

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Civil Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: CVX-4241 Engineering Hydrology
Academic Year	: 2022/2023
Date	: 2 nd February 2024
Time	: 0930-1230_hrs
Duration	: 03 hours

General Instructions

1. Read all instructions carefully before answering the questions.
 2. This question paper consists of **SIX (06)** questions on **Six (06)** pages.
 3. Answer **Any FIVE (05)** questions.
 4. Answer for each question should commence from a new page.
 5. Necessary additional information is provided.
 6. This is a Closed Book Test (CBT).
 7. Answers should be in clear handwriting.
 8. Do not use a Red colour pen.
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Q1)

a) The following equation is used in Modified Pul's method in reservoir routing. Please derive this equation using the continuity equation. You need to consider the notations in your derivation. (4 Marks)

$$\left(\frac{I_1 + I_2}{2}\right)\Delta t + \left(S_1 - \frac{Q_1\Delta t}{2}\right) = \left(S_2 + \frac{Q_2\Delta t}{2}\right)$$

b) The storage, elevation, and outflow data of a reservoir are given in **table 1.1**.

Table 1.1

Elevation (m)	Storage (10 ⁶ m ³)	Outflow discharge (m ³ /s)
299.5	4.8	2
300.2	5.5	4
300.7	6.0	17
301.2	6.6	44
301.7	7.2	78
302.2	7.9	120
302.7	8.8	165

The spillway crest is at an elevation of 300.2 m and the flood flow given in **table 1.2** is expected into the reservoir.

Table 1.2

Time (h)	0	3	6	9	12	15	18	21	24	27
Discharge (m ³ /s)	12	25	56	67	51	39	29	20	13	7

If the reservoir surface is at elevation of 305.00 m at the commencement of the inflow, route the flood to obtain;

(a) The graphs of Discharge versus Elevation and the discharge versus $(S+Q.\Delta t/2)$ (8 marks)

(b) The Ordinates of the outflow hydrograph (8 Marks)

Q2)

a) Using the Muskingum equation, derive a function for the storage of a linear reservoir. You need to consider the standard notations in your derivation. (4 Marks)

b) Observed values of inflow and outflow hydrographs at the ends of a reach in a river are given in **table 2.1**. Determine the **best value for X** to use in the Muskingum method of flood routing.

Table 2.1

Time (h)	0	6	12	18	24	30	36	42	48	54	60	66
Inflow (m ³ /s)	15	75	202	232	210	165	120	82	53	33	24	14
Outflow (m ³ /s)	20	20	50	150	200	210	185	155	120	85	55	23

(Hint: X value is between 0.45 and 0.35)

(16 Marks)

Q3)

a) The **figure 3.1** shows the rainfall hyetograph. Explain the steps used in calculating ϕ -index using the **figure 3.1** which is used to calculate effective rainfall.

(8

Marks)

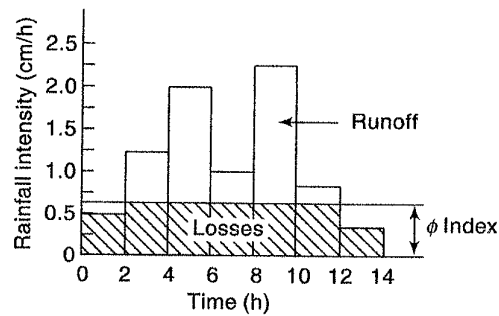


Figure 3.1

b) The mass curve of an isolated storm in a 500 ha watershed is given in **table 3.1**.

Table 3.1

Time from start (h)	0	2	4	6	8	10	12	14	16	18
Cumulative rainfall (cm)	0	0.8	2.6	2.8	4.1	7.3	10.8	11.8	12.4	12.6

If the direct runoff produced by the storm measured at the outlet of the watershed is 0.34

Mm³, estimate the ϕ -index of the storm and duration of rainfall excess.

(12 Marks)

Q4)

a) Explain the method of superposition to derive a unit hydrograph of 9 hours by using a unit hydrograph of 3 hours with the aid of neat sketches.

(8 Marks)

b) The ordinates of S-curve derived using a 3-h unit hydrograph for a basin are shown in the **table 4.1**. Derive the ordinates for a direct runoff hydrograph resulting from a cumulative rainfall of 6 cm over a period of 3 hr for the catchment associated with this unit hydrograph.

(12 Marks)

Table 4.1

Time (h)	0	3	6	9	12	15	18	21	24	27	30
S-Curve ordinates (m³/s)	0	12	87	219	399	609	792	948	1083	1227	1323
Time (h)	33	36	39	42	45	48	51	54	57	60	
S-Curve ordinates (m³/s)	1410	1476	1530	1572	1605	1629	1647	1659	1665	1671	

Q5)

a) Briefly explain the use of Iterative Risk Management (IRM) for mitigating climate change.

(8 Marks)

b) The **table 5.1** gives the observed annual flood values in the river Nile. Determine the flood peaks with return periods of 50, 100, and 1000 years by using Beard's method, $[P = (m - 0.31)/(N + 0.38)]$, where m: ranking; N : Sample size .

(12 Marks)

Table 5.1: Annual Flood Discharge in the river Nile

Water Year Beginning	Flood discharge (m³/s)	Water Year Beginning	Flood discharge (m³/s)
1980	2848	1995	1356
1981	1942	1996	2944
1982	1261	1997	5954
1983	1931	1998	1541
1984	1797	1999	2111
1985	1393	2000	774
1986	1801	2001	911
1987	1323	2002	1121
1988	3205	2003	937
1989	2504	2004	4163
1990	4361	2005	6312
1991	3150	2006	6708
1992	2127	2007	3868
1993	1812	2008	2884
1994	3915		

Please use the provided Semi-log sheet

Q6)

a) In a catchment, whose shape can be approximated by a polygon, four rain gauge stations are situated inside the catchment. The coordinates of the corners of the catchment that define its boundaries and the coordinates of the four rain gauge stations are given in **table 6.1**. Also

given are the annual rainfall recorded by the four stations in the year 2005. Determine the average annual rainfall over the catchment in that year by the Thiessen-polygon method by plotting the catchment in a graph sheet with a suitable scale. Distances are in kilometers (km) and a is the origin of the co-ordinates.

(10 Marks)

Table 6.1

Catchment Boundary	Corner	A	B	C	D	E
	Co-ordinates	(0,0)	(120,0)	(120,80)	(120,120)	(0,80)
Rain gauge station	Station	P	Q	R	S	
	Co-ordinates	(40,20)	(80,20)	(80,60)	(40,80)	
	Annual Rainfall (cm)	120cm	110cm	100cm	125cm	

b) The isohyets due to a storm in a catchment are drawn as shown in the **figure 6.1** and the area of the catchment bounded by isohyets are tabulated in **table 6.2**. (10 Marks)

Table 6.2

Isohyets (cm)	Area (km ²)
At station 12	30
12.0-10.0	140
10.0-8.0	80
8.0-6.0	180
6.0-4.0	20

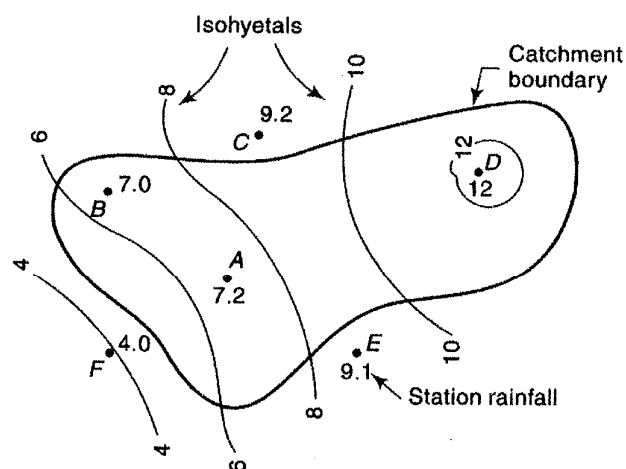


Figure 6.1

