Total number of printed pages: 3 **Programme:UG/Semester:VI/Code:UCE605**

2025

Hydrology and Water Resources Engineering

Full Marks: 100

Time: Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1.	Answer any four of the following:		4×5=20
	a)	Describe a hydrological cycle (with a sketch), and the water-budget equation relating its major components.	
	b)	Define return period, and show the relations between return period, probability of exceedance and frequency of occurrence of a storm. Plot a typical Intensity-Duration-Frequency curve by labelling the axes and naming the symbols used.	
	c)	What are the methods of reducing evaporation from a reservoir. Describe a method of reducing evaporation from a canal as was discussed in your class with reference to the Narmada canal in Gujarat.	
	d)	Define potential evapotranspiration, actual evapotranspiration and wilting point. By which methods can the evapotranspiration for a given type of vegetation be measured?	
	e)	Define field capacity and infiltration capacity. Write down the Horton's equation of infiltration capacity and provide the graphical representation of the same.	
2.	Answer any four of the following:		4×5=20
	a)	List the different categories and subcategories of streamflow measurement. How would the flow of an irrigation canal having a venturi flume be measured?	
	b)	Define stage of a river, and write the usefulness of crest staff gauge for manual measurement and bubble gauge for automatic recording of the stage.	
	c)	Name and briefly define with sketches the types of rivers according to (i) runoff characteristics and (ii) groundwater contribution.	
	d)	What are the factors which influence the runoff hydrograph from a catchment?	
	e)	List the different methods of estimating a design flood for a water resource engineering project. What are the key differences in terms of producing the values of the features of a flood hydrograph that each of these methods produce.	
3.	a)	Define φ-Index, Excess Rainfall and Direct Runoff.	6
	b)	For the data in the following table, show that 0.275 cm/hr would be the φ-Index, and that the Excess Rainfall duration would be 12 hr. Draw a sketch (not to scale) presenting the φ-Index for this set of data.	8+2=10
	c)	Schematically show the relation between an Excess Rainfall Hyetograph (ERH) and a Direct Runoff Hydrograph (DRH) as presented in your class. What is the transformation function in this relation called?	4

Time from start (hr)	0	2	4	6	8	10	12	14	16
Cumulative rainfall (cm)	0	0.4	1.3	2.8	5.1	6.9	8.5	9.5	10.0

4.	a)	A catchment has six rain-gauge stations located inside, and two stations outside but close to the catchment's boundary. The sub-areas (km^2) under the Thiessen polygon around each station and the corresponding rainfall (mm) recorded in a year are given below. Stations A and G are outside the catchment. Show that the average annual rainfall on the catchment would be 1450 mm and 1475 mm by the arithmetic mean and the Thiessen weighting methods respectively. Which method would you prefer and why?	8+2 = 10
	b)	With reference to the catchment average rainfall with Thiessen mean method in the above question, if the average discharge during the year in the river draining that catchment at the catchment's outlet worked out to 228.5 Cumec. Show that	3+2+2+3=10
		i) the river carried 7206 Million Cubic Metre (MCM) of water from that catchment in that year.	
		ii) 7000 MCM of water was lost from the precipitation by the combined effect of evapotranspiration and infiltration into ground.	
		iii) the runoff coefficient for the catchment is 50.7%.	
		iv) the amount of groundwater recharge would be 2000 MCM if the evapotranspiration of 51.915 cm is estimated over the catchment for the year.	
5.	a)	By observing the following photographs, name the method that your seniors were applying for measuring discharge of the stream near your campus.  	2
	b)	Describe with a sketch and mathematical expressions (Only one method): **Either**, the method referred to in Part (a) of this question, **Or**, the constant rate injection method of dilution technique for measuring flow, **Or**, the ultrasonic method for measuring an average velocity of flow, **Or**, the slope area method by only writing the energy, the roughness, the eddy-loss and the continuity equations.	6
	c)	Define and show a sketch of a typical rating (i.e. stage-discharge) curve. From the following data collected during a stream-gauging operation at a section of a small river, show that the discharge through that section was 9 m^3s^{-1}.	2+10= 12

Station	A	B	C	D	E	F	G	H
Thiessen area	720	1380	1440	1040	900	2220	475	1456
Rainfall	1600	1710	1640	1540	1220	1380	1700	1210

Distance from left water edge (m)	0	2	4	6	8	10	12
Depth of flow d (m)	0.0	1.3	2.5	1.7	1.0	0.5	0.0
Velocity at $0.2d$ ($m\ s^{-1}$)	—	0.6	1.0	0.7	0.6	0.4	—
Velocity at $0.8d$ ($m\ s^{-1}$)	—	0.3	0.7	0.5	0.4	0.3	—

6.	a)	What do you mean by plotting position? Define and show sketches of a Flow Duration Curve (FDC), and a mass curve of flow. Which method would you use to check the external consistency of discharge records of a river?	2+3+3+ 2=10
	b)	Show that 365 Mm^3 would be the minimum storage required in a reservoir if the monthly inflows and planned demands are as given in the following table.	10

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inflow (Mm^3)	50	40	30	25	20	30	200	225	150	90	70	60
Demand (Mm^3)	70	75	80	85	130	120	25	25	40	45	50	60

7.	a)	Define a Unit Hydrograph (UH). What are the Assumptions and Limitations of the UH theory.	2+4=6
	b)	Name the methods of deriving a new UH of duration different from the duration of a UH that is already available. Which of these methods is versatile (i.e. adaptable for different requirements)?	2+2=4
	c)	The flow at the outlet of a catchment of 480 km^2 area resulting from a storm of 6-hr duration were observed as given in the following table.	10

Time (hr)	0	6	12	18	24	30	36	42	48	54	60	66	72
Flow (m^3/s^{-1})	10	110	260	210	160	110	80	60	45	35	25	15	10

Show that the effective rainfall from this storm was 4.5 cm. Hence, derive the ordinates of the 6-hr UH
(*Hint: separate the baseflow as indicated by the flow values in the table to find the DRH*)

8.	a)	Show with the help of a sketch the different components, i.e., the rising and receding limbs, the crest segment and the peak, the baseflow, the basin lag and the time base of a flood hydrograph. Also show how the data of the storm producing this flood would be presented on the same sketch.	4
	b)	(i) Write the general equation of hydrologic frequency analysis. (ii) Describe the procedure for estimating the design flood of a specified return period (giving the formulae as discussed in your class) by **Either** the Rational method **Or** the Gumbel's method for practical use.	2+4
	d)	The soffit level of a bridge across a section of a river was fixed by adopting a design flood of 351 m^3s^{-1}. If the mean and the standard deviation of the available flood data of the river at that location over a period of 20 years are 121 and 60 m^3s^{-1} respectively, show, by Gumbel's method, that a 100-year return period was considered for the flood in this design. Take the values of the reduced mean and the reduced variate for 20-year sample size as 0.5236 and 1.0628 respectively. (Hint: *Calculate the value of the reduced variate first by using the general flood frequency equation by replacing the frequency factor by the expression containing the reduced variate, reduced mean and reduced standard deviation. Then calculate the probability of exceedance by using the basic form of the Gumbel's equation. Finally, find the return period from the probability of exceedance*).	10