) = q_o$ for $t \geq 0$. Assume a fictitious node upstream of node 1 and specify sediment discharge at that node equal to $3 \times q_s$. For Δx = 1m and CFL = 0.9, find the change in bed elevation after Δt at 1 and 2 m d/s. [12]

3. With appropriate data sets draw approximate stereographic projections for situation (i) Rock toppling and (ii) wedge failure. [3+3]

4. A channel is divided into 5 equal segments (Δx = 10m) with 6 nodal points. The flow in channel is steady and sub-critical. Porosity of the sediment bed layer, = 0.4. What will be the sediment discharge at the outlet of the channel (node 6) with respect to sediment discharge at the inlet of the channel (node1) if net change in bed level of the channel degradation is 2 m in two hours period? [5]

5. Explain with a plot how gauge to gauge forecasting tool is developed with additional information of change in stage of the base station. Describe how this methodology is used in multi-tributary model. [5+5]

6. Derive the expression for stress due to interparticle collision during debris flow. [5]

7. Prove that there will be erosion of the bed during debris flow event when $\bar{c} < c_\infty$. [5]

8. [5]

Given		Find
h (13:00, 25 m u/s) = 6 m		velocity (13:00, 25 m u/s) =?
h (13:00, 25 m d/s) = 4 m		velocity (13:00, 25 m d/s) =?
h (13:00, 75 m u/s) = 6.5 m		
h (13:00, 75 m d/s) =3.5 m		
M (12:00, 50m d/s) =27 m^2/s		
M (12:00, location A) = 25 m^2/s		
M (12:00, 50m u/s) =20 m^2/s		

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Minor Test: Hydraulic Structures, Time: 90 mins

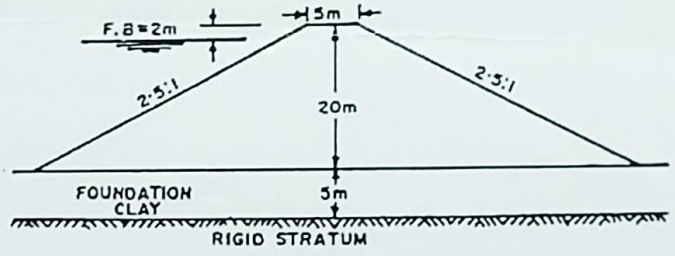
1. How low height dam is defined and designed? Explain the stress distribution at the base of concrete gravity dam for both Reservoir empty and Reservoir full case with neat sketches.

2. A homogenous earth dam section shown in figure has the following data:

a) Properties of materials of the dam
i) Dry density: 1800 kg/m^3
ii) Saturated Density: 2200 Kg/m^3
iii) Average angle of friction = 30^0
iv) Average Cohesion: 1600 kg/m^2

b) Properties of foundation of materials
i) Average unit weight: 1700 kg/m^3
ii) Average cohesion: 5400 kg/m^2
iii) Average angle of internal friction: 7^0

Find the seepage through the dam section and Check the section for the following:
i) Sloughing of the upstream slope during sudden drawdown
ii) Stability of foundation against shear



3. Check the stability of surge tank system having the dimensions given below. The specified factor of safety is 50 percent. The main data of the installation are as follows:
   Length of pressure tunnel : 700m
   Diameter of pressure tunnel: 3.5 m
   Velocity coefficient of pressure tunnel: 90
   Cross-sectional area of the upstream surge tank: 50 m^2
   Length of tailwater tunnel: 400m
   Diameter of the tailwater tunnel: 4.5 m
   velocity coefficient of tailwater tunnel: 70
   Cross sectional area of downstream surge tank: 120 m^2
   Design Discharge: 40 m^3/s
   Net head: 200m
   (Correct the system with appropriate hydraulic considerations, if found unstable)

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Hydraulic Structures

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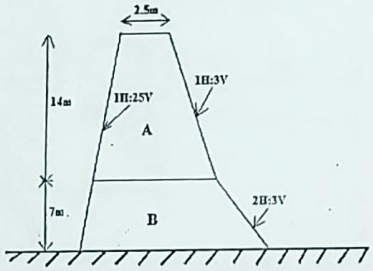
1. a) A concrete Gravity dam in the western region of Nepal is in the following shape and size. Estimate Force induced due to earthquake per unit length of dam using Seismic Coefficient Method. Take Unit weight of dam material = 25 kN/m^3. Use Recommendation of IS1893-1984. [8]



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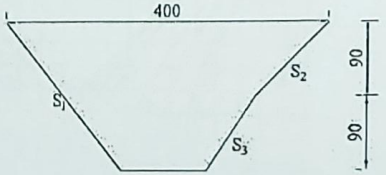

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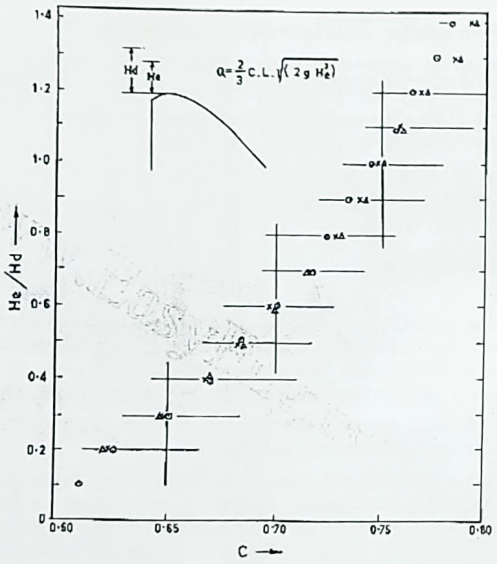

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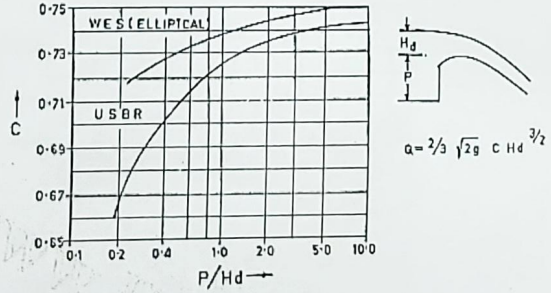

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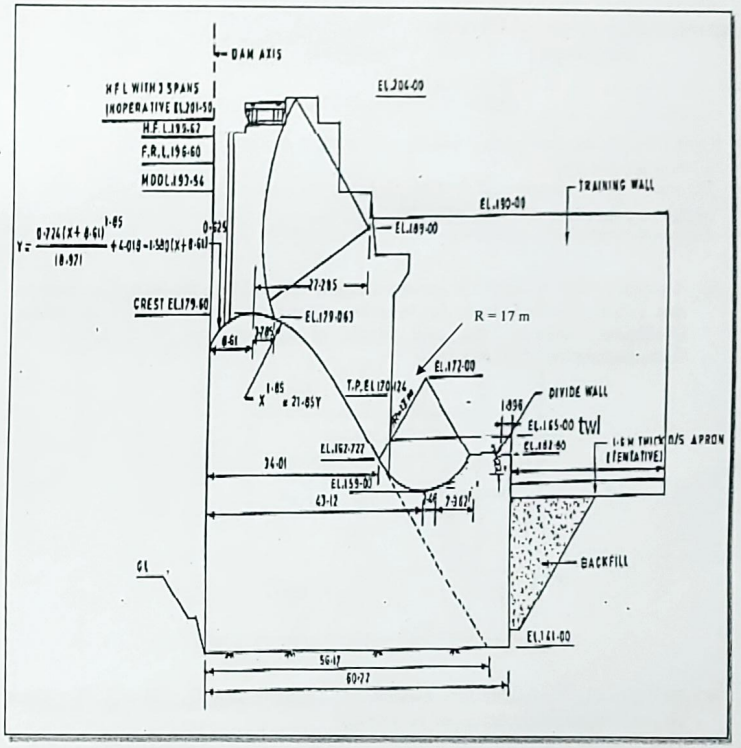

Tribhuvan University
Institute of Engineering
Pulchowk Campus
Internal Assessment, 25th March, 2024

Level: Master
Program: Water Resources Engineering
Subject: **Climate Change & Water Security**

Full Marks: 100
Time: 1.5 hours
Year/Part: I/II

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Q1. There are varieties of global climate models (GCMs) or regional climate models (RCMs) available for projecting future climate. How do you select suitable one(s) for your application to a specific study area? Can we rely on one or need to use multiple GCMs/RCMs and why? [15+10]

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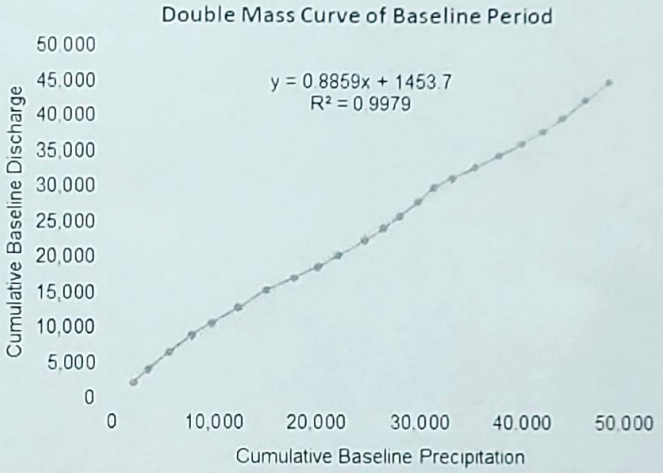

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TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
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Exam.	**Regular**		
Level	M.Sc.	**Full Marks**	60
Programme	MSWRE	**Pass Marks**	30
Year / Part	I / II	**Time**	3 hrs.

Subject: - Climate Change and Water Security (*Elective*)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Elaborate interaction between hydrosphere and atmosphere. Please elaborate interlinkages among carbon cycle, energy cycle and water cycle with appropriate illustrations. [5+7]

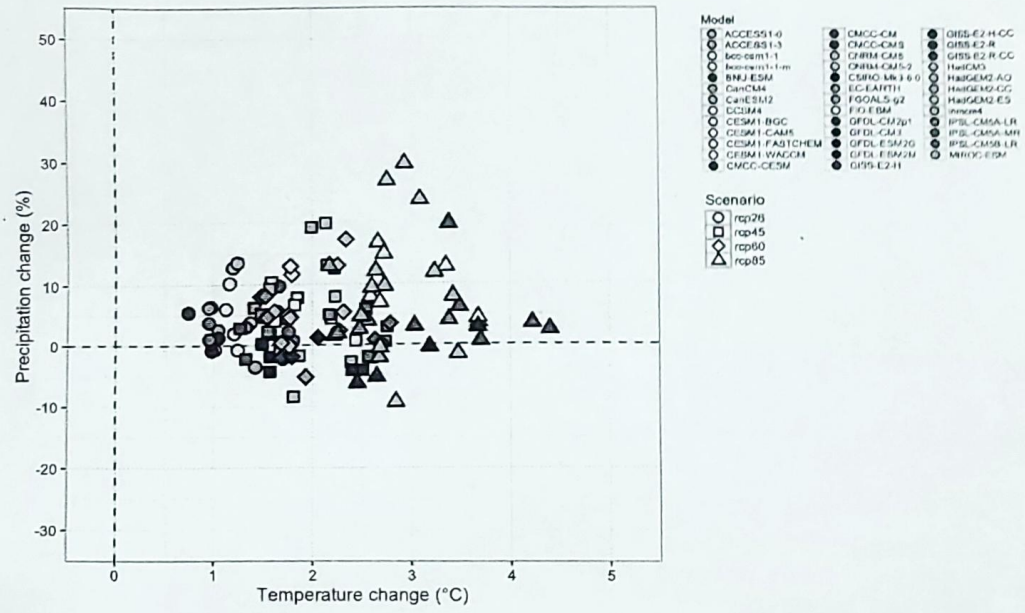
2. Average annual time series of precipitation (P, mm) and discharge (Q, mm) for a period is divided into baseline and variation periods. A double mass curve for the baseline period has a regression equation of $y = 0.8x+1200$ ($R^2 = 0.96$), where y is cumulative baseline discharge and x is cumulative baseline precipitation. Mean observed discharge of the entire baseline period is 1,890mm and precipitation and discharge for variation period (7 years) are shown in the following Table. Year 0 refers to the end of baseline period. Estimate relative contributions (%) of climate (rainfall) variability and anthropogenic activities to the total changes in river discharge. Provide your thoughts on better ways of attribution to climate change. [8+4]

Year	0	1	2	3	4	5	6	7
P (mm)	2200	2010	2300	1640	1400	2270	2060	1810
Q (mm)	1800	1300	1100	1050	970	1210	1580	1740

3. How climate change affects water security? How nexus approach helps towards achieving water security? Discuss international frameworks for responding to climate change. [4+4+4]

4. Following table shows precipitation (P) data for the period of 2026-2040 (15 years planning horizon) based on ARMA model. The Figure shows projected changes in climate from various General Circulation Models (GCMs) for the study region. Based on this information, please answer the following questions;

Year	P (mm)	Year	P (mm)	Year	P (mm)
2026	4	2031	58	2036	119
2027	0	2032	87	2037	107
2028	83	2033	26	2038	28
2029	164	2034	62	2039	0
2030	363	2035	163	2040	87



i) List the precipitation and temperature change factors you could use if your goal is to create a stress test that approximately encompassed the projections. [2]

ii) If you are using 50 stochastic realizations, how many model runs would you need using the change factors in question (i)? [1]

iii) If flooding is an issue, which extreme scenario(s) would be concerning? [2]

iv) If water supply is an issue, which extreme scenario(s) would be concerning? [1]

v) Develop a scenario of precipitation (one maximum case only) based on the change factor selected in question (i) and using data from table. [6]

5. Write short notes on: (Any Three) [3×4]

a) Framework for inclusivity analysis in climate resilient initiatives
b) Radiative forcing
c) Uncertainty in climate change impact assessment
d) Adaptation strategies to climate change
e) National responses to climate change

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Tribhuvan University

Institute of Engineering (IoE)

M. Sc. in Water Resources Engineering Program

Date: 19 March 2024

Internal Examination

Subject: Glacier and Glacio-hydrological Modeling
Year/Level: II
Time: 1 hour

Course:
Semester: I
F. M.: 30

1. Define in one sentence (Mark 1 x 5 = 5):

a) Cryosphere b) Glacial lake c) Snow water equivalent
d) Glacier moraine e) Ice sheet

2. How glacier mass balance will estimate in the field? (10)

3. Write short notes on any THREE from below (Marks 5 x 3 = 15):

a) Types of glacier
b) Define a hydrological model and discuss various model types.
c) Heat budget calculation on a snow and ice surface
d) How does ICHYMOD differ from traditional temperature index models in computing snow and glacier melt?

TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Chaitra

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / II	Time	3 hrs.

Subject: - Glacier and Glacio-hydrological Modelling

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** question.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

Group A

Answer the following questions: (Any Three) [3×10]

1. Describe methods of measuring accumulation and ablation of a glacier in the field.
2. Explain in detail how snow is transformed into ice in a glacier. List densities of different types of snow and firn.
3. How do glaciers and glacial lakes reflect climate change?
4. In the context of Nepal, which benefit of the Glacio-hydrological model stands out as the most impactful? (2 mams?)

Group B

5. Differentiate the following: (Any Three) [3×5]
   a) Glacier and permafrost
   b) Valley glacier and ice sheet
   c) Heat budget and statistical methods for estimating glacier ablation
   d) Polar glacier and sub-polar glacier

Group C

6. Write short notes on: (Any Three) [3×5]
   a) Causes of the earth's glaciation
   b) Importance of glacier and glacio-hydrological modeling studies in Nepal
   c) Importance of remote sensing data in glacier and glacial hazard studies
   d) Adaptation and mitigation techniques used in glacial hazards

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TRIBHUVAN UNIVERSITY
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Examination Control Division
2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Advanced Hydraulics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.* .
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) A rectangular channel of width 60 m and length 7.2 km has a constant bottom slope of 1:100. Assuming a value of manning's coefficient of 0.035, an initial condition of uniform flow along the channel at rate of 57 m^3/s and the inflow hydrograph given in the table below, calculate the discharge at 4.5 km downstream after 60 minutes using Kinematic wave approximations. Take dt = 6min and dx = 900 m. [6]

Inflow hydrograph	t(min)	0	12	24	36	48	60	72	84	96	108	120
	$Q(m^3/s)$	57	57	85	113	142	170	142	113	85	57	57

b) Consider the following Saint Venant equations for prismatic channel having no lateral inflow and outflow:

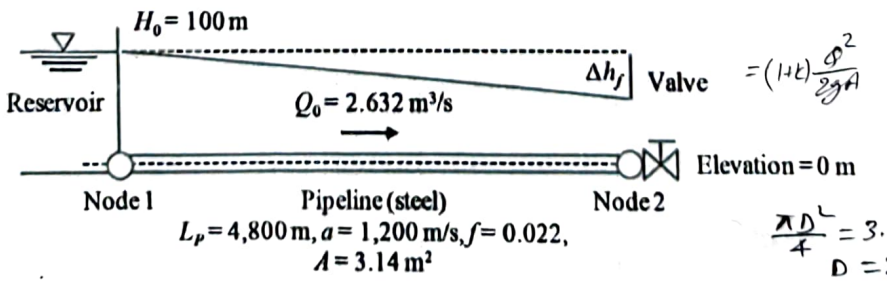
$$\frac{\partial y}{\partial t} + D_h\frac{\partial V}{\partial x} + V\frac{\partial y}{\partial x} = 0$$

$$\frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} + g\frac{\partial y}{\partial x} = 0$$

Transform the above governing equations into equations in λ – form for Lamda explicit scheme. Write also the finite difference schemes used for the predictor and corrector part of Lamda Scheme. [4+2]

2. a) A side-channel spillway channel is 100 m long and is rectangular in cross-section with B = 5 m, n= 0.020, β=1.30 and S_0= 0.15. If the lateral inflow rate is 1.75 $m^3/s/m$ length, find the critical depth and its location. [4]

b) Calculate the pressure head at Node 1 and Node 2 in due to sudden closure of valve in next possible time step using method of Characteristics. Assume suitable value if necessary. [8]



3. a) Sediment deposition is computed numerically in a sand trap. The water flow is uniform with a velocity U=3 m/s and a water depth H=4m. The fall velocity of the sediments is w = 0.15 m/s. The orthogonal grid cells has sizes dx=1m and dy=0.1m in

the horizontal and vertical directions, respectively. The Manning-Strickler's value is M=1/n=30. Compute the values of the a_{nb} coefficients for the SOU scheme. [8]

b) The analysis of flow measurement in a river reach gave:

	Station 1	Station 2
Location x (km)	10.8	12.1
Water depth (m)	0.55	0.45
Flow velocity(m/s)	0.45(+)	0.50(+)

At t = 1 h. Assuming a kinematic wave (S_o=S_f), plot the characteristics issuing from the measurement stations assuming straight lines. Calculate the location, time and flow properties at the intersection of the characteristics. [4]

4. a) The discharge and c/s area of the river at various sections d/s from the gated structure of hydropower due to some shock are given by the equations: (where x is distance from the gated structure)

$A = (-2 \times 10^{-5})x^2 + 0.0207x + 20.4, (m^2)$

$Q = (6 \times 10^{-5})x^2 - 0.0519x + 18.18, (m^3/s)$

The depth area relationship is also given by,

$y = -0.0632A + 3.4603$ (m)

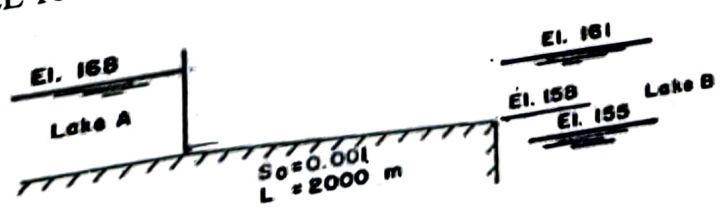
Considering $\Delta x = 150\ m$, Average Top width for all section = 100m, S_0 = 0.001, n = 0.013

Implement Leap Frog Scheme to the Full dynamic Saint Venant Equations to determine the discharge for the wide rectangular channel at next maximum possible time step at a distance of 450 m. [8]

b) A complex natural river is to be modelled with a finite volume CFD model. What types of grids are available? What are the advantages and disadvantages with the different types? Which type would you prefer for the modelling? [4]

5. a) What is SIMPLE algorithm? How will you solve Navier stokes equation using this algorithm? [6]

b) Lakes A and B are connected by a 10 m wide rectangular channel as shown in figure. If n for the flow surface is 0.013. Calculate discharge in the channel if the water level in lake B is at EL. 155 and EL 161. [3×2]



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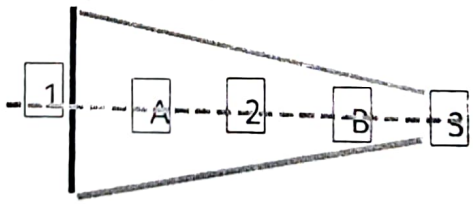
TRIBHUVAN UNIVERSITY
INSTITUTE OF ENGINEERING
Examination Control Division
2080 Jestha

Exam.	Back		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Advanced Hydraulics

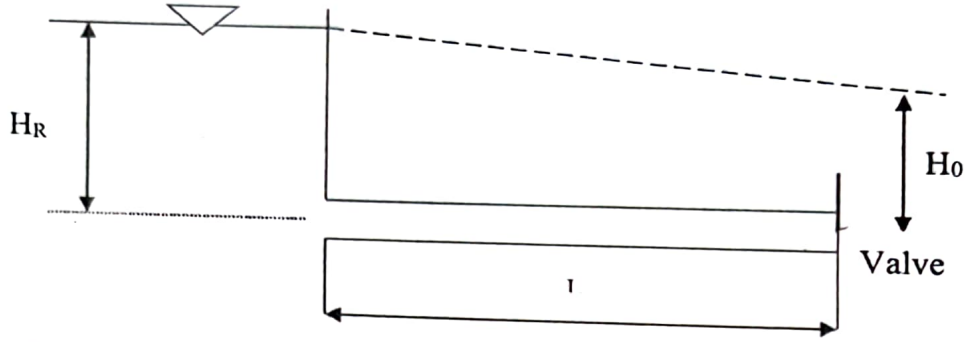
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. Derive the following Saint-Venant continuity equation for rectangular channel section: $\frac{\partial y}{\partial t} + y\frac{\partial v}{\partial x} + v\frac{\partial y}{\partial x} - \frac{q_i}{b} = 0$, where q_i is bulk lateral inflow and other symbols have their usual meanings. [8]
2. Derive the simple wave problem equation for a long channel carrying uniform flow having disturbance at the upstream end. Describe how this equation is useful for the dam break problem with dry downstream channel bed. [8]
3. How does the following concepts affect the quality of a grid: orthogonality, expansion ratio and aspect ratio? Sediment deposition is computed numerically in a settling basin. The water flow is uniform with a velocity U=5 m/s and a water depth H=5m. The fall velocity of the sediments is w = 0.10 m/s. The orthogonal grid cells has sizes dx=1m and dy=0.1m in the horizontal and vertical directions, respectively. The Manning-Strickler's value is M=1/n=40. Compute the values of the a_{nb} coefficients for the SOU scheme. [2+8]
4. One dimensional flow in a nozzle shown in figure below can be described by
   $\frac{d(\rho UA)}{dx} = 0$ and $\frac{d(\rho UA)U}{dx} = -A\frac{dP}{dx}$
   Where U is velocity, P pressure and A cross-sectional area.



   Given conditions are $\rho = 1$ everywhere, $A_A = 3$, $A_B = 2$, $P_1 = 100$, $P_3 = 0$. Assume that the fluid upstream of point 1 has negligible momentum. Obtain U_A, U_B, P_2 using SIMPLE Algorithm. Employ appropriate Under-relaxation. [10]
5. A 5-m wide rectangular concrete-lined canal takes off from a lake having a constant water level of 2 m above the channel bottom at the entrance. The channel is long, has a bottom slope of 0.004, and n = 0.013. If the head losses at the entrance are negligible, determine the discharge in the canal. [8]

6. The figure above shows the simple pipe line system with a valve at downstream. For instantaneous closure of valve and for the following data, calculate the pressure head values (Using method of characteristics) at the mid-point length of pipe for 0.1 second. Given, L =500 m, celerity = 1300m/s, Diameter of pipe= 0.4 m, friction factor, f= 0.018, HR = 100m, Ho = 50m. [8]



7. A 200 km long rectangular channel (B= 5 m) has a reservoir at the upstream end and a gate at the downstream end. Initially the flow condition in the canal are uniform at V = 0.35 m/s and y = 1.05 m. The water surface level in the reservoir begins to rise at a rate of 0.2m/h for 6 h. Calculate the flow condition in the canal at t = 2h. Assume $S_0 = S_f = 0$. Use Leapfrog Scheme and take appropriate Δx and Δt. [8]

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2080 Ashwin

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

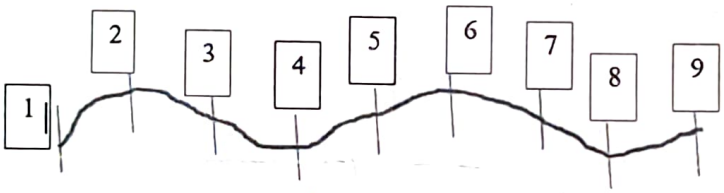
Subject: - Advanced Hydraulics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ ***Necessary formula is attached herewith.***
- ✓ *Assume suitable data if necessary.*

1. A 5m wide rectangular concrete lined canal takes off from a lake having a constant water level of 2 m above channel bottom at the entrance. The channel is long, has a bottom slope of 0.004 and n = 0.013.

   a) If the head losses at the entrance is neglected, determine the discharge in the canal.
   b) Compute the discharge if the bottom slope is changed to 0.001 and the entrance losses are $0.1\frac{v^2}{2g}$ [4+4]

2. The following figure shows calculation points of 800m river stretch (consider wide rectangular channel) with equal divisions. [10]



   The conditions (at t=10 sec) after some disturbance at section 1 are given as:

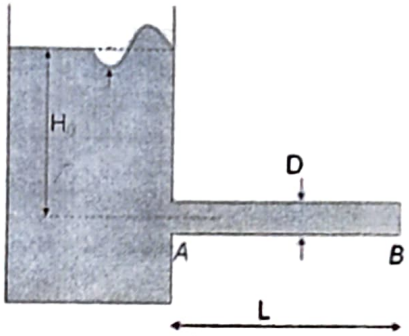
   Variation of depth and velocity from point 1 along the river; $y = (0.0005x + 1.05)m$ and $v = (0.001x + 0.44)m/s$ respectively, where x is distance in m from point 1.
   Bed slope, So = 0.001, manning's n = 0.013
   Calculate depth and velocity at point 4 in next maximum possible time step. Use Courant number of 0.9.

   [Hint: Write Full dynamic St. Venant equation for rectangular channel section first in terms of V and Y and Use Explicit Scheme (Diffusive scheme and Ligget and wolshier temporal finite difference with $\alpha = 0.1$)]

3. Derive the weighting coefficients for the second-order upwind scheme, used for the solution of the convection-diffusion equation. Describe two disadvantages and one advantage with this scheme, compared with the first-order upwind scheme. [6+2]

4. The 10th of October 2016, a Dutch tanker missed the shipping lights in the Rhine river in Germany and got stuck on the Jungferngrund sand bar near St. Goar. The tanker contained 786 tons of a toxic chemical. Luckily, no chemical was spilled, as the soft sand did not do any damage to the vessel. Let us assume that the ship had hit a rock outcrop 300 meters further downstream instead, and all the chemicals had spilled into the river over a time period of 10 minutes. What would the maximum chemical concentration be at Koblenz, 44 kilometers downstream? The discharge in the Rhine was 500 m^3 /s, and the average water depth was 1.0 meter. The slope of the river in this reach is 1/4000, and the average width is 300 meters. [8]

5. Use the method of characteristics to solve for the pressure head and flow at points A and B of pipe system shown in schematic. Assume f = 0.018, L = 1200m, D = 0.4 m, H_0 = 100 m and a = 1200 m/s. The equation of reservoir boundary is given by $H(t) = H_o + 2.5 \sin(\pi t/4)$. Initial conditions (t = 0) are $H_A = H_B$ = Ho = 100m and $Q_A = Q_B = 0\ m^3/s$. What is the pressure head at the dead end B and at A after t = 6 sec.? [10]

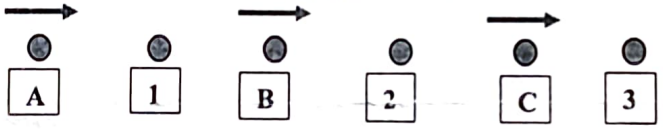


6. A flow in the pipe with nodes (A, 1, B, 2, C and 3) is as shown in schematic below. Given the momentum equation are:

$U_B = 10 + 5\,(p_1 - p_2)$
$U_C = 10 + 10\,(p_2 - p_3)$

Boundary Conditions are: $U_A = 15, p_3 = 15$

Use SIMPLE Algorithm to calculate p_1, p_2, U_B, U_C. [8]



7. Water flows in a channel at steady state (V = 1 m/s, d = 2 m). The channel is assumed smooth and horizontal. The flow is controlled by a downstream gate. At t = 0, the gate is very slowly raised and the water depth upstream of the gate decreases at a rate of 10 cm/min until the water depth becomes 1 m. (i) Plot the free-surface profile at t = 10 min. (ii) Calculate the discharge per unit width at the gate at t = 10 min. [4+4]

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Formulas (if necessary):

$$\Gamma = 0.058\frac{Q}{IB} \qquad \Gamma = 0.11\frac{(UB)^2}{Hu.}$$

$$c(x,t) = \frac{c_0 L}{2\sqrt{(\pi \Gamma t)}} e^{-\frac{(x-Ut)^2}{4\Gamma t}} \qquad Fr' = \frac{u_0}{\sqrt{\left(\frac{\rho_{res} - \rho_0}{\rho_{res}}\right) g d_0}}$$

$$\frac{\rho - \rho}{\rho} = 9\,Fr'^{-\frac{2}{3}} \left(\frac{z}{d_0}\right)^{\frac{5}{3}} e^{\left[-71\frac{r^2}{r^2}\right]}$$

$U = 1/n\, r_h^{2/3} I^{1/2}$ ↳ Manning eqn

$U = C r_h^{1/2} I^{1/2}$ chezys

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Examination Control Division
2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Hydrological Analysis

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) "Problems in hydrologic analysis various with scale". Please elaborate this statement with appropriate illustration and discussion. [4]

   b) Assume a 4-hr Unit Hydrograph with values as in Q4 (b) below. If an 8-hr storm with a total of 6 mm of effective rainfall (3 mm in the first 4 hours and 3 mm in the second 4 hours) covers the entire watershed, compute composite direct runoff hydrograph (using convolution method) and time base of the composite hydrograph. If baseflow is $9m^3/s$, also calculate total runoff hydrograph. [8]

2. a) Discuss infiltration process in an ideal soil with appropriate illustrations. [5]

   b) If an initial infiltration rate for a catchment is 2.5 cm/hr and infiltrates a total volume of 5.5 cm until it attains a constant infiltration rate of 0.5 cm/hr after 10 hours, calculate the Horton Constant (k) considering large time (t). [7]

3. a) "Catchment response varies with the catchment type and shape". Please elaborate this statement with appropriate illustrations/examples. [6]

   b) Discuss different types of response functions in linear system and their applicability. [6]

4. a) Discuss importance and differences among reservoir, stream channel and catchment routing. [4]

   b) Route the following hydrograph (using Muskingum method) through a river reach with K=10 hrs and X=0.2. Take the outflow discharge at the start of the inflow as $8m^3/s$. Also estimate attenuation and lag of peak. [8]

Time (h)	0	4	8	12	16	20	24
Inflow (m^3/s)	8	15	25	20	16	12	10

5. a) What is the meaning and practical significance of kinematic wave celerity? [3]

   b) Discuss kinematic, diffusion and dynamic routing techniques in the context of catchment routing. How kinematic and diffusion routings are implemented in catchment routing? [4+5]

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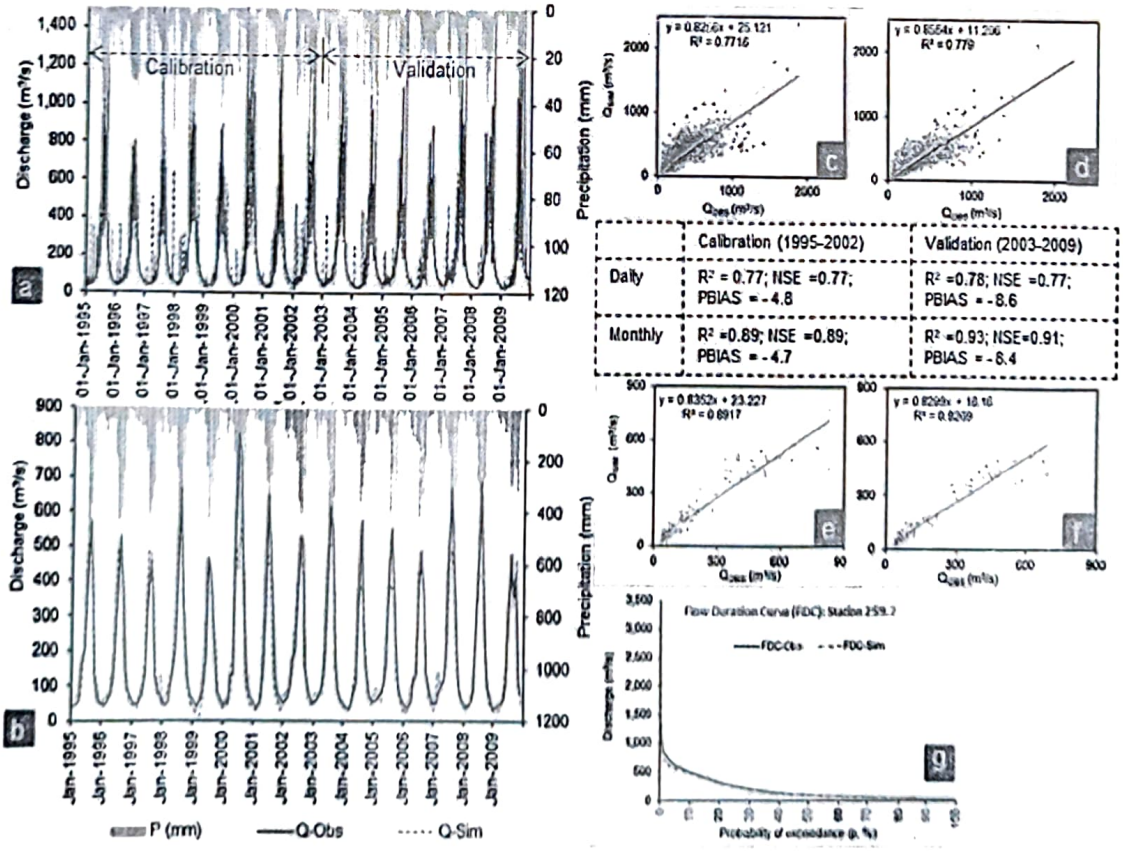
Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Hydrological Analysis

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Do you agree with the statement "problems in hydrology are scale-dependent"? Justify your answer with appropriate reasoning and examples. [5]
   b) Discuss on choice of a particular method for hydrologic analysis in terms of requirements and systematic evaluation. [7]
2. a) Elaborate concepts of infiltration excess and saturation excess overland flow and discuss on their application in practice. [5]
   b) "Unsaturated zone hydraulic properties affect infiltration". Please justify this statement with related concepts and illustration. [7]
3. a) Comment on overall performance of a hydrological model if observed and simulated streamflow and associated plots and statistics are as provided in this following figure. [5]
   b) Elaborate the concept, approach and applicability of different types of response functions in a linear system model. [7]



4. a) How does time of concentration affect calculation of peak discharge in Rationale method? [4]

   b) Derive a 2h UH from a 3h UH given in the following table using appropriate method. [8]

Time (h)	0	1	2	3	4	5	6	7	8	9
3-hr UH ordinates (m^3/s)	0	33	67	133	233	233	200	67	33	0

5. a) Discuss different types of hydraulic routing techniques and their applicability. [5]

   b) A 50 km^2 catchment has 4-h time of concentration with isochrones of 1-h intervals resulting in a time-area histography with inter-isochrone areas as shown in the table below. A 4-h storm has the following effective rainfall hyetograph. Calculate outflow hydrograph using time-area method. [7]

Time (h)	0-1	1-2	2-3	3-4
Peff (cm/h)	1.5	2.0	1.0	0.5
Inter-isochron Area (km^2)	5	15	20	10

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Examination Control Division
2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - System Mathematics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Define the term' Operation Research'. Write the various types of systems for Water Resources Engineering. [3]

   b) A canal section is to be lined to resist erosion using stratification of up to the three layers (base, middle, and top) layers. Total thickness of the lining should not exceed 20 mm. The base, middle, and top layer of lining can erode 0.6, 0.3 and 0.1 mm/year due to water current. Total life of the lining should be at least 50 years. The costs of the base, middle and top layers are Rs. 300, 400, and 500 per mm thickness, respectively. Formulate a Linear Programming (LP) problem and solve it using Simplex tables. [3+6]

2. a) Define dynamic programming (DP). Explain why DP is more superior to liner programming. [3]

   b) Using dynamic programming, solve the following 4-user water allocation problem to maximum the total returns. Given that: Water available for allocation = 60 units, to be allocated in discrete units of 0, 10, 20,..., 60. Returns from the four users for a given allocation are given in the following table. [9]

Allocation	Returns from			
(Units)	User 1	User 2	User 3	User 4
0	0	0	-30	10
10	30	40	30	10
20	50	40	50	10
30	60	40	50	70
40	30	40	40	80
50	30	60	20	70
60	30	70	0	50

3. Solve the following NLP problems.

   a) Maximize $f(X) = -5x_1^2 - 2x_2^2 + 10x_1x_2$

   s.t.: $x_1 + x_2 \leq 20;$

   $3x_1 + x_2 \geq 42;$ [6]

   b) Optimize $f(X) = -2x_1^2 - 2x_2^2 + 5x_1 + 9x_2$

   s.t.: $x_1 + x_2 \leq 9;$

   $-3x_1 - 4x_2 \geq -31;$ [6]

4. Using Gomory's Cutting Plane Method solve the following ILP problem.

Max $f(X) = x_1 + 2x_2$

s.t.: $2x_2 \leq 7;$

$x_1 + x_2 \leq 7;$

$2x_1 \leq 11$

$x_1, x_2 \geq 0$ and, x_1 and x_2 are integers [12]

5. Write short notes on: (Any three) [3×4]

a) Use of Big-M method to solve the linear programming problems
b) Surplus and slack variables in linear programming problems
c) Main components of the Scientific Paper
d) Use of System Engineering to Sustainable Water Resources

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Examination Control Division
2080 Ashwin

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - System Mathematics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. a) Explain the three stages of system solutions in Water Resources Engineering. [3]

   b) Solve the following LP problem using simplex method. [9]

$$\begin{aligned} \text{Max } Z = \; & 5x_1 + 8x_2 \\ \text{st } \; & 3x_1 + 2x_2 \geq 3 \\ & x_1 + 4x_2 \geq 4 \\ & x_1 + x_2 \leq 5 \\ & x_1, x_2 \leq 0 \end{aligned}$$

2. a) Explain Forward and Backward recursion methods in dynamic programming (DP). [3]

   b) Inflows during six seasons to a reservoir with storage capacity of 8 units are, respectively 6, 4, 3, 2, 3 and 5 units respectively. Only discrete values 0, 1, 2, … are considered for storage and release. Overflows from the reservoir are also included in the release. Reservoir storage at the beginning of the year is 0 units. Release from the reservoir during a season results in the following benefits, which are same for all the six seasons. Obtain the reservoir operation policy using Dynamic Programming. [Assume one unit equal to one Mm^3]. [9]

Releases (Units)	0	1	2	3	4	5	6	7	8
Benefits (NRs 10^3)	-100	40	80	120	200	300	220	150	100

3. Solve the following NLP problems.

   a) Maximize $f(X) = -8x_1^2 - 6x_2^2 + 10x_1x_2 - 3x_1 + 10x_2$
   s.t.: $2x_1 + x_2 = 20$;
   $3x_1 + 2x_2 \geq 42$; [6]

   b) Optimize $f(X) = -3x_1^2 - 3x_2^2 + 7x_1 + 9x_2$
   s.t.: $2x_1 + 3x_2 \leq 9$;
   $-3x_1 - 4x_2 \geq -31$; [6]

4. Using Gomory's Cutting Plane Method solve the following ILP problem.

$$\begin{aligned} \text{Max } f(X) = \; & 9x_1 + 10x_2 \\ \text{s.t.: } \; & x_1 \leq 9; \\ & x_2 \leq 8; \\ & 4x_1 + 3x_2 \geq 40; \\ & x_1, x_2 \geq 0 \text{ and, } x_1 \text{ and } x_2 \text{ are integers} \end{aligned}$$ [12]

5. Write short notes on: (Any Three) [3×4]

   a) Solving Shortest Route Problem using Dynamic Programming
   b) Dual Simplex Method to solve LPP
   c) Main components of the Scientific Paper
   d) Branch and Bound Method of solving ILPP

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INSTITUTE OF ENGINEERING
Examination Control Division
2080 Jestha

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Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - System Mathematics

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
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1. a) Discuss the various types of systems in Water Resources Engineering. [3]

   b) An Irrigation canal section is to be lined to resist erosion using stratification of up to the three layers (base, middle and top) layers. Total thickness of the lining should not exceed 22 mm. The base, middle, and top layers of lining can erode 0.7, 0.3 and 0.1 mm/year due to water current. Total life of the lining should be at least 60 years. The costs of the base, middle and top layers are Rs.300, 450 and 500 per mm thickness respectively. Formulate a Linear Programming (LP) problem and solve it using Simplex tables. [3+6]

2. a) List any five examples where Dynamic Programming is suitable to use in Water Resources Projects. [3]

   b) Using dynamic programming, solve the following 4-user water allocation problem to maximize the total returns. Given that: Water available for allocation = 36 units, to be allocated in discrete units of 0,6,12,.....,36. Return from the four users for a given allocation are given in the following table. [9]

Allocation (Units)	Returns from			
	User1	User 2	User 3	User 4
0	0	0	-40	10
6	30	40	30	10
12	50	40	50	10
18	60	40	50	70
24	30	40	40	80
30	30	60	20	70
36	30	70	0	50

3. Solve the following NLP Problems.

   a) Maximize $f(x) = -2x_1^2 - 3x_2^2 + 10x_1x_2$ [6]

   S.t.: $x_1 + x_2 = 12$

   $3x_1 + x_2 \geq 26$

   b) Optimize $f(x) = -3x_1^2 - 2x_2^2 + 15x_1 + 9x_2$ [6]

   S.t.: $x_1 + x_2 \leq 13$

   $-3x_1 - 4x_2 \geq -44$;

4. Using Gomory's Cutting Plane Method solve the following ILP problem. [12]

$$\text{Max } f(x) = x_1 + 2x_2$$

$$\text{S.t.: } 2x_2 \leq 7$$

$$x_1 + x_2 \leq 7;$$

$$2x_1 \leq 11$$

$$x_1, x_2 \geq 0 \text{ and, } x_1 \text{ and } x_2 \text{ are integers}$$

5. Write short notes on: (Any Three) [3×4]

a) Solution steps of Linear Programming problems using Simplex Methods

b) Surplus and slack variables in linear programming problems

c) Major differences between Dynamic Programming and Linear Programming

d) Criticisms of Gandak River Agreement between Nepal and India-1959 AD

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INSTITUTE OF ENGINEERING
Examination Control Division
2079 Jestha

Exam.	Regular		
Level	M.Sc.	Full Marks	60
Programme	MSWRE	Pass Marks	30
Year / Part	I / I	Time	3 hrs.

Subject: - Simulation Laboratory

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ ***All** questions carry equal marks.*
- ✓ *Assume suitable data if necessary.*

1. a) Develop finite difference molecules for

$$\left(\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}\right)$$

   b) Using numerical approximation of $\frac{\partial u}{\partial x}+\frac{\partial u}{\partial y}$, write down the equation in matrix form which determine the functions "u" in blank grid in the figure below.

10	10	10	10
8			8
6			6
4			4
2			2
0	0	0	0

2. a) Following effective rainfall produce direct run-off and ceases (becomes 0) at 23:00.

Time (h)	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Effective rain (cm)	1	2	3	4	5	6	

   Prepare a coefficient Matrix of effective rainfall required for the estimation of non-zero ordinates of UH using LST.

   b) Write a program to plot above hyetograph in window coordinate

3. Water table (H) and Rainfall (R) are related as $H = \alpha+\beta R$.

H	R
11	3
8	2

Since the number of unknown and number of equations available here are equal, α and β can also be calculated uniquely without using least square technique. Estimate the new value of α and β manually using previously estimated values if new set of value H = 6 and R = 1 become available, using recursive (updating) least square procedure. Check the results by estimating using LST using three sets of known variables as well. You are required to show all calculation details.

4. Solve using the steps to convert following differential equation into a difference equations for N = 4

$$\frac{du}{dx}+u=2x^2+x \qquad 0\le x\le 1 \quad u(0)=3$$

5. Write codes with proper explanation for the following:
   a) Random number generation between (10 and 100).
   b) Calculation of variance recursively.
   c) Smoothening of graphs using artificial viscosity.

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Subject: - Simulation Laboratory

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
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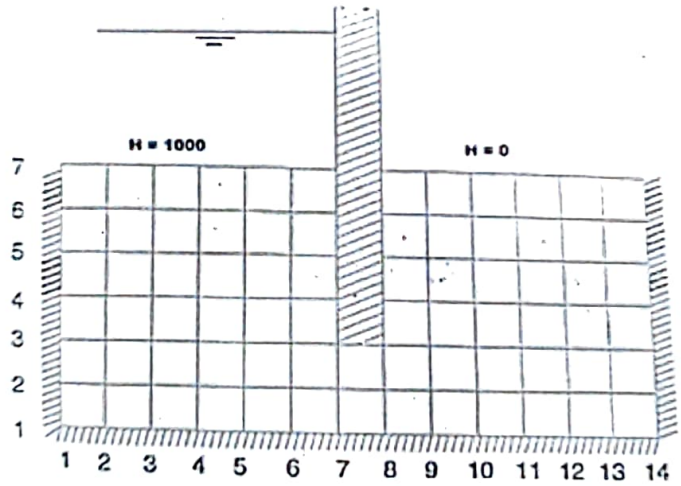
1. Write down the governing equations describing motion of fluid. What are the reasons that there is no general analytic solution to those equations? Show that there will be oscillatory issues when Navier-Stokes equation is solved numerically using non-staggered grids. [2+3+5]

2. Describe about iterative convergence process for numerical solution of non-linear differential equation. Write down the equations in matrix form with steps to convert following differential equation into a difference equations for N = 4.

$$\frac{du}{dx} + u = 2\cos(2x) \qquad 0 \le x \le 1 \quad u(0) = 0$$

Write source code to solve above equations in matrix form. [2+4+4]

3. Write down the equations in matrix form whose solutions will give piezometric heads at each grid of the figure below. The figure presents 1000m head of surface water which is retained by a sheet pile. All grids in the figure are below the ground. Sheet pile does not allow the seepage flow through it. [10]



4. Express d^5u/dx^5 in discretized form using molecule multiplication procedure. Explain Physical and Window coordinates system adopted in Graphics Library of visual Fortran. [5+5]

5. Derive the expression which estimate the error in parameter estimation using LST if the recent observed information is not included in the model. Write codes which plots grids (covering full display screen) using Window coordinates (Real coordinates) and comply following: [5]

   i) Black background color
   ii) bright yellow line color
   iii) 10 grid lines along x -axis with corresponding values and 10 grid lines along y- axis with corresponding values
   iv) Range of x values is 0.1 to 0.6
   v) Range of y values is 10 to 200. [5]

6. Water table (H) and Rainfall (R) are related as $H = \alpha R^{\beta}$.

H	R
10	4
7	3
15	6

Estimate α and β using recursive LST. [10]

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Exam.	**Regular**		
Level	M.Sc.	**Full Marks**	60
Programme	MSWRE	**Pass Marks**	30
Year / Part	I / I	**Time**	3 hrs.

Subject: - River and Sedimentation Engineering

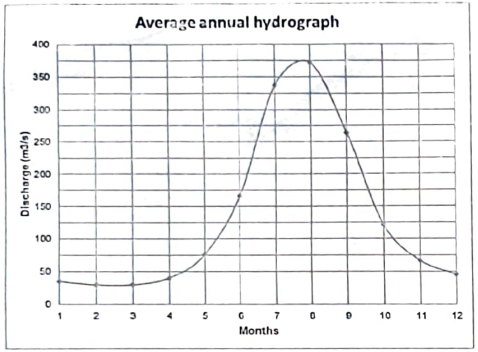
- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ *Attempt **All** questions.*
- ✓ *The figures in the margin indicate **Full Marks**.*
- ✓ *Assume suitable data if necessary.*

1. What are the different spatial scales in Geomorphology? You are provided with a task to compute an average water depth along a river reach of a sand bed river with dunes, at a known discharge. How would you resolve this task? [4]
2. Write the Universal Soil Loss Equation (USLE) explaining each factors in the formula. What is the difference between erosion and sediment yield? [4]
3. A 100 m wide river has an average water depth (h) of 3 m, energy gradient (I) of 1.67×10^{-4}, depth-averaged flow velocity (u_{avg}) of 1.2 m/s. The median size of the bed material (d_{50}) is 2 mm. Which sediment transport formulae would you apply for calculating the sediment transport rates and why? Calculate the sediment transport rates. You may refer the following table as a reference for the fall velocity. [6]

Particle Fall velocity

Upper limit of class	Size (mm)	Fall velocity (m/s)
Very coarse gravel	64	0.831
Coarse gravel	32	0.587
Medium gravel	16	0.415
Fine gravel	8	0.293
Very fine gravel	4	0.206
Very coarse sand	2	0.144
Coarse sand	1	0.098
Medium sand	0.5	0.062
Fine sand	0.25	0.033
Very fine sand	0.125	0.012
Coarse silt	0.062	0.003
Medium silt	0.031	0.001
Fine silt	0.016	0.000
Very fine silt	0.008	0.000

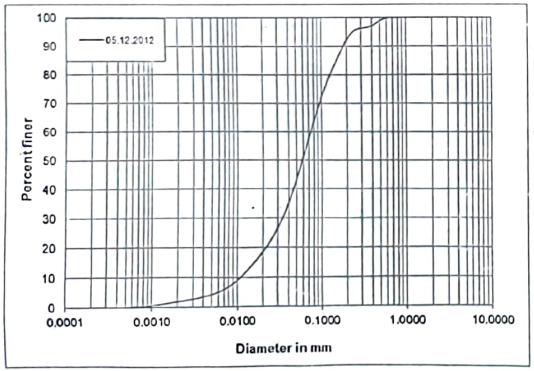
4. You are working as a design consultant for Run-of-River (ROR) hydropower project that has a gross head of 400 m. The developer asks you to advise him/ her in planning for the suspended sediment sampling of the project. [8]
   - What are the main parameters that you would recommend to obtain from the suspended sediment sampling and why?
   - The river at the headworks is about 15 m wide and has a bed slope of 10%. Which sediment sampling method would you choose and why?
   - The river discharge has a seasonal variation, as shown in the figure below. Describe the suspended sediment sampling frequency that you would recommend for different months.
   - Define Isokinetic sampling. Why is it important in suspended sediment sampling?



5. A sequence of alternate bars was observed in a straight irrigation canal. How would you classify these bars? What is the main factor influencing the bar formation? [4]

6. Draw and label a typical diagram of sedimentation phenomenon in a reservoir projects. How would you justify a reservoir project as a renewable or an exhaustible resource? [4]

7. A designer has designed a settling basin of a high head Run-of-River power project achieving 95% efficiency for the particles of size 0.2 mm and larger. The bank which is financing the project request you to prepare a due diligence report for the headworks design. The sediment investigation report suggests an average particle size distribution expected in the suspended sediment load as shown in the figure below. Similarly, the hard mineral content in the suspended sediment load is expected to be about 60%. What would be your evaluation regarding the provided design of the settling basin?

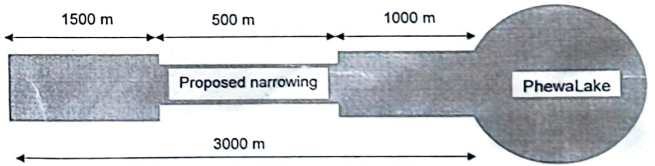


The settling basin discussed above is now already constructed at a headworks site of a 50 MW project. Field measurements carried during it's first year of operation shows that the basin settles 95% of the particles > 0.2 mm, 75% of the particles of size 0.1 - 0.2 mm, 50% of the particles of size 0.01 – 0.1 mm and 25% of the particles < 0.01 mm size. Estimate the cutoff limit of the plant operation with respect to the suspended sediment concentration in the river assuming that flood events with a high sedimentation concentration would last for 8 hours on an average? The revenue generated from the plant operation is 4.80 NPR/kWh. The loss in efficiency of the turbine can be estimated using Equation 1 and the cost of repair and maintenance of the turbine for recovering the lost efficiency can be estimated using Equation 2.

Equation 1: $\Delta E = 0.04 \times SSL^{0.5}$
Equation 2: $C = 1.15 \times \Delta E^{0.6}$
Where,
ΔE = Reduction in the turbine efficiency (%)
SSL = Suspended sediment load passing through the turbine (PPM)
C = Repair and maintenance cost of turbines (Million NPR) [15]

8. A 3000 m reach of a river passes through the city of Pokhara and drains into Phewa Lake. The river flowing along this reach is so far is in its natural course. The river has an average annual discharge of 80 m^3/s, reach average width of 40 m and longitudinal slope of 0.5%. The city council of Pokhara is planning to develop a recreation park in the city center. So, it plans to reduce the width of 500 m reach to 20 m for developing the park. The council recruits you as a river morphologist and requests you to make the assessment of the project. What would be short-term and morphological response of the river in the reach? Explain with appropriate sketches. What would be your recommendation for the design to the city council? You may assume rectangular river cross-sections and a constant water level in Phewa lake throughout the year. The non-linearity of sediment transport can be assumed as 4.

City of Pokhara



**The dimensions in the sketch are not to scale. [15]

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Level	M.Sc.	**Full Marks**	60
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Year / Part	I / I	**Time**	3 hrs.

Subject: - Sedimentation and River Engineering (***Elective***)

- ✓ Candidates are required to give their answers in their own words as far as practicable.
- ✓ ***Attempt All questions.***
- ✓ ***The figures in the margin indicate Full Marks.***
- ✓ ***Assume suitable data if necessary.***

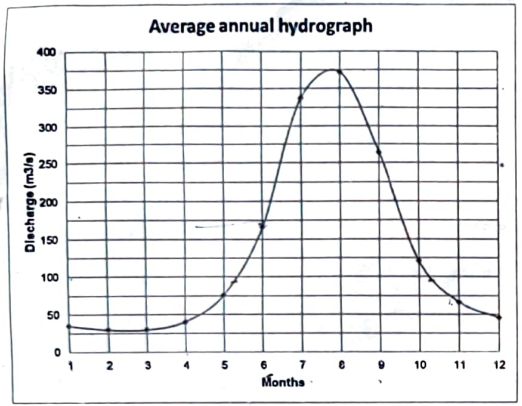
1. What are the physical functions of rivers? Define different reaches/zones observed in a river systems with suitable examples. [4]
2. What are the different sources of sediment production in a catchment? Define sediment delivery ratio. What are the factors that affect the sediment delivery ratio? [4]
3. You carried out a pit sampling in a bar of a river to determine the sediment characteristics of the deposits. The following data is obtained from the sample. Compute the standard deviation, geometric mean and median diameter of the sample. Comment on the characteristics of the sediment deposits. [8]

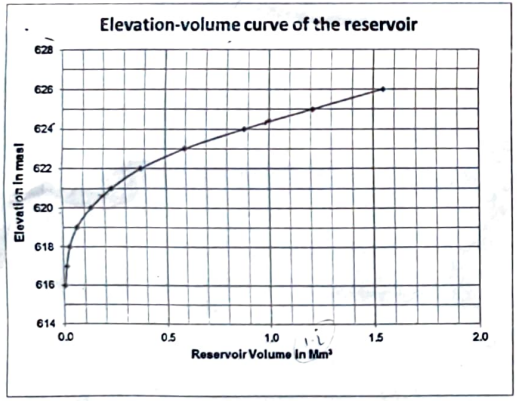
Sieve Size (mm)	Weight retained (kg)
125	110.9
100	64.8
75	11.6
50	42.4
45	17.5
31.5	11
22.5	16
16	12
12.5	12
8	17.44
4.5	9.50
2.36	19.44
1.6	5.75
0.5	38.63
0.3	22.69
0.18	7.06
0.063	3.98
Fine	2.19

4. An automatic suspended sediment sampler is installed near the headworks area of a project which carries out sampling at an hourly frequency. The data collected during a flood event on 20th August 2020 is shown in Table below. Calculate the total suspended sediment load which occurred during the flood using different applicable methods.
Table: Suspended sediment concentration and discharge recorded during the sampling period. [8]

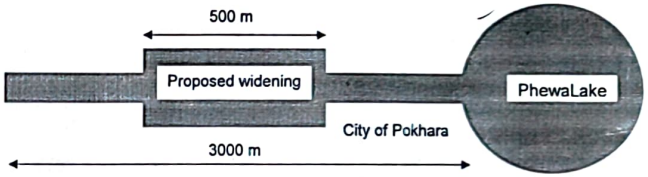
Date - Time	Suspended Sediment Concentration (PPM)	Discharge (m^3/s)
20/8/2020 - 8:00	15.72	14.0
20/8/2020 - 9:00	24.08	14.9
20/8/2020 - 10:00	34.01	19.0
20/8/2020 - 11:00	34.86	23.0
20/8/2020 - 12:00	199.89	35.3
20/8/2020 - 13:00	2056.87	80.7
20/8/2020 - 14:00	919.54	102.3
20/8/2020 - 15:00	2542.52	98.0
20/8/2020 - 16:00	873.48	81.4
20/8/2020 - 17:00	494.39	70.7
20/8/2020 - 18:00	103.91	65.4
20/8/2020 - 19:00	128.13	61.6
20/8/2020 - 20:00	108.00	52.7
20/8/2020 - 21:00	56.06	45.7
20/8/2020 - 22:00	32.47	38.4

5. Define river bars. How are they classified? Why are river bars important for the water resources infrastructure project development? [4]
6. You are assigned to design a headworks of a peaking run-of-river hydropower project in the middle hills of Nepal. The project has an installed capacity of 75 MW and net head of 100 m and has to be operated to meet the 6 hours of daily peaking demand (3 hours in the morning and 3 hours in the evening). The estimated long-term annual hydrograph at the headworks and the elevation volume curve of the reservoir is provided in the figures below. Determine the capacity inflow ratio of a reservoir. Which design paradigm would you follow and why? Explain the annual reservoir operation that you would recommend for this project. You may assume an overall mechanical efficiency of 85% and neglect the effect of reservoir levels in the net head, for power calculations. After the project is implemented, the owner of the project again recruits you as the operation and maintenance expert. Now you need to perform the repair and maintenance of the turbines. What would be your maintenance strategy to maximize the annual revenue? [16]





7. A 3000 m long river reach passes through the city of Pokhara and drains into Phewa Lake. The river along this reach is channelized by flood walls along both banks. The river has an average annual discharge of 30 m^3/s, reach average width of 30 m and longitudinal slope of 0.5%. The city council of Pokhara is planning to increase the width of 500 m reach in the middle to 60 m and develop a city park in the same area. The council recruits you as a river morphologist and requests you to make the assessment of the project. What would be short-term and morphological response of the river in the reach? Explain with appropriate sketches. What would be your recommendation to the city council? You may assume a constant water level in Phewa Lake throughout the year. [16]



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$CIR = \frac{1.2 \times 10^6}{150 \times 0.2 \times 0.5 \times 3.65 \times 86400}$