M.E. WATER RESOURCES AND HYDRAULIC ENGG.
FIRST YEAR SECOND SEMESTER - 2024

ADVANCED HYDROLOGY

Time: Three Hours | Full Marks: 100

Answer any *five*

1. (a) Write a brief descriptions of different AMC conditions based on SCS CN method.

(b) Write the theory of SCS-CN Method of Estimating Runoff Volume.

(c) The land use and soil characteristics of a 5000 ha watershed are as follows:

Soil: Not a black soil. Hydrologic soil classification: 60% is group B and 40% is 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 past five days was 30 mm. The season is dormant season.

i. Compute the runoff volume from a 125 mm rainfall in a day on the watershed.
ii. What would have been the runoff if the rainfall in the previous five days was 10 mm.?
iii. 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.

4+4+12=20

2. (a) For a proposed reservoir the following data were calculated. The prior water rights required the release of natural flow or 5.5 m^3/s, whichever is less. Assuming an average reservoir area of 35 km^2, estimate the storage required to meet these demands. (Assume runoff coefficient of this area submerged by the reservoir = 0.5)

Month	Mean Flow (m^3/s)	Demand (million m^3)	Monthly evaporation (cm)	Monthly rainfall (cm)
January	25	22.0	12	2
February	20	23.0	13	2
March	15	24.0	17	1
April	10	26.0	18	1
May	4	26.0	20	1
June	9	26.0	16	13
July	100	16.0	12	24
August	108	16.0	12	19
September	80	16.0	12	19
October	40	16.0	12	1
November	30	16.0	11	6
December	30	22.0	17	2

(b) Surface runoff from a developed area is intercepted by a storm drain, where the catchment is characterized by a runoff coefficient of 0.8, an average slope of 0.03, a Manning's coefficient of 0.02, and a runoff length of 70 m. The catchment is located in a region with type I rainfall, and the 2 year 24-h rainfall is 90 mm. Estimate the time of concentration in the sheet flow regime.

(c) An urban catchment with an asphalt surface has an average slope of 0.6%, and the distance from the catchment boundary to the outlet is 85 m. At the catchment location, the 2-year 24-hour rainfall is estimated as 52 mm. For a 20-min storm with an effective rainfall rate of 80 mm/h, estimate the time of concentration using: (a) the kinematic-wave equation, (b) the NRCS method, (c) the Kirpich equation, (d) the Izzard equation, and (e) the Kerby equation.

5+5+10=20

3. (a) What is Instantaneous Unit Hydrograph (IUH)?

(b) What are the advantages of IUH?

(c) The co-ordinates of the IUH of a catchment are as follows:

Time (hr)	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ordinates (m^3/s)	0	11	37	60	71	75	72	66	60	52.5	45	39	33	27	21	16.5	12	9	6	3	0

(i) Derive the 3 hr unit hydrograph for this catchment

(ii) What is the areal extent of the catchment?

2+2+14+2=20

4.(a) The IUH of a catchment is triangular in shape with a base of 36 hr. and peak of 20 m^3/s occurring at 8 hrs from the start. Derive the 2 hr unit hydrograph from this catchment.

(b) When do "air-line" and "wet line" corrections needed in the measurement by the current meter? With the help of a neat sketch show the correctional length expression.

(c) During the measurement of a streamflow by a current meter, the depth of flow at a vertical and the vertical distance between the index point and the water surface were found to be 4.83 m and 5.26 m respectively. If the current meter is to occupy a position at 0.4 times the depth of flow from the streambed and if the cable line makes an angle of 26° with the vertical, what is the cable length to be lowered from the index point? [As per IS: 2913-1964 for vertical angle 26°, air line correction (percentage) and wet line correction(percentage) are 11.26 and 3.5 respectively.]

12+4+4=20

5. (a) What do you mean by "river stage and stage – discharge" relation?

(b) Why do we need to explore slope-stage-discharge relation?

(c) Three points on a smooth curve drawn to best represent the stage-discharge data of a stream have the following coordinates:

Stage, y in m	315.56	316.44	318.73
Discharge, Q in m^3/s	50	250	1250

Develop an equation in the form $Q= k(y-a)^b$

(d) The following measurements are available for the main gauge and auxiliary gauge which is at downstream:

Discharge (m^3/s)	Main Gauge (m)	Auxiliary gauge (m)
315	132.5	132
600	132.5	131

If the main gauge reading is 132.5 m and the auxiliary gauge reading is 131.5 m, what is the discharge in the stream?

3+2+8+7=20

6. (a) What is design storm? What are the different categories of design storm?

(b) Under what circumstances two basins can be considered meteorologically homogeneous?

(c) Determine the PMP of catchments?

Area of Catchment - 9885 Sq.km

Isohyetals (mm)	285	235	190	170	150	75	50
Area enclosed (sq. km.)	580	1650	1995	2894	5090	8120	10150

Measured **3** day maximum rainfall of two stations located inside the isohyet 295 mm are – 303.55 mm and 297.67 mm.

4+3+13=20

7. (a) What is the utility of a synthetic unit hydrograph?

(b) For a basin of 500 km^2, having L=25 km; L_{ca}=10 km; C_t=1.6; C_p=0.16, derive and plot Unit hydrograph for the catchment.
Develop a 2-hour unit hydrograph by using SCS Dimensionless unit hydrograph.

2+18=20

8. (a) Distinguish between Hydrologic storage routing and Hydrologic channel routing.

(b) A reservoir has the following elevation, discharge and storage relationships

Elevation	**Storage**	**Outflow Discharge**
m	**10^6 m^3**	**m^3/s**
100	3.35	0
100.5	3.472	10
101	3.38	26
101.5	4.383	46
102	4.882	72
102.5	5.37	100
102.75	5.527	116
103	5.856	130

Route the following flood hydrograph through the reservoir by Goodrich method.

Time (h)	0	6	12	18	24	30	36	42	48	54
Discharge (m^3/s)	10	30	85	140	125	96	75	60	46	35

The initial conditions are: when t=0, the reservoir elevation is 100.60 m

2+18=20

9. (a) Define the term Forest Hydrology and discuss the major scientific aspect of forest hydrology

(b) An 500 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	250	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

$$\mathbf{i} = \frac{6.311\,T^{0.1523}}{(D+0.50)^{0.945}}$$

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 50 ha and the cultivated land encroached up on the pasture and forest land to have a total coverage of 450 ha

5+15=20