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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: CVX 4241 Engineering Hydrology**
Academic Year	: 2021/2022
Date	: 2nd February 2023
Time	: 0930-1230hrs
Duration	: **03 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **SIX (06)** questions on **Seven(07)** 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 Red colour pen.

Q1)

a) The following equation is used in Modified Pul's method in reservoir routing. Derive this equation using the continuity equation. You need to consider the standard denominators and 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 below:

Elevation (m)	**Storage (10^6 m^3)**	**Outflow discharge (m^3/s)**
299.5	4.8	0
300.2	5.5	0
300.7	6.0	15
301.2	6.6	40
301.7	7.2	75
302.2	7.9	115
302.7	8.8	160

The spillway crest is at an elevation of 300.2 m and the following flood flow is expected into the reservoir.

Time (h)	0	3	6	9	12	15	18	21	24	27
Discharge (m^3/s)	10	20	52	60	53	43	32	22	16	10

If the reservoir surface is at elevation 300.00m at the commencement of the inflow, route the flood to obtain;

(i) The graph of Discharge versus Elevation and (S+Q.Δt/2) (8 Marks)

(ii) Ordinates of the outflow hydrograph (8 Marks)

Q2)

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

b) Observed values of inflow and outflow hydrographs in a river are given below. Determine the **best value for x** to use for the Muskingham method of flood routing.

Time (h)	0	6	12	18	24	30	36	42	48	54	60	66
Inflow (m^3/s)	20	80	210	240	215	170	130	90	60	40	28	16
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) The land use and soil characteristics of a 5000-ha watershed are as follows:

Soil type: Any soil type other than Black soil.

Hydrologic soil classification: 60% Group B and 40% Group C

Land use: Hard surface areas = 10%, Waste Land = 5%, Orchard (without understory cover) = 30%, Cultivated (Terraced) poor condition = 55%.

Antecedent rain: The total rainfall in the past five days was 30 mm. The season is dormant seating,

(a) Compute the runoff volume from a 125 mm rainfall in a day on the watershed. (8 Marks)

(b) What would have been the runoff if the rainfall in the previous 5 days was 10 mm? (4 Marks)

(c) If the entire area is urbanized with 60% residential area (65% average impervious area), 10% of paved streets, and 30% commercial and business area (85% impervious), estimate the runoff volume under AMC -II condition for one-day rainfall of 125 mm. (8 Marks)

You may use the table 3.1, Table 3.2 and Table 3.3 of this calculation

Q4)

a) Describe the S -curve method of developing a 6-h Unit Hydrograph by using 12-h Unit Hydrograph of the catchment. (4 Marks)

b) The 3-h unit hydrograph for a basin has the following ordinates. Using the S-curve method, determine the 9-h unit hydrograph ordinates of the basin. (16 Marks)

Time (h)	0	3	6	9	12	15	18	21	24	27	30
3-h UH ordinates (m^3/s)	0	12	75	132	180	210	183	156	135	144	96
Time (h)	33	36	39	42	45	48	51	54	57	60	
3-h UH ordinates (m^3/s)	87	66	54	42	33	24	18	12	6	6	

Q5)

a) Briefly explain the use of Iterative Risk Management (IRM) for mitigating climate change. (4 Marks)

b) The following table gives the observed annual flood values in the river Mana at Karishma. Determine the flood peaks with return periods of 50, 100, and 1000 years by using Weibull's method. (16 Marks)

Please use the semi-log sheet provided

Table 5.1: Annual Flood Discharge in the river Mana at Karishma

Water Year Beginning	Flood discharge (m^3/s)	Water Year Beginning	Flood discharge (m^3/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		

Q6)

a) There is a great variance in the actual value of the earth's average surface temperature of 288K (+15 ^{0}C). The actual temperature differs from the blackbody temperature because of the greenhouse effect. Scientifically explain the phenomenon of Blackbody temperature and compare it with the actual average temperature (15 ^{0}C) resulting from global warming. (8 Marks)

b) Technically describe the impacts of climate change and methods of mitigation and adaptations. (6 Marks)

c) Briefly describe the process of Risk Analysis which includes Risk Management, Risk Assessment, and Risk Communication. (6 Marks)

Table 3.1: Antecedent Moisture Condition (AMC) for determining the value of CN

AMC Type	Total Rain in Previous 5 days	
	Dormant Season	**Growing Season**
I.	Less than 13 mm	Less than 33 mm
II.	13 mm to 28 mm	36 mm to 53 mm
III.	More than 28 mm	More than 53 mm

Table 3.2: Runoff Curve Numbers [CN_{II}] for Hydrologic Soil Cover Complex [Under AMC-II Conditions]

Land Use	Cover		Hydrologic soil group			
	Treatment or Practice	Hydrologic Condition	A	B	C	D
Cultivated	Strait row		76	86	90	93
Cultivated	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
Cultivated	Contoured &	Poor	66	74	80	82
	Terraced	Good	62	71	77	81
Cultivated	Bunded	Poor	67	75	81	83
		Good	59	69	76	79
Cultivated	Paddy		95	95	95	95
Orchards	With understory cover		39	53	67	71
	With understory cover		41	55	69	73
Forest	Dense		26	40	58	61
	Open		28	44	60	64
	Scrub		33	47	64	67
Pasture	Poor		68	79	86	89
	Fair		49	69	79	84
	Good		39	61	74	80
Wasteland			71	80	85	88
Roads (dirt)			73	83	88	90
Hard Surface areas			77	86	91	93

For AMC-I: $CN_I = \frac{CN_{II}}{2.281 - 0.01281\, CN_{II}}$

Table 3.3: CN_{II} Values for Suburban and Urban Land Uses

Cover and treatment	Hydrological soil group			
	A	B	C	D
Open space, lawns, parks, etc.				
In good condition, grass cover in more than 75% area	39	61	74	80
In fair condition, grass cover of 50 to 75% area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential, average (65% impervious)	77	85	90	92
Paved parking lots, paved roads with curbs, roofs, driveways, etc.	98	98	98	98
Street and rods				
Gravel	76	85	89	91
Dirt	72	82	87	89

For AMC-III: $CN_{III}=\frac{CN_{II}}{0.427+0.00573\,CN_{II}}$;For value of λ =0.2; $Q=\frac{(P-0.2S)^2}{P+0.8\,S}$ for P>0.2S