M.E. (Water Resources & Hydraulic Engineering) Examination, 2025

(1st Semester)

PRINCIPLE OF WATER RESOURCES ENGINEERING

(Program Core 1)

Time: Three Hours | Full Marks: 100

Answer all questions from Question 1 and any four from Questions no 2 to 7.

1. (i) In the standard SCS-CN method, if CN=85, the runoff volume for a one-day rainfall of 150 mm is about

a) 38 mm b) 113 mm c) 56 mm d) 81 mm

(ii) A basin with an area of 756 km^2 has the 6-h unit hydrograph, which could be approximated as a triangle with a base of 70 hrs. The peak discharge of the direct runoff hydrograph due to 5 cm of rainfall excess in 6 hours from that basin is

a) 535 m^3/s b) 60 m^3/s c) 756 m^3/s d) 300 m^3/s

(iii) The peak flow of a flood hydrograph caused by an isolated storm was observed to be 130 m^3/s. The storm was 6 hours in duration and had a total rainfall of 7.5 cm. If the base flow and the φ-index are assumed to be 30 m^3/s and 0.25 cm/s, respectively, the peak ordinate of the 6-h unit hydrograph of the catchment is

a) 12.0 m^3/s b) 15.0 m^3/s c) 16.0 m^3/s d) 20.0 m^3/s

(iv) An aquifer confined at the top and bottom by impervious layers is stratified into three layers with a total thickness of 15 m. Permeability values are 30, 10, and 20 m/d with thicknesses of 3 m, 2 m, and 10 m, respectively. The transmissivity of the aquifer in m^2/d is

a) 6000 b) 18.2 c) 20 d) 281

(v) Rational formula is used to arrive at designed peak flow of Qp. If a storm intensity is doubled and duration is increased three times ,the resulting peak discharge is

(i) Q_p (ii) $2Q_p$ (iii) $3Q_p$ (iv) $Q_p/2$

(vi) A triangle DRH due to a 6hr storm in a catchment has a time base of 100 hr and a peak flow of 40 m^3/s. The catchment area is 180 km^2. The 6 hr unit hydrograph of this catchment will have a peak flow in m^3/s of.

a) 10 (b) 20 (c)30 (d) none of these answers

(vii) For a catchment with an area of 360 km^2, the equilibrium discharge of the S curve obtained by summation of 4 hr unit hydrograph is

a) 250 m^3/s (b) 90 m^3/s (c) 278 m^3/s (d) 360 m^3/s

(viii) An intermittent steam

a) has only flash flows in response to storms
b) has flows in the stream during wet season due to contribution of groundwater.
c) has water table above the stream bed throughout the year.
d) does not have any contribution of groundwater at any time.

(ix) The Double mass curve technique is adopted to
a) Check the consistency of raingauge record.
b) To find the average rainfall over number of years
c) To find the number of raingauges required
d) To estimate the missing rainfall data

(x) Lysimeter is used to measure.
a) Infiltration (b) evaporation (c) evapotranspiration (d) Vapour pressure

2. (a) Deduce the equilibrium equation for the steady flow in a confined aquifer.
(b) Establish the correlation between permeability, intrinsic permeability, geometric property, and fluid property using the dimensional analysis method.

10+10=20

3. The following table gives the observed annual flood values in the River Bhagirathi at Tehri. Estimate the flood peaks with return periods of 50 and 100 years by using Gumbel's Extreme value distribution.

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
Flood (m^3/s)	3210	4000	1250	3300	2480	1780	1860	4130	3110	2320	2480
Year	1974	1975	1976								
Flood (m^3/s)	3400	1820	1560								

(20)

4. a) Annual Rainfall data for a Station M as well as the average annual rainfall values for a group of ten neighboring stations located in a meteorologically is given below.

Year	Annual Rainfall Station M (mm)	Average Annual rainfall of group (mm)	Year	Annual Rainfall Station M (mm)	Average Annual rainfall of group (mm)
1960	677	781	1975	1244	1400
1961	579	661	1976	999	1140
1962	96	111	1977	573	650
1963	463	521	1978	596	646
1964	473	541	1979	375	350
1965	700	801	1980	635	590
1966	480	541	1981	497	490
1967	432	491	1982	386	400
1968	494	560	1983	438	390
1969	503	575	1984	568	570
1970	415	480	1985	236	377
1971	531	600	1986	685	653
1972	504	580	1987	825	787
1973	828	950	1988	426	410
1974	770	770	1989	612	588

Test the consistency of annual rainfall data of Station M and correct the record if there is any discrepancy. Estimate the mean annual precipitation in station M.

b) A storm with 10 cm of precipitation produced a direct runoff of 5.8 cm. The duration of rainfall was 16 hours, and its time distribution is given below. Estimate the ø index of the storm.

Time from start (h)	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

12+8=20

5. (a) Describe the factor affecting evapotranspiration

(b)Calculate the potential evapotranspiration from area near Kolkata in the month of November by Penman's formula. The following data are available.

Latitude: 22°4' N

Elevation: 10 m above the sea level

Table: Saturation Vapour Pressure of Water

Temperature (°C)	Saturation vapour pressure e_w (mm of Hg)	A (mm/°C)
0	4.58	0.30
5.0	6.54	0.45
7.5	7.78	0.54
10.0	9.21	0.60
12.5	10.87	0.71
15.0	12.79	0.80
17.5	15.00	0.95
20.0	17.54	1.05
22.5	20.44	1.24
25.0	23.76	1.40
27.5	27.54	1.61
30.0	31.82	1.85
32.5	36.68	2.07
35.0	42.81	2.35
37.5	48.36	2.62
40.0	55.32	2.95
45.0	71.20	3.66

Table: Mean monthly solar radiation at Top of Atmosphere H_a mm Evaporable Water /day

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0°	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
10°	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
20°	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
30°	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
40°	6.0	8.3	11.0	13.9	15.9	16.7	16.3	14.8	12.2	9.3	6.7	5.4
50°	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0

Table Mean monthly values of possible sunshine hours, N

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0°	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
10°	11.6	11.8	12.1	12.4	12.6	12.7	12.6	12.4	12.9	11.9	11.7	11.5
20°	11.1	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
30°	10.4	11.1	12.0	12.9	13.7	14.1	13.9	13.2	12.4	11.5	10.6	10.2
40°	9.6	10.7	11.9	13.2	14.4	15.0	14.7	13.8	12.5	11.2	10.0	9.4
50°	8.6	10.1	11.8	13.8	15.4	16.4	16.0	14.5	12.7	10.8	9.1	8.1

Mean Monthly temperature	19°C
Mean relative humidity	75%
Mean observed sunshine hours	9h
Wind velocity at 2 m height	85 km/day
Nature of surface cover	Close-ground green crop

6+19=25

6. (a) a) Briefly discuss the limitation of unit hydrograph.

(b) The 6-hour unit Hydrograph of a catchment is triangular in Shape, with a base of width of 64 hours and a peak ordinate of 30 m^3/s. Calculate the equilibrium discharge of the S -6hour Curve of the catchment.

(c) Using the ordinates of 12 -h unit hydrograph given below compute the ordinates of the 6-h unit hydrograph of the basin.

Time (h)	Ordinate of 12-h UH (m^3/s)	Time (h)	Ordinate of 12-h UH (m^3/s)	Time (h)	Ordinate of 12-h UH (m^3/s)
0	0	54	130	108	17
6	10	60	114	114	12
12	37	66	99	120	8
18	76	72	84	126	6
24	111	78	71	132	3
30	136	84	58	138	2
36	150	90	46	144	0
42	153	96	35		
48	146	106	25		

[Note that the tail portion of the resulting 6-h UH needs fairing]

2+5+13=20

7. a) Under what condition, S Curve is mandatory for Hydrographic analysis.
   b) The ordinate of a 6-hunit hydrograph given

Time (h)	0	3	6	9	12	18	24	30	36	42	48	54	60	66
6-h UH ordinate (m^2/s)	0	150	250	450	600	800	700	600	450	320	200	100	50	0

A storm had three successive 6-h intervals of rainfall magnitudes of 3.0, 5.0 and 4.0 cm respectively. Assuming a ϕ index of 0.20 cm/h and base flow of 30 m^3/s, determine and plot the resulting hydrograph of flow.

5+15=20