

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	: CVX4241 Engineering Hydrology
Academic Year	: 2024/2025
Date	: 2 nd February 2026
Time	: 13:30-16:30 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 **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 a 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 300.00 m at the commencement of the inflow, route the flood to obtain;

(i) The graph of Discharge versus Elevation and $(S+Q.\Delta t/2)$ (8 Marks)

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

Q2)

The following equation represent the Horton's model which is used to estimate the infiltration capacity of soil.

$$(f_p - f_c) = (f_0 - f_c)e^{-K_h t} \text{ for } 0 \leq t \leq t_c$$

Where;

f_p = infiltration capacity at any time t from the start of the rainfall

f_0 = initial infiltration capacity at $t = 0$

f_c = final steady-state infiltration capacity occurring at $t = t_c$. Also, f_c is sometimes known as constant rate or ultimate infiltration capacity.

K_h = Horton's decay coefficient which depends upon soil characteristics and vegetation cover

t = time

a) Infiltration capacity data obtained in a flooding-type infiltration test is given below in Table 01.

Table 01

Time since start (minutes)	5	10	15	25	45	60	75	90	110	130
Cumulative infiltration depth (cm)	1.75	3.00	3.95	5.50	7.25	8.30	9.30	10.20	11.28	12.36

For this data, plot the curves of

- (i) infiltration capacity vs time (7 Marks)
(ii) cumulative infiltration vs time (7 Marks)

b) Obtain the best values of the parameters in Horton's infiltration capacity equation to represent this data set. (6 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 seeding,

- (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 for 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)

Table 02

Time (h)	0	3	6	9	12	15	18	21	24	27	30
3-h UH ordinates (m³/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 (m³/s)	87	66	54	42	33	24	18	12	6	6	

Q5)

a) There is a great variance in the actual value of the earth's average surface temperature of 288K (+15 °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 °C) resulting from global warming using quantitative energy balance derivation. (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)

Q6)

a) Briefly explain the difference between Actual Evapotranspiration (AET) and Potential Evapotranspiration (PET). (2 Marks)

b) Briefly explain 'Reference Crop Evapotranspiration' (ET_o) and how it is used to estimate Potential evapotranspiration of crops (PET). You may use mathematical expressions to describe this correlation. (4 Marks)

c) Using the Blaney-Criddle formula, estimate the PET of an area for the season November to February in which wheat is grown. The area is in North India at a latitude of 30° N with mean monthly temperatures as below. (14 Marks)

Table 6.1

Month	November	December	January	February
Temperature (°C)	16.5	13.0	11.0	14.5

Table 6.2: Values of K for Selected Crops

Crop	Average value of K	Range of monthly values
Rice	1.10	0.85-1.30
Wheat	0.65	0.50-0.75
Maize	0.65	0.50-0.80
Sugarcane	0.90	0.75-1.00
Cotton	0.65	0.50-0.90

Table 6.3: Monthly Daytime Hours Percentages, P_h , for use in Blaney-Criddle Formula

North Latitude (deg)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	8.50	7.66	8.49	8.21	8.50	8.22	8.50	8.49	8.21	8.50	8.22	8.50
10	8.13	7.47	8.45	8.37	8.81	8.60	8.86	8.71	8.25	8.34	7.91	8.10
15	7.94	7.36	8.43	8.44	8.98	8.80	9.05	8.83	8.28	8.26	7.75	7.88
20	7.74	7.25	8.41	8.52	9.15	9.00	9.25	8.96	8.30	8.18	7.58	7.66
25	7.53	7.14	8.39	8.61	9.33	9.23	9.45	9.09	8.32	8.09	7.40	7.42
30	7.30	7.03	8.38	8.72	9.53	9.49	9.67	9.22	8.33	7.99	7.19	7.15
35	7.05	6.88	8.35	8.83	9.76	9.77	9.93	9.37	8.36	7.87	6.97	6.86
40	6.76	6.72	8.33	8.95	10.02	10.08	10.22	9.54	8.39	7.75	6.72	6.52

Blaney-Criddle Formula

$$E_T = 2.54KF$$

Where; $F = \sum \frac{P_h \bar{T}_f}{100}$

ET= PET in a crop season in cm

K= an empirical coefficient, depends on the type of the crop and stage of growth

F= sum of monthly consumptive use factors for the period

$\bar{T}_f$ = mean monthly temperature in ($^{\circ}\text{F} = ^{\circ}\text{C} \times 9/5 + 32$)

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 roads				
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 $\lambda = 0.2$; $Q = \frac{(P - 0.2S)^2}{P + 0.8S}$ for $P > 0.2S$

