M.E. (Water Resources & Hydraulic Engg.) Examination (6 Semester), 2025

(3rd Semester)

WATER RESOURCES MANAGEMENT

(Paper - VIII)

Time: Three Hours | Full Marks: 100

Answer any ***four*** questions

1. (a) A pumped storage plant is planned to transfer water back and forth between two reservoirs. A single pump turbine (PT) will be used. Preliminary calculations indicate that as a pump the PT will deliver water at the rate of 20 m^3/s against a net head of 110 m. Estimates of efficiencies of the PT and motor-generator (MG), when acting as pump and motor, are 0.83 and 0.86 respectively. When acting as a turbine the PT will deliver 12500 hp to the generator shaft. As a generator, the MG is assumed to have an efficiency of 0.92. Enough storage is available in the reservoirs to permit the PT as a pump for 4.0 hours each day. This same value of water will pass through the PT when acting as a turbine in 3.4 hours if the electricity i.e. generated for peaking purposes has a value of Rs. 6.50 per kWh, the off-peak power used for pumping, has a cost of Rs. 2.50 per kWh and the annual cost of operation & maintenance estimated to be Rs. 60,00,000 per year, how much money can be justifiably invested in the project assuming a project life of 40 years and an interest of 8%? Neglect the effect of changes in the water surface levels in the reservoirs.

(b) Two mutually exclusive alternative water supply projects are given below: -

	Project A	Project B
	(Rs in 1000)	(Rs in 1000)
Construction Cost	40000	30000 1st stay 42000 2nd stay
Operation & Maintenance Cost	160 / year for 40 years	120 / year for 1st 20 years 200 / year for 2nd 20 years
Economic Life	40 years	40 years
Period of Analysis	30 years	30 years
Annual Benefits	2500	2800
Discount Rate	10%	10%

Which is the more economical project?

7+18=25

2. (a) Differentiate between hydrologic and hydraulic uncertainty with examples.

(b) Deduce an expression of surface runoff for the entire catchment area which is used in the rational formula where roughness, catchment area and rainfall intensity are to be uncertain.

(c) Determine the mean discharge and standard deviation of average discharge in cumec and also the mean coefficient of variation. The coefficient of variation and the following parameter values for discharge using Manning's equation are given below.

Parameter	Mean	Coefficient of variation
n	1.011	0.09
D	1000 mm	1.0
S_o	1 in 500	0.009

Assume any data if required.

(d) The flow rate Q for a combination of both rectangular and Vee-Weir can be expressed as

$$Q = 2/3C_d \quad \sqrt{2g}\, H^{\frac{3}{2}} + \frac{8}{15} C_d \tan\left(\frac{\theta}{2}\right)\sqrt{2g}\, H^{\frac{5}{2}}$$

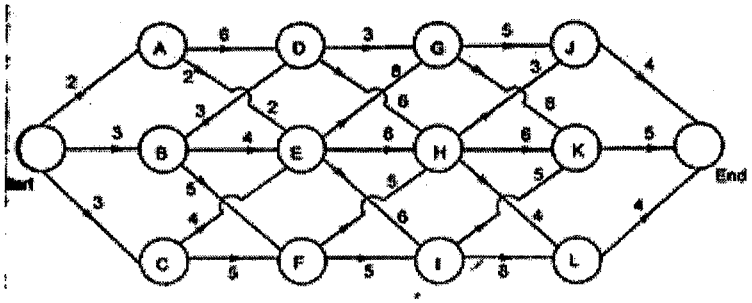
where, C_d = Co-efficient of discharge, H= head of the weir. The variable H is subjected to be uncertain. The mean and coefficient of variation are as follows,

Parameter	Mean	Coefficient of variation
H	1.58 m	0.72

Use first-order uncertainty analysis, to estimate the mean, coefficient of variation and standard deviation of Q in the SI system using C_d =0.80, apex angle, $\theta=90^0$.

3+5+8+9=25

3. (a) A pipeline is to laid be between node 'Start' and 'End' as shown in the figure below. The pipeline can pass only along solid lines. Obtain the shortest route and distance for the pipeline by using dynamic programming. All values are in km.



(b) A farmer is considering growing two types of crops. Each crop requires the amount of land, labour, fertilizer and water per unit of crop produced, as shown in Table 1. The maximum available units of each resource are also shown. Net income in rupees per unit of crop produced is Rs. 800/unit and Rs.600/unit for crops A and B, respectively. Formulate a linear programming model and solve it, using the Simplex method or Graphical Method, to determine the number of units of each crop to obtain maximum net income.

Table 1. Details of available resources

Resource	Units of resources per unit of		Limit available resource
	Crop A	Crop B	
Land	6	2	82
Labour	2	3	50
Fertilizer	4	2	72
Water	3	4	68

10+15=25

4. (a) Define drought. Classify different types of drought with scales.

(b) There are five types of roof in the office building namely administrative building roof, departmental building, Workshop, car park with RCC roof and cycle stand with asbestos roof having individual areas 450 m^2, 380 m^2, 250 m^2, 180 m^2 and 100 m^2 respectively. The average rainfall is considered as 1600 mm. Assume average recharging depth = 80 m; Length and diameter of strainer = 45 m and 300 mm. {No of Rainy days= 120 days (85% of the rainfall considered to be occurred during rainy days and 15% in other days of the year); Occurrence of rainfall during monsoon = 85%; Rainfall to be harvested from the rooftop after allowing the diversion of the first rain= 80%}

(c) Estimate the total water available that could be harvested (both rainy and non-rainy seasons) and also design RTRWH and recharging with sketches.

5+6+14=25

5. (a) A reservoir has a capacity of 60 Mm^3 and average annual inflow of 85 Mm^3 and a drainage area of 1200 km^2. The sediment yield is 580 t/km^2. The sediment has an average in place. Sp.wt. of 1475 kg/m^3. Using 3 increments calculate how long will it take for the reservoir to become 75% filled with sediment. The trap efficiency (Y) of the reservoir and X is the capacity inflow ratio may be assumed as given below. What is the percentage error on your answer if a single increment is used in calculations?

$$Y=100\{1-\frac{1}{65x+1}\}^2$$

(b) The mean monthly discharge data for a proposed reservoir site are given below:

Month	Mean monthly discharge (cumec)	Month	Mean monthly discharge (cumec)
Jan	8	Jul	25
Feb	4	Aug	30
Mar	2	Sep	32
Apr	3	Oct	25
May	9	Nov	15
Jun	2	Dec	12

Determine the monthly average discharge that can be expected throughout the year. Deduce the general expression for the range using the Horst equation and diagram as well.

(c) "In the context of integrated flood management 'a Participatory Approach is key to its success"-elucidate

10+13+2=25

6 . (a) Briefly explain design of stormwater management system.

(b) Briefly describe the selection criteria of a water quality control system.

(c) The estimated runoff hydrographs from a site before and after development are as follows:

Time (min)	0	30	60	90	120	150	180	210	240	270	300	330	360	390
Before (m^3/s)	0	1.2	1.7	2.8	1.4	1.2	1.1	0.91	0.74	0.61	0.50	0.28	0.17	0
After (m^3/s)	0	2.2	7.7	1.9	1.1	0.8	0.7	0.58	0.38	0.22	0.1	0	0	0

The post development detention basin is to be a detention pond drained by an outflow weir. The elevation versus storage in the detention pond is:

Elevation (m)	Storage (m)
0	0
0.5	5544
1.0	12,200
1.5	20,056

where the weir crest is at elevation 0 m, which is also the initial elevation of the water in the detention pond prior to runoff. The performance of the weir is given by $Q= 1.83\ bh^{3/2}$, where Q is the overflow rate (m^3/s), b is the crest length (m) and h is the head on the weir (m). Determine the required crest length of the weir for the detention pond to perform its desired function. What is the maximum water surface elevation expected in the detention pond?

(d) What is major drainage system?

4+3+15+3=25

7. (a) Define the term Transboundary Water Resources Management?

(b) Compute Lp - metric values of alternatives and corresponding ranking pattern for the payoff matrix presented in below Table using Compromise Programming method for p = 1, 2. Assume equal weights for each criterion. Alternatives A_1 to A_6 in payoff matrix represent hydropower projects and criteria C_1 to C_6 correspond to manpower, Hydropower (MW), construction cost maintenance cost, number of villages to be evacuated and security level respectively. Assume necessary data.

Payoff matrix

Crit / Alt	C_1	C_2	C_3	C_4	C_5	C_6
A_1	80	90	6	5.4	8	5
A_2	64	57	2	9.7	1	1
A_3	83	60	4	7.2	4	7
A_4	40	80	10	7.5	7	10
A_5	52	72	6	2.0	3	8
A_6	94	96	7	3.6	5	6
Max/Min	Min	Max	Min	Min	Min	Max

4+21=25