

M.E. (Water Resources & Hydraulic Eng.) Examination (6 Semester), 2025
(1st Semester)

ADVANCED HYDROLOGY
(Paper - VII)

Time : Three Hours

Full Marks : 100

Attempt any *five* questions

1. a) Establish the correlation between actual runoff (Q) and potential runoff (P) using the Runoff Curve Number (CN) Method for midsize catchments condition in the SI System.

$$Q = \frac{[(P + 50.8)CN - 5080]^2}{CN[CN(P - 203.2) + 20320]}$$

Which is subject to the restriction that $P \geq (5080/CN) - 50.8$.

- b) A Watershed 300 ha in size has group C soil. The land cover can be classified as 35% open forest, 60% poor quality pasture and the remaining 5% for waterbody. Assuming AMC-II at the average condition and the soil found to be black soil, estimate the direct runoff volume due to rainfall of 90 mm in 1 day. Deduce the expression used for the estimation using the AMC-II condition (Group-C soil).

Land Use	Percentage of soil	CN
Open Forest	35%	62
Poor quality pasture	60%	76
Waterbody	5%	98

10+10= 20

2. a) A catchment consists of an asphalt pavement ($n=0.011$) that drains into a circular concrete channel ($n=0.012$). The asphalt pavement has an average slope of 0.67% and the distance from the catchment boundary to the drain is 50 m. The drainage channel is 40 m long, 35 cm wide and side slope 2 (H): 1 (V) and has a slope of 0.8%. For an effective rainfall intensity of 60 mm/hr, the flow rate in the channel is estimated as 0.6 m³/s. Find out the value of two coefficients (α and m) using Manning's equation and also estimate the velocity of flow in cumecs and time of concentration of the entire catchment area in minutes using the Kinematic Wave equation and Empirical equation and compare their results. Assume any data if required.
- b) Deduce an expression of time of concentration (t_c) for overland flow for a Kinematic Wave to travel the distance from the catchment boundary to the catchment outlet (L) and rainfall excess rate (i_e).

13+7= 20

[Turn over

3. a) What are the different steps for determining the PMP of a river basin?
 b) What are the guidelines that should be considered for storm transposition?
 c) Draw the DAD curve and determine the PMP of sub-catchments A and B, which are part of catchment C.

(Increase 20% for storm maximization)

Area of Catchment A = 5578 sq. km.

Area of Catchment B = 4120 sq. km.

Total catchment C area – (catchment A + catchment B) = 9790 sq. km

Isohyetals (mm)	300	275	250	200	150	100	50
Area enclosed (sq. km.)	530	1550	2023	2994	4923	8220	10089

Measured 3 day maximum rainfall of two stations located inside the isohyets 315 mm are – 302 mm and 305 mm.

4+4+12= 20

4. a) For a basin of 500 km², having L=25 km; L_{ca}=10 km; C_t=1.6; C_p=0.16, derive a Unit hydrograph for the catchment.
 b) A reservoir has the following elevation, discharge and storage relationships

Elevation	Storage	Outflow Discharge
m	10⁶ m³	m³/s
100	3.35	0
100.5	3.472	10
101	3.38	30
102	4.383	55
102.5	4.882	72
103	5.37	100
103.5	5.527	116
104	5.856	135

Route the following flood hydrograph through the reservoir by the Modified Pulse method.

Time (h)	0	6	12	18	24	30	36	42	48	54
Discharge (m³/s)	10	30	85	140	125	96	75	60	46	35

The initial conditions are: when t=0, the reservoir elevation is 100.50 m

10+10= 20

5. a) What do you mean by prism storage and wedge storage?
 b) Explain the terms “flood attenuation” and “time lag of flood”.
 c) Show that in the level pool routing the peak of the outflow hydrograph must intersect the inflow hydrograph.
 d) Using the NASH model derive that the IUH of a catchment can be written as

$$u(t) = \frac{1}{K\Gamma(n)} \left(\frac{t}{K} \right)^{n-1} e^{-t/K}$$

Assume proper notations.

4+4+5+7= 20

6. (a) What is Instantaneous Unit Hydrograph (IUH) ?
 (b) What are the main advantages of IUH.
 (c) The ordinates of 4 hour UH of catchment is given below determine the ordinate of IUH of the catchment.

Time (hour)	Ordinates of 4 hour UH (m ³ /s)
0	0
1	1.0
2	6.38
3	17.0
4	29.13
5	39.0
6	42.5
7	38.6
8	31.3
9	23.5
10	16.6
11	11.0
12	6.6
13	3.5
14	1.5
15	0.4
16	0

3+3+14=20

- 7.(a) The IUH of a catchment is triangular in shape with a base of 36 hr. and peak of 20 m³/s occurring at 8 hrs from the start. Derive the 2 hr unit hydrograph from this catchment.
 (b) Define the term Forest Hydrology and discuss the major scientific aspect of forest hydrology
 (c) Write short notes on
 i) Flooding Forest ii) Stream Network

12+3+5=20

[Turn over

8. (a) A small watershed consists of 1.5 km² of cultivated area ($c = 0.2$), 2.5 km² under forest ($c = 0.1$) and 1 km² under grass cover ($c = 0.35$). There is a fall of 20 m in a watercourse of length 2 km. The I–D–F relation for the area is given by $I = (80T^{0.2}) / (t+12)^{0.5}$. Estimate the peak rate of runoff for a 25-year frequency

- (b) An 650 ha water shed has the /land use land cover and corresponding runoff coefficient is given below table.

Land Use/cover	Area (ha)	Runoff coefficient
Forest	400	0.10
Pasture	50	0.11
Cultivated land	200	0.30

The maximum length of travel of water in watershed is about 3000 m and the elevation difference between the highest and outlet point is 25 m. The maximum intensity duration frequency relationship of the watershed is given by

$$i = \frac{6.311 T^{0.1553}}{(D+0.50)^{0.945}}$$

Where i = intensity in cm/h, T = return period in years and D = Duration of the rainfall in hours. Estimate the

- (i) 25 years peak runoff from the watershed
- (ii) The 25 years peak runoff if the forest cover has decreased to 100 ha and the cultivated land encroached up on the pasture and forest land to have a total average of 550 ha

5+15=20