RS

S'05 : 5 AN : CV 405 (31)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc) should be answered at one place.

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Group A

1. (*a*) Explain the terms: the economic life and physical life of Water Resources Project. 6

(*b*) 'More stress should be laid on river basinwise long term planning.' Discuss the statement with reference to any one river valley in India. 7

(*c*) Using simplex algorithm solve the following Linear Programming Problem:

Max $F = 1x_1 + 2x_2 + 3x_3$

subject to $1x_1 + 1x_2 + 1x_3 \leq 5$

$2x_1 + 3x_2 + 4x_3 \leq 24$ 7

(Turn Over)

2. (*a*) Write all explanatory note on 'Optimisation techniques' as used in water resources systems. 6

(*b*) In a multipurpose project, discuss two purposes—one whose use is compatible and another, which is not compatible. 7

(*c*) Explain the terms: deterministic model and stochastic model. 7

3. (*a*) With reference to a multipurpose project, define the terms: separable costs, joint costs, distributed costs and specific costs. 6

(*b*) Differentiate between linear programming and dynamic programming. Which is more useful to water resources systems? 7

(*c*) What is Lagrange multiplier method? How this is used in planning of water resources systems? 7

4. (*a*) Explain the terms: digital simulation model and analog simulation model as used in water resources systems. 6

(*b*) 'The basic factor in design and operation of a multipurpose project is compromise'—substantiate the statement. 7

(*c*) Discuss the various data required to be collected for planning of a water resources project. 7

Group B

5. (*a*) Explain the terms: decision under certainity and decision under risk. Give examples. 6

(*b*) What is water demand forecasting? Explain its importance in water resources development. 7

(*c*) Discuss the application of systems methodology in operation and maintenance of drainage systems. 7

6. (*a*) Cost function of a pumping main is given by $F = K_m L D^m + K_T \varrho g Q h_0$ where K_m and m are pipe cost parameters; K_T is a pumping cost coefficient; L is the length of pumping main; ϱ is mass density at water; g is gravitational acceleration; Q is discharge pumped and h_0 is the pumping head. The discharge Q has to be conveyed from a point of elevation z_0 to z_1. Using Lagrange multiplier method show that the optimal diameter is

$$D^{\star} = \left(\frac{40 \varrho K_T f Q^3}{\pi^2 m K_m} \right)^{\frac{1}{m+5}}$$

where f is Darcy-Weisbach friction factor. 6

(*b*) Write an explanatory note on urban drainage system. 7

(*c*) Distinguish between flood retarding reservoirs and flood detention reservoirs. Where each is preferred? 7

7. (*a*) 'Looking several decades into the future is a prerequisite of water resources planning'—substantiate the statement. 6

(*b*) Explain water distribution system with reference to irrigation. 7

(*c*) 'Storage system works like a bank of collecting water from upstream catchment and distributing the same to the downstream users'—Explain the statement. 7

8. (*a*) Explain a method of computing the runoff from urban catchment. 6

(*b*) 'Under designed flood control is more dangerous than not giving flood protection'—do you agree? Give reasons. 7

(*c*) Write an explanatory note on decision models in water resources systems. 7

Group C

9. (*A*) Match the following: 1×10

Group X		*Group Y*	
(*i*)	Subsystem	(*I*)	Cost savings and increased revenue exceed the cost of developing a system
(*ii*)	Intangible benefits	(*II*)	One of the components of larger system
(*iii*)	Economic feasibility	(*III*)	A process to measure feasibility
(*iv*)	Cost-benefit analysis	(*IV*)	Harder/difficult to estimate
(*v*)	Normalisation	(*V*)	Preceeds system design as a problem solving phase
(*vi*)	System analysis	(*VI*)	Stake holders in system
(*vii*)	Data flow diagram	(*VII*)	Advantages and disadvantages of every legitimate solutions are identified
(*viii*)	System design	(*VIII*)	Gives the logical flow of data
(*ix*)	System users	(*IX*)	Physical design
(*x*)	Feasibility analysis	(*X*)	Step of system development cycle
		(*XI*)	Process of simplifying relationship between data elements in record.

(*B*) Complete the sentences: 1×10

(*i*) Dynamic programming is superior to linear programming because ——.

(*ii*) Data collection for water resources planning include ——.

(*iii*) Objection for river basinwise planning include ——.

(*iv*) The hydel power production is more compatible in multipurpose project, because ——.

(*v*) For decision under uncertainity, the data estimation is ——.

(*vi*) The economic indications of objective functions are ——.

(*vii*) The use of water distribution subsystem is ——.

(*viii*) In analog simulation, the relationships are presented in the form of ——.

(*ix*) In the economic analysis of water resources planning, the following periods of time are considered ——.

(*x*) Storm drainage collects runoff from ——.

RS

W'05 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

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All parts of a question (a, b, etc) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

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Group A

1. (*a*) What are the characteristics of water resources planning/management problems ? Discuss which are the most suitable for quantitative systems analysis techniques. 10

(Turn Over

(*b*) A water resources project has benefits of Rs. 20,000 at the end of the first year and increase on a uniform gradient series to Rs. 1,00,000 at the end of the fifth year. The benefits remain constant at 1,00,000 each year until the end of the 30th year, after which they decrease to Re. 0 on a uniform gradient at the end of the 40th year. What is the present value of these benefits at an interest rate of 6% APR ? 10

2. (*a*) Solve the following linear programming problem using Simplex method :

Max $z = 5x_1 + 4x_2$

subject to

$$6x_1 + 4x_2 \leq 24$$
$$x_1 + 2x_2 \leq 6$$
$$-x_1 + x_2 \leq 1$$
$$x_2 \leq 2, \quad x_1, x_2 \geq 0$$

10

(*b*) Explain in short the problems encountered in the optimal operation of the following types of reservoirs : 10

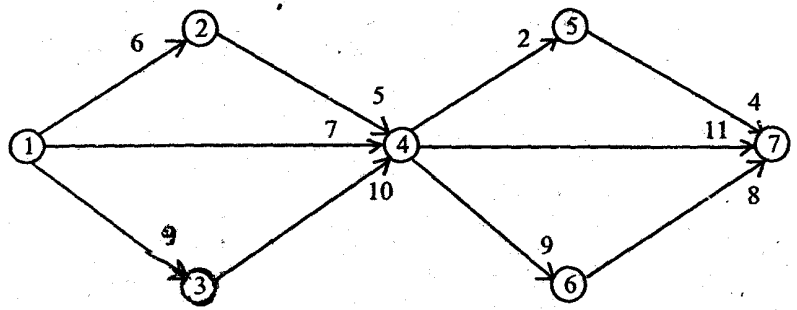
(*i*) Single purpose flood control reservoirs

(*ii*) Other single purpose reservoirs

(*iii*) Multiple purpose reservoirs with flood control

(*iv*) Multiple purpose reservoirs without flood control.

3. (*a*) What do you understand by forward recursion, backward recursion and principle of optimality in dynamic programming ? Determine the shortest path by tabulation method for the following network : 6 + 4



(*b*) Using Lagrangian multipliers (non-negative), solve the following non-linear programming problem :

Max $f(x) = 60 + 8x_1 + 2x_2 - x_1^2 - 0 \cdot 5x_2^2$

subject to

$$40x_1 + 20x_2 - 140 \leq 0$$
$$\text{and } 50x_1 + 35x_2 - 200 \leq 0$$

10

4. (*a*) What do you understand by Simulation ? List and briefly describe the advantages and limitations of simulation. 2 + 4 + 4

(*b*) Compare the following types of simulation models used in water resources systems : 10

(*i*) Physical and mathematical models

(*ii*) Discrete and continuous models

(*iii*) Static and dynamic models

(*iv*) Conceptual and descriptive models

(*v*) Lumped parameter and distributed parameter models.

Group B

5. (*a*) List and briefly elaborate on different types of uncertainties occurring in water resources systems. Write a short note on the need for reliability analysis in water resources systems. 10

(*b*) Define reliability and give an expression for reliability in terms of return period. 5

(*c*) A bridge has an expected life of 25 years and is designed for a flood magnitude of 100-year return period. Compute the reliability of this design. 5

6. (*a*) What are the different water demands? Elaborate how water demand can be forecasted individually for each of the demands as well as collectively for all the demands. 10

(*b*) Write a note on types, design, construction and maintenance of water distribution systems. 10

7. (*a*) With appropriate sketches, compare conduit pipe flow with open channel flow. Describe how a pipe network problem can be solved by Hardy-Cross method. 10

(*b*) The following table gives the mean monthly flows in a river during a particular calendar year, which is not a leap year. Calculate the minimum storage demand required to maintain a demand rate of $40\,m^3/s$: 10

Month	Jan.	Feb	Mar	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Mean flow (cumec)	60	45	35	25	15	22	50	80	105	90	80	70

8. (*a*) An urban catchment has an area of $0{\cdot}85\,km^2$. The slope of the catchment is 0·006 and the maximum length of travel of water is 950 m. The maximum rainfall depth with a 25-year return period is as given below:

Duration (min)	5	10	20	30	40	60
Rainfall Depth (mm)	17	26	40	50	57	62

If a culvert for drainage at the outlet is to be designed for a return period of 25 years, estimate the required peak flow rate by rational formula, assuming runoff coefficient 0·3. Time of concentration ($t_{c,\,min}$) can be computed as

$$t_c = 0{\cdot}01947\, L^{0{\cdot}77} \cdot S^{-0{\cdot}385}$$

where $L \Rightarrow$ max. travel length (m) and $S \Rightarrow$ slope. 10

(*b*) With relevant sketches describe various structural/non-structural methods for flood control including flood plain management system. 10

Group C

9. (*A*) Fill up the blanks: 2 × 5

(*i*) For an economically feasible water resources project, the minimum benefit costs ratio at all the times is ——.

(*ii*) Karmarkar algorithm is used to solve —— —— ——.

(*iii*) Rule curve is a curve used in —— ——.

(*iv*) The sum of risk and reliability is equal to ——.

(*v*) Return period is the —— of frequency.

(*B*) State whether *True* or *False* : 2 × 5

(*i*) A water resources simulation model can be either deterministic or stochastic.

(*ii*) In simplex method of solving linear programming problems, the initial solution is inside the feasibility region.

(*iii*) Reservoir operation for flood control is exactly similar to reservoir operation for irrigation.

(*iv*) Urban drainage is a part of land drainage.

(*v*) Reliability analysis can't be performed by probability analysis.

S'06 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc) should be answered at one place.

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Group A

1. Explain briefly the following types of systems : 4 x 5

(*a*) Simple and Complex systems

(*b*) Linear and Non-linear systems

(*c*) Lumped parameter and Distributed parameter systems

(*d*) Deterministic and Probabilistic systems

(*e*) Time variant and Time invariant systems.

(Turn Over)

2. (*a*) What is simulation technique and how is it different from optimization ? List two typical examples where simulation is used in water resources studies. 10

(*b*) Describe the basic principles of differential calculus method of constrained optimization of a function of n variables with a single equality constraint. 10

3. (*a*) A piece of land having an area of 2000 ha is provided with irrigation facility. Two crops A and B are proposed in this land. The cost of production and benefits from these crops are as below :

Crop	Cost of Production (Units/ha)	Benefits (Units/ha)
A	3	5
B	1	2

If a total of 3000 units of money is available, what areas should be provided to grow crop A and crop B respectively to maximize total net benefits ? Write complete formulation of the problem and solve by using graphical LP method. 12

(*b*) Write short notes on *any two* of the following : 4×2

(*i*) Demand curve

(*ii*) Supply curve

(*iii*) Market price determination.

4. (*a*) Explain briefly : 4×2

(*i*) The Primal and Dual problems

(*ii*) Piece-wise linearization.

(*b*) A multi-purpose reservoir has to meet the needs of (*i*) Irrigation, (*ii*) Hydroelectric power, (*iii*) Flood control and (*iv*) Recreation. Discuss the complementary and conflicting demands (if any) of each of the above purposes that should be taken into consideration in the optimum regulation of the reservoir. 12

Group B

5. (*a*) Write short notes on *any two* of the following items as related to urban drainage systems : 8

(*i*) Detention basins

(*ii*) Rain water harvesting

(*iii*) Estimation of storm runoff.

(*b*) Describe briefly a typical simple reservoir optimization problem and briefly list the important steps in dynamic programming to obtain optimal solution for this reservoir operation problem. 12

6. (*a*) Write brief notes on : 4×2

(*i*) Non-structural methods of flood control

(*ii*) Operation of a storage reservoir for flood control.

(*b*) Write a brief note on simulation technique used in water resources studies. Your answer should include description of simulation processes viz. identification and conceptualization of systems and implementation of the model. 12

7. (*a*) Describe the process of determining the capacity of a reservoir to meet a specified demand pattern using sequent peak algorithm. 8

(*b*) A water resources project has an expected life of 20 years (*i*) For an acceptable risk of 5% against the design flood, what design return period is to be adopted? (*ii*) If the above return period is adopted and the life of the structure can be enhanced to 50 years, what is the new risk value? 12

8. (*a*) A lift irrigation project is designed to cover a certain command area. Descrbe the procedure to estimate the irrigation demand from this command area to enable design of the conveyance system. 10

(*b*) Describe the salient features of a typical urban water distribution system. 10

Group C

9. (*A*) Match the following two lists: $1\frac{1}{2} \times 8$

A) Simplex method	(1) Multi-objective planning
B) Concave function	(2) Periodic deposits at compound rate
C) Backward recursion	(3) Payment of a debt in equal installments at uniform intervals of time
D) Sequential peak algorithm	(4) Simulation
E) Response surface	(5) Storage of Reservoirs
F) Sinking fund	(6) Dynamic Programming
G) Amortization	(7) Maximization
H) Non-inferior solutions	(8) Linear programming

(*B*) Choose the *correct* alternatives: 2×4

(*i*) While selecting a project from among a set of alternative plans, the plan which has

(*a*) the least initial investment is to be selected

(*b*) the least operating and maintenance cost is to be selected

(*c*) the lowest total annual cost is to be preferred

(*d*) the lowest interest rate is to be preferred

(*ii*) Projects *X, Y* and *Z* have costs of 130, 180 and 150 units respectively. If the benefit cost ratios are 1·3, 1·8 and 1·9 respectively, then from economic considerations

(*a*) Project *X* is to be preferred

(*b*) Project *Y* is to be preferred

(*c*) Any one of projects *X, Y* and *Z* can be selected

(*d*) Project *Z* is to be preferred

(*iii*) In a cascade of reservoirs across a stream, improper regulation of an intermediate reservoir can cause flooding

(*a*) in the upstream areas of the reservoir only

(*b*) in the downstream areas of the reservoir only

(*c*) in both upstream and downstream areas of the reservoir

(*d*) in the donwstream areas in small rivers and on the upstream areas in big rivers

(*iv*) It is usual practice to design water resources projects in the country for

(*a*) 75% dependability

(*b*) 75 percentile dependability

(*c*) 25% dependability

(*d*) 25% risk

S'07 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

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Group A

1. (*a*) Briefly describe atmospheric water system, surface water system and subsurface water system. Explain the interaction between different pairs of the above-mentioned systems. 6+4

(*b*) Explain (in short) the following terminology : 10

(*i*) Benefit-cost ratio

(*ii*) Tangible and intangible benefits

(*iii*) Sociological and environmental costs

(*iv*) Incremental rate of return.

2. (*a*) By using the graphical method, solve the following linear programming, problem:

$$\text{Maximize } z = 5x_1 + 4x_2$$

$$\text{subject to } 6x_1 + 4x_2 \leq 24,$$
$$x_1 + 2x_2 \leq 6,$$
$$-x_1 + x_2 \leq 1,$$
$$x_2 \leq 2,$$
$$x_1, x_2 \geq 0$$

12

(*b*) Briefly explain how dynamic programming can be applied to determine the shortest route between a starting node and the end node in a network. 8

3. (*a*) Describe in short where and how Lagrangian multipliers can be used to solve optimization problems. 10

(*b*) Determine the optimum scale of development for a hydroelectric project using the benefit-cost analysis and the incremental benefit-cost analysis, for the following data: 10

Scale (MW)	Costs (lakh Rs.)	Benefits (lakh Rs.)
50	150	180
60	174	210
75	210	267
90	234	298
100	260	327
125	325	385
150	375	425
200	500	490

4. (*a*) Distinguish between the following types of simulation models: 4 × 2

(*i*) Physical model and mathematical model

(*ii*) Lumped parameter model and distributed parameter model

(*iii*) Deterministic model and stochastic model

(*iv*) Static model and dynamic model.

(*b*) Write short notes on: 3 × 4

(*i*) Single purpose reservoir operation for flood control

(*ii*) Single purpose reservoir operation for any other purpose

(*iii*) Multipurpose reservoir operation (with flood control).

Group B

5. (*a*) Write short notes on: 4 × 3

(*i*) Hydrologic uncertainty

(*ii*) Hydraulic uncertainty

(*iii*) Structural uncertainty

(*iv*) Economic uncertainty.

(*b*) Elaborate briefly how we can forecast water demand for irrigation and domestic use after 10 years from now if the irrigated area, type of crops, water demand for each crop, population, per capita daily domestic water demand are known for the current year. 8

6. (*a*) Describe the Hardy-Cross method of analysis of pipe networks. 10

(*b*) The population of a city is 8,00,000 and it is supplied with water from a reservoir 6·4 km away at the rate of 140 litres per head per day. Half the supply is to be delivered in 8 hours. The full supply level of the reservoir is RL 180·00 m and the lowest allowable water level is RL 105·00 m. The delivery end of the main is at RL 22·50 m and the head required there is 12 m Neglecting minor losses, find the pipe dia. Take $f = 0{\cdot}04$ in the equation $h_f = \frac{fLV^2}{29\,d}$. 10

7. (*a*) Describe the mass curve method of determining the storage capacity of a reservoir to be designed for a uniformly steady demand rate. 10

(*b*) Elaborate briefly the rational method of estimating stormwater in an urban drainage system. Also list and briefly explain the methods by which urban stormwater runoff can be reduced to some extent. 10

8. (*a*) Using data of 30 years, and Gumbel's method, the flood magnitudes for return periods of 100 and 50 years were found to be 1200 and 1060 m^3/s for a river. Determine the mean ($\bar{x}$) and standard deviation σ_{n-1}) of the data used. Given that frequency factor for Tyr. return period $(K_T) = \frac{Y_T - \bar{y}_n}{S_n} = \frac{x_T - \bar{x}}{\sigma_{n-1}}$

where the reduced variate $Y_T = -\ln\left(\ln\frac{T}{T-1}\right)$ reduced mean $(\bar{Y}_n) = 0{\cdot}5362$ and reduced standard deviation $(S_n) = 1{\cdot}1124$. Here x_T is the flood magnitude for Tyr. return period, $\bar{x}$ is the mean of the data and σ_{n-1} is the standard deviation of the data. 10

(*b*) What do you understand by the two basic objectives of flood routing? Briefly describe any one method of flood routing. 5+5

Group C

9. (*A*) Match the following: $1\frac{1}{2} \times 8$

A. Sequent peak algorithm	i. Optimization
B. Non-structural methods	ii. Flood peak estimation
C. Rainwater harvesting	iii. Economic feasibility analysis
D. Rational method	iv. Probability analysis
E. Darcy's equation	v. Flood control
F. Log-normal distribution	vi. Frictional head loss determination
G. Benefit-cost ratio	vii. Water conservation
H. Dynamic programming	viii. Reservoir capacity determination

(*B*) Select the correct response from the given alternatives: 4×2

(*i*) Maximum water demand is generally for

(A) Municipal water supply

(B) Irrigation

(C) Industrial water supply

(D) Commercial water supply

(*ii*) As per the Gumbel's distribution, the mean annual flood for a large sample space of annual peak flood data has a return period of

(A) 1·33 yrs

(B) 2·33 yrs

(C) 2·67 yrs

(D) 1·67 yrs

(*iii*) According to the definition of reliability, the sum of risk and reliability in any system is equal to

(A) 1

(B) 2

(C) 0

(D) - 1

(*iv*) Rule curve is used in

(A) Reservoir capacity determination

(B) Reservoir location

(C) Reserviur operation

(D) Reservoir sedimentation.

W'07 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

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Group A

1. (*a*) With the help of neat sketches, explain briefly the following: 2×5

(*i*) Local maximum

(*ii*) Global maximum

(*iii*) Global minimum

(*iv*) Strictly concave function

(*v*) Saddle point.

(*b*) Using Lagrangian multiplier method, maximise the convex function $f(x) = -x_1^2 - x_2^2$

subject to: $x_1 + x_2 = 4$

and $2x_1 + x_2 \geq 5$ 10

2. (*a*) Eight water resources projects are under consideration. The estimated annual costs and annual benefits for the projects are as follows:

Project	Average Annual Cost (Rs in crore)	Average Annual Benefits (Rs. in crore)
P	65·0	78·0
Q	48·0	59·0
R	27·0	39·0
S	105·0	119·0
T	40·0	61·0
U	71·0	70·0
V	39·0	52·0
W	70·0	81·0

Which projects should be built if budgetary limitations restrict the annual costs to Rs. 75 crore? 12

(*b*) Write a detailed note on the cost allocation for multipurpose projects in economic analysis of projects. 8

3. In connection with linear programming, describe briefly the following:

(*a*) Primal simplex method 7

(*b*) Difference between the primal simplex and dual simplex method 7

(*c*) Sensitivity analysis. 6

4. Describe the typical characteristics of a serial multistage decision problem. Considering a three-stage water allocation problem, describe a backward recursion dynamic programming solution procedure. 20

Group B

5. Write a note on simulation in water resources system study. Your note should clearly include the components of a simulation model, steps in simulation, and typical situations of water resources systems where simulation is being used advantageously to solve problems. 20

6. (*a*) Describe sequent peak algorithm approach to determine the reservoir capacity to meet a specific demand. What are the assumptions and disadvantages (if any) of this method. 12

(*b*) Write a brief note on risk and reliability in water resources system design. 8

7. (*a*) List, briefly, the various steps to be accomplished in planning a municipal water supply system. 8

(*b*) Describe briefly the flood management procedures commonly adopted in India. Your answer should include both the structural and non-structural methods. 12

8. (*a*) Briefly describe, with the help of appropriate examples, environmental considerations necessary in water resources planning. 11

(*b*) Write brief notes on: 3 × 3

(*i*) Rain water harvesting

(*ii*) Estimation of storm runoff in urban drainage system design

(*iii*) Water demand forecasting in urban water supply system.

Group C

9. Select appropriate answer for the following:

(*i*) Benefit-cost analysis of four flood mitigation projects are given below: 4

Project	Annual Benefit B (in Rs. crore)	Total Annual Cost C (in Rs. crore)	B/C Ratio	$(B-C)$ (in Rs. crore)
A	150	128	1·172	22
B	210	156	1·346	54
C	275	208	1·322	67
D	300	285	1·052	15

From economic considerations, the project to be selected is

(*a*) D

(*b*) B

(*c*) C

(*d*) Any one of the four

(*ii*) A bridge has an expected life of 25 years and is designed for a flood magnitude of return period 100 years. The risk of this hydrologic design is 4

(*a*) about 22%

(*b*) 1%

(*c*) 4%

(*d*) about 78%

(*iii*) In an urban water supply project, it is usual practice to have economical diameters for 2

(*a*) all raising mains and all pipes in the distribution system.

(*b*) only the raising mains

(*c*) all pipes in the distribution network larger than a certain specified size and all the raising mains.

(*d*) all pipes in the distribution system.

(*iv*) In a reservoir project, the percentage reliability of the output is determined by using available past data and using 2

(*a*) linear programming.

(*b*) simulation.

(*c*) dynamic programming.

(*d*) mass curve.

(*v*) Match the lists *I* and *II* : 3

List I	*List II*
(*A*) Dynamic programming	1. Where multistage decision is involved
(*B*) Linear programming	2. Interest rate used in discounting future cash flows
(*C*) Discount rate	3. Consumption of investment in property
(*D*) Depreciation	4. Payment of a debt in equal instalments at uniform rate

List I	*List II*
(*E*) Amortization	5. Single-most applied optimization technique the world over

Codes:	*A*	*B*	*C*	*D*	*E*
(*a*)	5	1	3	2	4
(*b*)	1	5	2	3	4
(*c*)	1	5	2	4	3
(*d*)	5	1	2	3	4

(*vi*) Identify the non-structural methods of flood management in the following list: 2

(1) Flood plain zoning

(2) Flood insurance

(3) Watershed management

(4) Storage and detention reservoirs

(5) Flood forecast and warning

Codes: The correct answer is

(*a*) 1, 2, 3 and 5

(*b*) 1 and 2

(*c*) 1, 2 and 5

(*d*) 2, 3, 4 and 5

(*vii*) Consider the linear programming problem

Max. $V = 0{\cdot}4\,C + 0{\cdot}3\,P$

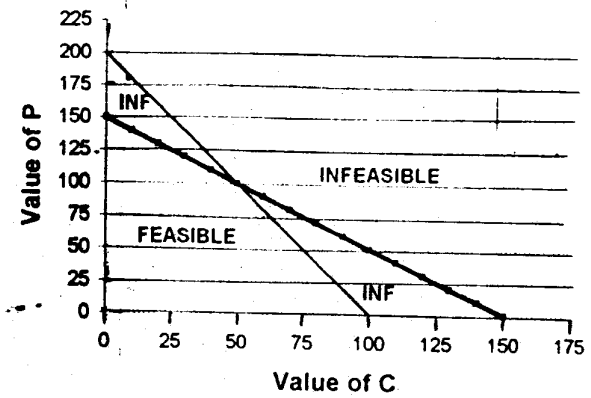
subject to $0{\cdot}8\,C + 0{\cdot}4\,P \leq 80$

$C + P \leq 150$

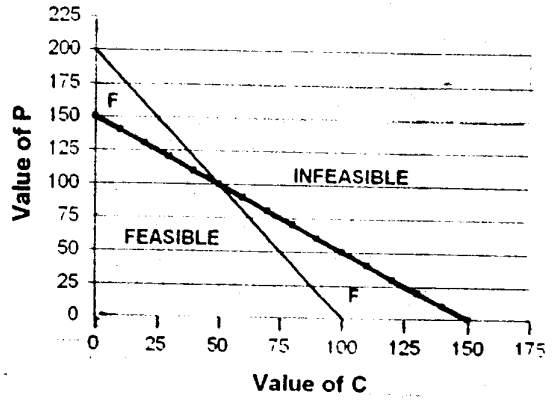
with C and P are non-negative.

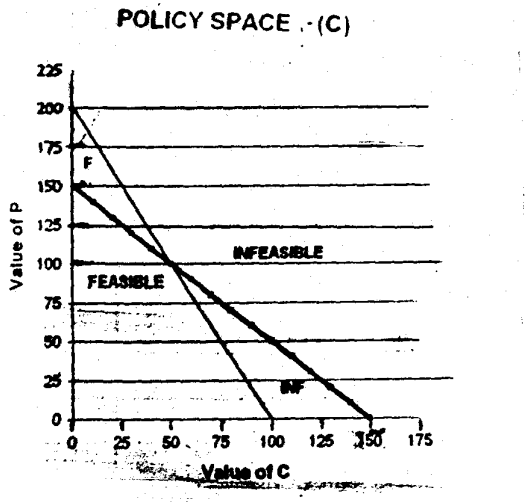
The policy space of this problem is represented as given in figure:

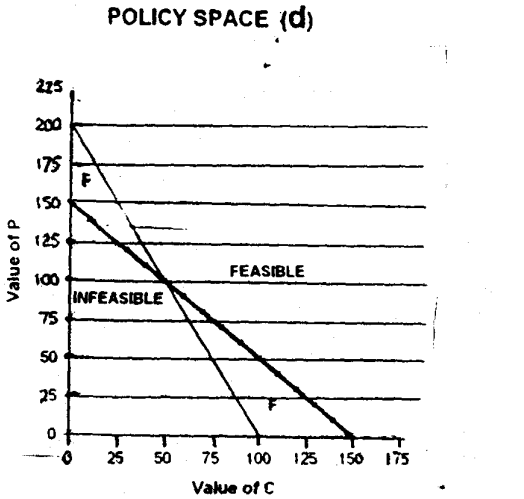
POLICY SPACE (a)



POLICY SPACE (b)







(*a*) Policy Space (*a*) (*b*) Policy Space (*b*)
(*c*) Policy Space (*c*) (*d*) Policy Space (*d*)

S'08 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

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Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Prove that the change in optimal value of the objective function per unit increase in the resource parameter of a constraint, which is defined as the shadow price, is given by the Lagrange multiplier. 8

(*b*) Obtain the governing equations for the following optimal open channel cross-section design problem:

Minimize A_t

subject to $H = \frac{Qn}{\sqrt{S_0}} - \frac{A^{5/3}}{P^{2/3}} = 0$

where $A_t = \{B + z(y+f)\}(y+f)$; $A = (B+zy)y$; $P = B + 2y\sqrt{z^2+1}$; Q = design flow (m^3/s); n = Manning's roughness factor; S_0 = longitudinal bed slope of the channel, A = wetted area (L^2); P = wetted perimeter (L); A_t = total area of the channel cross-section (L^2); B = bed width of the channel, $z(H):1(V)$ = side slope of the channel; y = flow depth (L); f = free-board of the channel cross-section (L). In the above problem definition, the specified quantities are Q, n, S_0 and f; and the variables to be optimized are B, z and y. 6

(*c*) Write the expression of a general non-linear programming problem. With the help of this general non-linear programming problem, explain the terms 'binding constraints' and 'non-binding constraints'. Write the first order Kuhn-Tucker condition for the general non-linear programming problem. 1+2+3

(*a*) Solve the following problem by using either traditional two-phase simplex tableau method or traditional Big-M simplex tableau method: 14

Maximize $Z = -3x_1 + x_2 + x_3$

subject to $1x_1 - 2x_2 + x_3 \leq 11$

$-4x_1 + 1x_2 + 2x_3 \geq 3$

$2x_1 + 0x_2 - 1x_3 = -1$

$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0.$

(*b*) Express a linear programming problem with m constraints and n variables in standard form. State the main features of the standard form. Express the standard linear programming problem in matrix vector notation. 2+2+2

3. (*a*) A total of 6 units of water is to be allocated optimally to three users. The allocation is made in discrete steps of one unit ranging from 0 to 6. Three users are denoted as user 1, user 2 and user 3, respectively. The returns obtained from users for a given allocation are given in the following table. Compute the backward recursion in tabular format to obtain optimal solutions to the problem of finding the allocation to three users such that the total return is maximized. Explain how you arrive at the optimal allocations. 12

Amount of Water Allocated x	*Return from*		
	User 1 $R_1(x)$	*User 2* $R_2(x)$	*User 3* $R_3(x)$
0	0	0	0
1	5	5	7
2	8	6	12
3	9	3	15
4	8	-4	16
5	5	-15	15
6	0	-30	12

(*b*) Enumerate basic features of a dynamic programming problem. 8

4. Explain the rules of the (*i*) present-worth method, (*ii*) rate-of-return method, (*iii*) benefit-cost ratio method, and (*iv*) annual-cost method of discounting technique for comparing project plans and evaluation of relative merits. 20

Group B

5. (*a*) What is firm yield? 1

(*b*) Briefly describe the flow-duration curve method of determining the firm yield of an unregulated river. 3

(*c*) Write short notes on determination of firm yield by using (*i*) mass-curve analysis, and (*ii*) sequent peak analysis. 4+4

(*d*) Write a note on development of linear programming model for reservoir capacity determination when the reservoir is intended solely for the purpose of water supply. 8

6. (*a*) What is simulation? 3

(*b*) Mention some specific major areas of application of simulation programs to describe the operation of water resources systems. 2

(*c*) Why do we use simulation? 5

(*d*) Briefly describe the common steps in simulation. 5

(*e*) Simulation is surrogate for asking 'what if'. Explain. 2

(*f*) Give a general classification of simulation models. 3

7. (*a*) Briefly explain the first-order analysis of uncertainties or delta-method of uncertainty analysis. 6

(*b*) Write a short note on load-resistance concept of reliability analysis. 2

(*c*) By using the concept, briefly explain the terms 'reliability', 'risk', 'relation between reliability and risk', 'static reliability', 'safety margin', 'safety factor'. 1×6

(*d*) Prove that by applying the first order second moment method, a deterministic optimization model becomes a special case of chance constrained optimization model (detailed derivations are not required). 6

8. (*a*) What is the importance of forecasting municipal water demand? 3

(*b*) Explain briefly the major forecasting approaches. 12

(*c*) Write a note on general form of water demand models. 5

Group C

9. Answer the following questions precisely:

(*A*) Write the *five* steps for graphical solution of linear programming. 5

(*B*) Let $f = f(X) = f(x_1, x_2, ..., x_N)$ be a function of multiple variables $x_1, x_2, ..., x_N$. Write the expressions for its gradient vector and Hessian matrix. 1+2

(*C*) (*i*) A linear system is described by m equations and n variables. Identify the system for the following cases: 2

(*a*) $m > n$
(*b*) $m < n$

(*ii*) Write the dual formulation of the following: 2

Maximize $Z = cx$
subject to $Ax \leq b$
$x \geq 0$

(*iii*) Let $f(x)$ be a continuous function of x defined within an open interval (a, b) and f is differentiable to the nth order over the interval. Let x^* is a point within interval (a, b). Write the necessary condition for x^* to be a local minimum (maximum). 2

(*iv*) Muskingum stream flow routing procedure uses the hydrologic continuity equation and a linear storage model. Write the hydrologic continuity equation and the linear storage model. 2

(*D*) (*i*) Write the dual formulation of the problem. 1

(*ii*) In optimization, the form of the following problem is given a special name. What is the name of the form? 1

Minimize $Z = x_1 + x_2 + x_3$

subject to

$$1x_1 + 0x_2 + 0x_3 - x_4 + 0x_5 - 2x_6 = 5$$
$$0x_1 + 1x_2 + 0x_3 + 2x_4 - 3x_5 + 1x_6 = 3$$
$$0x_1 + 0x_2 + 1x_3 + 2x_4 - 5x_5 + 6x_6 = 5$$
$$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0,\ x_4 \geq 0,\ x_5 \geq 0,\ x_6 \geq 0$$

(*iii*) What is the main drawback of dynamic programming? 1

(*iv*) Write the correct statement for the following when we consider a system having certainty of performance. 1

Period of analysis = Economic life ≥ Construction horizon = Physical life.

W'08 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

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Group A

1. (*a*) Formulate reservoir operation problem by writing (*i*) objective function for maximization of overall benefits on account of generation of energy and availability of water for irrigation, (*ii*) constraints representing continuity equation and intial and final conditions. 10

(*b*) Sketch deposition profiles occurring on account of deposition of sediments in a reservoir. Define the life of a reservoir. On what factors the life of reservoir depends ? How can the reservoir life be increased ? 10

2. The objective function and the constraints of a water resources project are linearized as follows :

Minimize $x_0 = 10x_1 + 20x_2$

subject to $0{\cdot}2x_1 + 0{\cdot}1x_2 \leq 10$

$x_1 + x_2 = 100$

Using simplex algorithm, find the optimal values of x_0, x_1 and x_2. 20

3. Using Lagrange multiplier method, find the bed width b and the normal depth y of a rectangular canal that minimizes the flow area $A = by$. The constraint is $Qn/\sqrt{S_0} = (by)^{5/3}/(b+2y)^{2/3}$, where Q = discharge carried by the canal; S_0 = bed slope, and n = roughness coefficient. Also, find the corresponding minimum area. 20

4. (*a*) Describe why it is difficult to generate monthly runoffs in comparison to annual runoffs. 10

(*b*) Discuss Pearson family of probability distributions. 10

Group B

5. A discharge Q has to be carried to a distance L from a point at an elevation z_0 to a point at an elevation z_L (z_L is higher than z_0) by a pipeline. Find the optimum diameter, D, of the pipeline and the pumping head, h_0, for accomplishing this task. The cost function, F, of a pumping main is given by

$$F = k_m L D^m + k_T \varrho g Q h_0$$

where k_m and k_T = constants; m = exponent; ϱ = mass density of water; and g = gravitational acceleration. The hydraulic constraint to be satisfied is

$$(8fLQ^2/\pi^2 gD) - h_0 - z_0 + H + z_L = 0$$

where f = friction factor and H = terminal head. Using Lagrange multiplier method, find the optimal diameter of the pumping head and the corresponding cost. 20

6. (*a*) An amount P is taken as a loan with an annual interest rate of Rs r. The loan has to be repaid in N annual instalments of equal size A. Find A. 10

(*b*) Sketch possible layouts of water supply and sewerage networks. Indicate the methodology for analyzing these networks. 10

7. (*a*) Sketch diurnal variation of water demand for an urban water supply system and explain its shape. 10

(*b*) What are advantages of forming zones in a water distribution system of a large city? Discuss how a water supply system is divided into various zones. 10

8. (*a*) Define uniformly distributed random number or uniform variable. How will you generate such numbers? 10

(*b*) Generate five uniformly distributed random numbers by pressing the random number key of your calculator. Using inverse transform method, convert these numbers to the random number having following distribution :

$$F(x) = 1 - e^{-x/100}$$ 10

Group C

9. Distinguish between the following: 2×10

(*i*) Slack, surplus and artificial variables

(*ii*) One-phase and two-phase simplex method

(*iii*) Gravity main and pumping main

(*iv*) Annuity method and capitalization method

(*v*) Decision variables and state variables

(*vi*) Zeroth, first and second order methods of optimization

(*vii*) Primal and dual objective functions

(*viii*) Failure rate and hazard rate

(*ix*) Normal and lognormal distributions

(*x*) Direct and indirect methods of optimization.

S'09 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

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Group A

1. Verify if (1, 1) is an optimal solution for the following problem using Kuhn-Tucker conditions: 20

Maximize $f(x) = \ln(x_1 + 1) - x_2^2$

subject to

$x_1 + 2x_2 \leq 3$

and both x_1 and x_2 are non-negative.

2. Solve the following LP problem by the Simplex method: 20

Maximize $Z = -x_1 + 4x_2$

subject to

$-3x_1 + x_2 \leq 6$

$x_1 + 2x_2 \leq 4$

$x_2 \geq -3$

$x_1 \geq 0$

(*Turn Over*)

3. If X is normally distributed with mean μ and standard deviation σ, i.e., $N(\mu, \sigma^2)$, show that

$$Y = aX + b \text{ is } N(a\mu + b, a^2\sigma^2).$$ 20

4. (*a*) Write the dual problem for the following optimization problem:

Maximize $Z = 4x_1 + 3x_2$

subject to

$$x_1 + \frac{2}{3}x_2 \leq 6000$$
$$x_1 - x_2 \geq 2000$$
$$x_1 \leq 4000$$
x_1 unrestricted, $x_2 \geq 0$ 10

(*b*) Define the unbounded, multiple and infeasible solution for an optimization problem. Represent these solutions graphically with Z-line and feasible policy space for two-dimensional problem. 10

Group B

5. A reservoir of live capacity K irrigates a total area A in which five crops may be grown. For each unit of water supplied to a unit area of crop i ($i = 1, 2, ..., 5$), a benefit W_i^t is obtained in month t ($t = 1, 2, ..., 12$). Each crop must be grown on at least 12% of the total area. In addition, the reservoir also serves the purpose of navigation for which a constant release R_N is made during each month. Assuming that the inflow Q_t during month t is known, **formulate an optimization model** (no need to solve) to decide the optimal cropping pattern (i.e., the area A_i on which crop i should be grown) and the release policy (i.e., the release R_t from the reservoir in period t, for irrigation) to maximize the benefits. Is the problem so formulated a LP problem? Why? 15+2+3

6. A random variable, X, has a density function, $f(x) = ce^{-3x}$; $x > 0$. Find

(*a*) the value of the constant, c; 6

(*b*) the cumulative distribution function, $F(x)$; 5

(*c*) $P(1 \leq X \leq 2)$; 3

(*d*) $P(X \geq 3)$; and 3

(*e*) $P(X \leq 1)$ 3

7. A water resources project has benefits that equals Rs. 20,000 at the end of first year and increases on a uniform gradient series to Rs. 1,00,000 at the end of fifth year. The benefits remain constant at Rs. 1,00,000 each year until the end of year 30, after which it decreases to zero on a uniform gradient at the end of 40th year. What is the present value of these benefits using 6% discount rate? 20

8. The inflows to a reservoir of capacity 4 units are 2, 1 and 1 unit in three seasons of a year. Returns from release during any season are as given below:

Release	0	1	2	3	4	5	6
Returns	0	2000	3500	4500	5000	3500	1000

Obtain the release policy using dynamic programming, if the storage at the beginning of the year = storage at the end of the year = 2 units. 20

Group C

9. Answer the following in brief: 10 × 2

(*i*) State two axioms of probability.

(*ii*) Distinguish between union, intersection and complement.

(*iii*) Distinguish between 'linear programming' and 'nonlinear programming'.

(*iv*) Distinguish between 'point source' and 'non-point source'.

(*v*) Distinguish between 'local minima' and 'global minimum'.

(*vi*) Distinguish between 'continuous random variable' and 'discrete random variable'.

(*vii*) Distinguish between 'population' and 'sample'.

(*viii*) Distinguish between 'multiple purposes' and 'multiple objectives'.

(*ix*) Describe 'conflicting objectives' with an example.

(*x*) If X is a random variable, which one of the following statements is correct?

(*a*) If X is lognormally distributed, $\log_e (X)$ is normally distributed.

(*b*) If $\log_e (X)$ is lognormally distributed, X is normally distributed.

W'09 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

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Group A

1. (*a*) What do you understand by the term 'system' ? 3

(*b*) What are major issues in systems approach in water resources engineering ? 3

(*c*) How do you test the adequacy of number of rain gauge stations in a catchment ? 3

(*d*) Describe various methods for estimation of missing rainfall data for a rain gauge station. 2

(*e*) Discuss various methods of converting the point rainfall values at various stations into an average value over a catchment. 9

2. (*a*) A set of paired observations is represented by $(x_1, y_1), (x_2, y_2), \ldots, (x_i, y_i), \ldots, (x_n, y_n)$. Develop the required expressions to fit the observed data to a best-fit straight line in a step-by-step manner. 12

(*b*) How do you extend your derivation procedure to multiple linear regressions ? 8

3. (*a*) Give a comparison between conventional design and optimal design. 8

(*b*) Write a note on Kuhn-Tucker conditions. 4

(*c*) Express a linear programming (LP) problem in standard and in matrix vector forms. 8

4. (*a*) Solve the following LP problem by using traditional simplex tableau method : 12

$$\begin{aligned} \text{Minimize } & Z = x_1 + x_2 + x_3 \\ \text{subject to } & x_1 - x_4 - 2x_6 = 5 \\ & x_2 + 2x_4 - 3x_5 + x_6 = 3 \\ & x_3 + 2x_4 - 5x_5 + 6x_6 = 5 \\ & x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0, \\ & \qquad x_5 \geq 0, x_6 \geq 0 \end{aligned}$$

(*b*) Express the standard and matrix-vector representation of primal-dual problem in symmetric form. 8

Group B

5. (*a*) Name the various discounting techniques that are used in water resources systems planning. What are their advantages and disadvantages ? 2 + 8

(*b*) Write short notes on : (*i*) predictive uncertainty, and (*ii*) planning horizons. 5 + 5

6. (*a*) Enumerate the typical environmental consequences of water resources projects. 10

(*b*) State important features of various classes of reservoirs. 5

(*c*) Write a short note on reservoir losses. 5

7. (*a*) Explain the term 'reservoir yield' with an emphasis on the analysis of the relation between yield and capacity considering their importance in storage-reservoir design. 4

(*b*) Write short notes on determination of firm yield by using (*i*) mass-curve analysis, and (*ii*) sequent peak analysis. 4 + 4

(*c*) Write a note on development of linear programming model for reservoir capacity determination when the reservoir is intended solely for the purpose of water supply. 8

8. Presuming that all possible water uses–irrigation, municipal and industrial supply, hydroelectric power, navigation, recreation, enhancement of fisheries and wildlife, and the control functions, i.e., flood and pollution mitigation–are pertinent, outline the steps required to prepare a plan for water resources development. 20

Group C

9. Answer the following in brief :

(*i*) State the principles that the probabilities of events generally obey. 3

(*ii*) Define/explain the following terms : Relative frequency function, cumulative frequency function, probability density function, and probability distribution function. 4

(*iii*) State the basic steps of economic analysis. 4

(*iv*) What is cash flow diagram ? 2

(*v*) Explain the term 'planning' in the light of water resources planning. 2

(*vi*) What are objectives of developing water resources projects of national interest ? 2

(*vii*) What is catchment yield ? What is the relationship between catchment yield and reservoir yield ? 2

(*viii*) Explain the term 'project' in the light of water resources development. 1

S'10 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

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Group A

1. Solve the following LP problem by simplex method :

Maximize $z = x_1 + 2x_2$

subject to $x_1 + 3x_2 \leq 6$
$4x_1 + 3x_2 \leq 12$
$3x_1 - x_2 \leq 36$
$x_1, x_2 \geq 0$ 20

2. Consider the following LP problem :

Minimize $z = x_1 + 4x_2$

subject to $3x_1 + x_2 \geq 24$
$3x_1 + 4x_2 \leq 60$
$2x_1 + x_2 \leq 48$
$x_1, x_2 \geq 0$

(*a*) Determine the optimal solution by any suitable simplex method, and (*b*) by looking at the optimal solution, how do you classify it? 18+2

3. (*a*) The cumulative distribution function of a random variable, X, is given below:

x	1.0	2.0	3.0	4.0	5.0
$F(x)$	0.2	0.4	0.6	0.8	1.0

Determine (*i*) $P(1 \leq X \leq 3)$, (*ii*) $P(X<5)$, (*iii*) $P(X>2.5)$, and (*iv*) $P(X \leq 2)$. 4×2

(*b*) Simultaneous observations of two random variables, x and y, are given below:

x	1	2	3	4	5
y	2	3	4	6	5

Estimate (*i*) mean and standard deviation of x, (*ii*) mean and standard deviation of y, (*iii*) covariance of x and y, and (*iv*) correlation coefficient between x and y. 2+2+4+4

4. Water can be allocated from a project in discrete units of 0, 10, 20 and 30 to three users A, B and C. The benefit to each user is given below:

No. of units allocated, x	Benefit to user, $R(x)$		
	A	B	C
0	0	5	0
10	10	5	9
20	20	18	12
30	25	20	20

The total water available for allocation to all users is 30 units. Determine the optimal allocation, by dynamic programming, to each user so that the total benefit to all users is maximized. 20

Group B

5. The total cost of a water supply project is given by $C=3Q+5Q^2/8$, and the total benefit from the project is estimated as $B=10Q-(4/3)Q^2$, for demand Q. (*a*) Determine the price (marginal benefit) for unit demand, when the project is operated for maximum net benefit, and (*b*) determine the price elasticity of demand at the price in (*a*) above. 15+5

6. A reservoir is to supply constant amount of water to a town each season for four seasons in a year. The inflow in each season is given below:

Season	Inflow
1	15
2	12
3	5
4	8

Neglecting reservoir losses, (*a*) determine the maximum seasonal constant demand that the reservoir can possibly meet, (*b*) determine the minimum required active storage capacity of the reservoir to meet a constant seasonal demand of 10 units, by the sequent peak method, and (*c*) identify the season at the end of which the (*i*) reservoir will be empty, and (*ii*) reservoir will be full. 2+16+2

7. A water supply project serves two communities— rural and urban. The total benefit to the rural community, $B_r=20x-3x^2$, where x is the rural demand. The urban demand is $B_u=5y-y^2/4$, where y is the urban demand. Determine the (*a*) demand (marginal benefit) curve for rural community, (*b*) demand (marginal benefit) curve for urban community, and (*c*) combined demand when the price, $p=3$. 5+5+10

8. A farmer takes a loan of Rs. 10,000 from a bank at 8% annual interest, to be paid in equal quarterly instalments, over a period of five years. If interest is compounded quarterly by the bank, (*a*) determine the quarterly instalment, (*b*) compute how much amount is credited towards interest, and how much towards loan repayment, out of the instalment paid at the end of the second quarter, (*c*) if the farmer, instead, purchased a pump-set for Rs. 10,000, with his own money, how much money should he put at the end of each quarter in a sinking fund (which grows at 8% annual interest), to accumulate enough to buy a new pump-set at the end of 5 years? The service life of the pump-set is 5 years with no salvage value and there is no inflation, and (*d*) what is the difference between two quarterly amounts in (*a*) and (*c*) due to? Verify. 4×5

Group C

9. Answer the following in brief: 10×2

(*i*) What is meant by 'standard operating policy' of a reservoir? Mention briefly with a sketch, relating the reservoir release with available water in a given time period.

(*ii*) What is 'curse of dimensionality' in dynamic programming? What is it due to?

(*iii*) What is the basic difference between 'optimization' and 'simulation' in water resources planning? Is optimization possible through simulation?

(*iv*) What are 'direct' and 'inverse' problems in systems analysis? Give a clear example of each.

(*v*) Distinguish between a 'normal good' and a 'public good' in demand analysis.

(*vi*) Distinguish between a 'deterministic system' and a 'stochastic system'.

(*vii*) A LP problem has all equality constraints. The number of constraints is the same as the number of decision variables. How does the solution change with a change in the coefficients (of decision variables) in the objective function?

(*viii*) X and Y are two random variables. (*a*) If they are independent, are they necessarily uncorrelated? (*b*) If they are uncorrelated, are they necessarily independent?

(*ix*) State the criterion used in simple regression for the best fit line relating two random variables.

(*x*) If the output, y, of a system is related to the input, x, by the relation $y = mx + c$, state if the system is linear or non-linear and why?

W'10 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

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Group A

1. (*a*) Define the term 'system analysis' and explain it briefly. 3

(*b*) Hydrologic measurements are subject to errors. Write the types of these errors and briefly explain them ? 3

(*c*) A catchment has four rain gauging stations : Bijapur, Padampur, Binka, and Sabli. Rainfall at these stations for July month was 262.0 cm, 421.0 cm, 177.0 cm, and 338.0 cm, respectively. Thiessen weights of first three stations are 0.12, 0.35 and 0.28. Find the weighted average rainfall for the catchment using Thiessen polygon method. 4

(*d*) What is a rating curve? Write the equation of a rating curve and explain variables used in it. 3

(*e*) Write *four* physical parameters of water quality? 2

(*f*) What is 'bed load' and 'suspended load'? 2

(*g*) Define and explain 'integrated water resources management'. 3

2. (*a*) What is 'remote sensing' and what are active and passive sensors? 6

(*b*) What is NDVI and how is it calculated? 5

(*c*) In the context of a GIS, define vector and raster data? 5

(*d*) Explain what is digital elevation model (DEM)? 4

3. (*a*) Write *four* axioms of probability. 8

(*b*) The histogram of annual flows of a river is given in table below. Find the mean and variance of the data using the method of moments. 12

Discharge Range, cumec	*Frequency*
100-300	6
300-500	11
500-700	15
700-900	10
900-1100	6
1100-1300	2

4. (*a*) Area of a farmer's field is 200 hectares (ha) and he wants to grow wheat and pulses on this land. It costs Rs. 3/ha to raise wheat crop while for pulses, the cost is Re. 1/ha. The benefit from wheat crop is Rs. 5/ha and from pulses crop, it is Rs. 2/ha. A sum of Rs. 300 is available for raising both crops. Formulate a linear programming problem to find the optimal cropping plan (how much area be allotted to wheat crop and how much to pulses) so as to maximize the total net benefits and solve it using the simplex method? 12

(*b*) What do you understand by simulation? Under what conditions, simulation models are better than optimization models and in what conditions, optimization models are better than simulation models? 8

Group B

5. (*a*) Write a short note on cash flow diagram. 4

(*b*) Explain the Rule of 72. 3

(*c*) A bank launches a new scheme in which an investor has to deposit Rs. 1,000 each year for 10 years and he will get Rs. 14,500 at the end of 10 years. What is the rate of interest that an investor will be getting upon joining this scheme? 8

(*d*) Write a short note on benefit-cost ratio. 5

6. (*a*) A dam is proposed across a river in Himalayas. It will supply water for irrigation. List and briefly explain three possible beneficial and three harmful environmental consequences of the project. 10

(*b*) Write a short note on sustainable water resources development. 6

(*c*) What do you understand by rehabilitation and resettlement? 4

7. (*a*) In a canal command area, two crops— wheat and paddy— are grown. How will you compute irrigation water requirements for this command for each crop, including various losses. Please give steps of calculations. Write relevant equations. 8

(*b*) In your opinion, what are the advantages and disadvantages in involving public in decision making for water resources projects? 7

(*c*) How will you improve municipal water supply in your city, if you are assigned this work? Write *five* actions and be specific. It will of help if your statements are supported by relevant data. 5

8. (*a*) What are various storage zones of a reservoir? Write their functions. 5

(*b*) The inflows to a proposed reservoir for 12 months are given as: 8, 45, 227, 186, 93, 48, 17, 47, 76, 4, 1, and 0 million m^3 (MCM). If a constant release of 30 MCM is desired from this reservoir, find out the required storage capacity using the sequent peak method. 12

(*c*) What is reservoir routing and what for it is performed? 3

Group C

9. (*i*) What is a current meter and what does it measure? 2

(*ii*) What is the main difference between an ordinary rain gauge and a self-recording rain gauge? 3

(*iii*) What is the velocity-area method and what does it compute? 3

(*iv*) Write the names of *two* remote sensing satellites that have been launched by India. Which organization has launched them? 3

(*v*) Define correlation. For two variables x and y, the standard deviations are 6.5 and 5.4 and their covariance is 24. Find correlation between x and y. 3

(*vi*) What do you understand by 'free board'? 3

(*vii*) What do you understand by 'environmental impact assessment' and name two methods used for it? 3

S'11 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** *and* ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define and briefly explain integrated water resources management. 4

   (*b*) What do you understand by bottom-up planning and what are its main features ? 3

   (*c*) What are the major problems in applying systems analysis techniques in India ? 4

   (*d*) Give names of *three* major rivers that flow from India into some other country and give the name of that country also ? 3

   (*e*) For hydrologic data, what are primary validation, secondary validation, and hydrologic validation ? 6

(*Turn Over*)

2. (*a*) In a storm, rainfall (mm) at four stations was measured as 120.1, 148.4, 103.6, and 25.7. Check if the data of the last station is consistent with the data of other stations ? The distances of other three stations from the last station are 25 km, 67 km, and 43 km, respectively. 7

(*b*) What is the Evaporation Pan ? How is it employed to estimate amount of evaporation of water from a lake ? Write the equation and explain various terms. 4

(*c*) Write *four* criteria that an ideal stream gauging site should satisfy. 4

(*d*) What do you understand by 'remote sensing' ? List its *four* main advantages. 5

3. (*a*) While measuring discharge at a river gauging site, the cross-section was divided in six sections, each of 4 m width. At these sections, the average water depths (in m) were 0.9, 1.3, 2.2, 2.3, 1.2, and 0.6 ; the respective velocities (in m/s) were 0.7, 0.9, 1.2, 1.4, 1.0, and 0.6, respectively. Compute the discharge in the river ? 8

(*b*) The annual flow of a river for 10 years is given in the following table :

year	Flow, MCM
1990	780
1991	220
1992	430
1993	590
1994	200
1995	350
1996	840
1997	600
1998	1390
1999	740

Compute the mean annual flow, their standard deviation, and the coefficient of variation. 10

(*c*) What is 'bias' in the context of parameter estimation ? 2

4. (*a*) Write a brief note on hypothesis testing. 3

(*b*) Write the simple linear regression equation and explain the terms ? 3

(*c*) The correlation coefficient between two variables is 0.9. What is your interpretation of this value ? 2

(*d*) Solve the following linear programming problem using the simplex method : 12

Maximize $Z = 3x_1 + 5x_2$

subject to

$x_1 \leq 4$

$2x_2 \leq 12$

$3x_1 - 2x_2 \leq 18$

$x_1 \geq 0,\ x_2 \geq 0.$

Group B

5. (*a*) The estimated cost of installing a hydropower plant is Rs. 50 crore. Assume that Rs. 10 crore have been spent on the project. Subsequently, a thermal power plant costing Rs. 30 crore is found to be capable of supplying the same energy. Which facility should be selected assuming all other future costs and all benefits from both the plants to be the same ? Explain your answer briefly. 6

(*b*) What do you understand by 'salvage value of a project' ? 3

W'11:5 AN:CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) Define the three terms 'system', 'attributes', and 'optimal system'. 3×2

(*b*) Enlist the factors that characterize a 'system'. 3

(*c*) What are the major types of problems that must be solved for various types of hydrosystems by using systems approach ? 2

(*d*) Explain the systems classification. 9

2. (*a*) There are six rain gauge stations in an Indian city catchment. In 2010, the annual rainfalls recorded by these six rain gauges are as follows :

Station	Rainfall, cm
X 1	136.7
X 2	110.3
X 3	120.9
X 4	82.6
X 5	98.8
X 6	180.3

Assuming a 10% error in the estimation of the mean rainfall, calculate the optimum number of stations in the catchment. 3

(*b*) There are seven rain gauge stations in a catchment. The normal annual rainfalls are known and given in the following table. In 2010, because of some unforeseen reason, one rain gauge became inoperative. The other rain gauges recorded their annual rainfalls that are also given in the following table. Estimate the missing annual rainfall by using arithmetic averaging and normal ratio methods. 3

Station	Normal Annual Rainfall, cm	Recorded Annual Rainfall, cm
X 1	136.6	145.7
X 2	160.7	158.1
X 3	164.6	163.4
X 4	155.5	157.7
X 5	145.3	140.4
X 6	160.7	163.8
X 7	158.8	Record Missing

(*c*) There are seven rain gauge stations in a catchment. The annual rainfalls are recorded and given in the following table for 2010. Thiessen polygons were drawn and the areas were determined which are also given in the table. Compute the average precipitation over the catchment by using arithmetic mean and Thiessen mean method. If the average runoff coefficient for the entire catchment equals to 0.65, what was the volumetric yield for the catchment. 4

Station	Recorded Annual Rainfall, cm	Area of Thiessen Polygon, km^2
X 1	186.6	45.0
X 2	190.7	50.0
X 3	174.6	55.0
X 4	165.5	60.0
X 5	175.3	55.0
X 6	160.7	50.0
X 7	168.8	45.0

(*d*) Following data were recorded from a stream-gauging operation that was carried out at a gauging site.

Distance from Left Water Edge, m	Depth, m	Revolutions of the Current Meter kept at 0.6 m depth	Duration of Observation, sec
0	0	0	0
3.0	2.0	70	150
9.0	4.0	90	150
15.0	5.0	130	180
21.0	6.0	150	180
27.0	7.0	200	240
33.0	6.0	150	180
39.0	5.0	130	180
45.0	4.0	90	150
51.0	2.0	70	150
54.0	0	0	0

A current meter was used to record the flow velocity. The current meter rating equation is given by $v = 0.61\ N_s + 0.05$ m/sec, where v = flow velocity in m/sec and N_s = number of revolutions of the current meter per second. Calculate the discharge in the stream. 10

3. (*a*) State the principles that the probabilities of events generally obey. 3

(*b*) Define/explain the following terms : Relative frequency function, cumulative frequency function, probability density function, and probability distribution function. 4×1

(*c*) State the objective of statistics. Define statistics ? Explain the measures of the following : Central tendency, variance, and symmetry. 1 + 2 + 6

(*d*) Write a note on testing the Goodness of fit by using Chi-square test. 4

4. (*a*) Write a note on Kuhn-Tucker conditions. Express a linear programming problem in standard form and also in matrix vector form. What are the main features of the standard form ? 3 + 3 + 2 + 4

(*b*) Solve the following LPP problem by using simplex tableau method : 8

Minimize $Z = x_1 + x_2 + x_3$

subject to $x_1 - x_4 - 2x_6 = 5$

$x_2 + 2x_4 - 3x_5 + x_6 = 3$

$x_3 + 2x_4 - 5x_5 + 6x_6 = 6$

$x_1, x_2, x_3, x_4, x_5, x_6 \geq 0$

Group B

5. (*a*) What are the different periods of time that must be considered in any economic analysis ? Define them. What is their inter-relationship ? 2 + 4 + 1

(*b*) Write a note on general steps of structuring project alternatives. 5

(*c*) Enlist the basic steps of economic analysis. 4

(*d*) Explain the terms 'cash flow diagram' and 'depreciation'. 2 + 2

6. (*a*) Classify the environmental impact of water resources projects in detail. 8

(*b*) Explain the term 'planning' in the light of water resources planning. 2

(*c*) Assuming that all possible water uses are pertinent, outline the steps required to prepare a plan for water resources development. 10

7. (*a*) Compare between thermal and hydropower. 6

(*b*) Classify hydroelectric plants on the basis of hydraulic characteristics and operating heads on turbines. 4

(*c*) Name the component parts of a typical hydroelectric plant according to serial order of occurrence. 4

(*d*) A run-off river plant is to be constructed across a river at a site where a net head of 25 m is available on the turbines. The river carries a sustained minimum flow of 30 cumec as dry weather flow. Behind the power station, sufficient water pondage has been provided to supply daily peak load of demand with a load factor of 70%. Assuming the plant efficiency of 60%, determine the (*i*) maximum generating capacity of the generators to be installed at the power house, and (*ii*) volume of pondage to be provided to supply the daily demand, assuming that the daily load pattern consists of average load for 21 hr and of peak load for 3 hr. 6

8. (*a*) State the important features of various classes of reservoirs. 6

(*b*) Write short notes on determination of firm yield by using (*i*) mass-curve analysis, and (*ii*) sequent peak analysis. 4 + 4

(*c*) Write a short note on the development of level pool routing procedure of computing outflow hydrograph from a reservoir. 6

Group C

9. (A) Answer the following in brief :

(*i*) Define 'amortization'. 1

(B) Explain the term 'project' in the light of water resources development. 2

(C) (*i*) Enlist various applications of remote sensing in hydrology and water resources. 3

(*ii*) Write short notes on 'reservoir yield', 'catchment yield' and 'reservoir losses'. 3

(*iii*) The choice of a particular type of hydropower plant at a given site depends upon various factors. What are these factors ? 3

(D) (*i*) Express the standard and matrix-vector representation of primal-dual problems in symmetric form. 4

(*ii*) An individual invested the following amount at 4% interest. How much amount would he have at the end of year 25 ? Draw the cash flow diagram : 4

Year	*Investment*	*Year*	*Investment*
1	5	11	45
2	10	12	40
3	15	13	35
4	20	14	30
5	25	15	25
6	30	16	20
7	35	17	15
8	40	18	10
9	45	19	5
10	50	20-25	0

S'12: 5 AN: CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What do you mean by the 'system' ? Classify the systems and explain them. 10

(*b*) Give your interpretation on 'water resources' as a system. 6

(*c*) Make a detailed note on various techniques of water resources systems analysis. 4

2. (*a*) The rating curve of a current meter used for measuring velocity in a small river is given as $V = 0.62\ N + 0.032$ m/sec, where N is in rev/sec.

(Turn Over)

Velocity is measured at the mid of the sections. Calculate the discharge of the river from the following data: 8

Distance from Bank, m	0	2	5	8	12	15	18	21	23	24
Depth, m	0	0.6	1.2	1.8	2.4	1.9	1.4	1.1	0.5	0
N at 0.6 d	0	60	90	120	150	140	100	80	50	0
Time, sec	0	150	140	140	160	140	140	140	140	0

(*b*) A hilly basin of area 1200 km^2 has 7 rain-gauge stations. The annual rainfalls observed in these stations are 62, 95, 60, 49, 36, 85 and 72. Determine the optimum number of gauges required in the basin, if it is desired to limit the error in mean rainfall to 10%. Also, state the number of gauges required as per IS recommendation. 8

(*c*) State the rain-gauge network recommendations. 4

3. (*a*) The weighted catchment rainfall for the month of July along with the runoff for July at a river is given below. Develop a linear relationship between rainfall and runoff for the month of July. Also, calculate the correlation coefficient *r*. Test that it is significantly different from zero and therefore a good correlation exists. 10

S. No	Year	Rainfall, mm	Runoff, mm
1	1978	344.4	187.1
2	1979	661.2	427.8
3	1980	369.6	122.9
4	1981	297.7	80.7
5	1982	372.2	194.9
6	1983	462.6	211.3
7	1984	302.4	125.12
8	1985	656.7	309.4
9	1986	446.7	221.4
10	1987	325.7	46.8
11	1988	336.5	247.9

(*b*) What are the central tendency characteristics ? Describe them. 5

(*c*) Make a detailed note on Extreme Value Distribution and its application in water resources study. 5

4. (*a*) Solve the Linear Programming Problem using the simplex method: 8

$$\text{Maximize } z = 2x_1 + x_2$$
$$\text{subject to } x_1 + 2x_2 \le 10$$
$$x_1 + x_2 \le 6$$
$$x_1 - x_2 \le 2$$
$$x_1 - 2x_2 \le 1$$
$$x_1, x_2 \ge 0$$

(*b*) What is simulation ? Discuss its advantages and application. 8

(*c*) Write about Kuhn-Tucker conditions. 4

Group B

5. (*a*) Define and distinguish the terms 'discounting' and

'compounding'. Discuss the discounting factors. 10

(*b*) Among the following plans, identify the more economical plant at 6% interest rate. Adopt the Present Worth (PW) comparison. 6

	Plane A	Plane B
Cost of equipment	50,000/-	35,000/-
Annual O & M costs	2,000/-	2,500/-
Salvage value	7,000/-	6,000/-
Service life	30 years	15 years

(*c*) Define the following : (*i*) Amortization, and (*ii*) cash flow diagram. 4

6. (*a*) Discuss the positive and negative impacts of water resource projects. 12

(*b*) List the steps involved in environmental impact assessment of water environment. 8

7. (*a*) Explain the methods of estimating the reservoir capacity. 12

(*b*) Discuss the water resources planning methods and objectives. 8

8. (*a*) Between two reaches A and B of a river, the values of Muskingum coefficients determined are K = 24 h and X = 0.20. Take outflow at the beginning of routing step equal to inflow. Find the outflow hydrograph at B. 12

Time, hr	12	24	36	48	60	72	84	96	108	120	132	144	156	168
Inflow, m^3/sec	14	22	36	93	141	102	86	73	61	50	38	26	20	16

(*b*) Explain the different flood control methods. 8

Group C

9. (A) Answer the following in brief : 7 × 2

(*i*) What are decision variables ?

(*ii*) Brief about Gamma distribution and state its application in water resources study.

(*iii*) What is an objective function ?

(*iv*) What do you mean by feasible and infeasible solutions ?

(*v*) Define and state examples for spatial and non-spatial data of GIS.

(*vi*) Define sustainable development. List out its objectives.

(*vii*) What is meant by plan formulation ? List the methods of carrying out plan formulation.

(B) Choose the *correct* answer for the following : 6 × 1

(*i*) The nearest object from the rain gauge should be located at a minimum distance equal to

(*a*) height of that object.

(*b*) twice the height of that object.

(*c*) thrice the height of that object.

(*d*) four times the height of the rain gauge platform.

(*ii*) Sequent peak analysis in water resources study helps in

(*a*) cost estimation.

(*b*) finding cumulative deficit.

(*c*) flood analysis.

(*d*) evaporation losses estimation.

(*iii*) Salinity of water

(*a*) reduces the evaporation.

(*b*) increases the evaporation.

(*c*) reduces the precipitation.

(*d*) does not alter the evaporation.

(*iv*) Gumbel's distribution is best applicable for the

(*a*) rainfall at a location.

(*b*) rainfall mass curve analysis.

(*c*) flood frequency analysis.

(*d*) meteorological analysis.

(*v*) The rating curve of a stream gauging station gives the variation of discharge in the stream with the

(*a*) cross-sectional area of flow.

(*b*) stage.

(*c*) depth of flow.

(*d*) velocity of flow.

(*vi*) Which one of the following form of equation is used in Modified Pul's method of flood routing ?

(*a*) $\left(\frac{I_1+I_2}{2}\right)\Delta t+\left(\frac{Q_1+Q_2}{2}\right)\Delta t=S_2-S_1$

(*b*) $\left(\frac{I_1+I_2}{2}\right)\Delta t-\left(\frac{Q_1+Q_2}{2}\right)\Delta t=S_2-S_1$

(*c*) $\left(\frac{I_1+I_2}{2}\right)\Delta t+\left(S_1-\frac{Q_1\Delta t}{2}\right)=\left(S_2+\frac{Q_2\Delta t}{2}\right)$

(*d*) $\left(\frac{I_1+I_2}{2}\right)\Delta t+\left(S_1+\frac{Q_1\Delta t}{2}\right)=\left(S_2+\frac{Q_2\Delta t}{2}\right)$

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) A river basin has four rain gauge stations and normal rainfalls at these stations are : 310 mm, 285 mm, 360 mm and 290 mm. In a storm, the rainfall at first three stations was 85 mm, 68mm and 94 mm. Find the rainfall at the fourth station by the normal ratio method. 6

(*b*) Why are hydrological networks established ? What are the factors considered in setting up these hydrological networks ? 6

(*c*) Annual rainfall in a city for 10 years from 1980 to1989 are given below :

Year	Annual Rainfall, mm
1980	840
1981	940
1982	1120
1983	985
1984	1070
1985	901
1986	1187
1987	884
1988	993
1989	1065

Compute the coefficient of variation and the co-efficient of skewness of data. 8

2. (*a*) Briefly explain how rainfall is measured? 7

(*b*) Write a short note on the slope-area method of river discharge measurement. 7

(*c*) Define the 'normalized difference water index' and explain its use. 6

3. (*a*) In a goodness of fit test, the data were divided into 11 classes and the value of chi-square turned out to be 11.95. If two parameters of the distribution were determined from the data, test whether the chosen distribution is suitable at 5% significance level. Some values of chi-square which may be useful are : $\chi^2_{5,5} = 11.07$, $\chi^2_{5,8} = 14.07$, $\chi^2_{5,10} = 18.31$. 5

(*b*) The mean annual flood of a river is 32,000 cumec and the standard deviation of flood peaks is 6000 cumec. Assume that the peaks follow the Gumbel distribution. What is the probability of a flood of magnitude of 45,000 cumec occurring in the river within the next 5 years? 9

(*c*) Briefly explain two mutually exclusive events, and intersection and union of two events with the help of diagrams. 6

4. Solve the following linear programming problem by using the simplex method : 20

Maximize $z = 2x_1 + x_2$

subject to

$$3x_1 + x_2 \le 300$$

$$x_1 + x_2 \le 200$$

$$x_1, x_2 \ge 0$$

Group B

5. (*a*) Gross and dead storage capacities of a reservoir are 120 MCM and 10 MCM, respectively. Storage in reservoir at the beginning of the simulation is 25 MCM. The maximum storage capacity of the reservoir is 100 MCM.

Month	Reservoir Inflow, MCM	Volume of Evaporation, MCM	Water Demand, MCM
June	45	8	70
July	130	12	93
August	165	10	101
September	115	10	90

Simulate the operation of the reservoir and prepare the working table of the reservoir by using the given data. The working table should show for each period initial storage, inflow, evaporation, demand, release, spill, and final storage. 12

(*b*) For a hydropower plant, the net head is 95.0 m and the efficiency of the power plant is 0.85. Compute the power produced, if the discharge through the turbines is 40 cumec. How much electric energy will be generated in one day? 8

6. (*a*) What is sunk cost ? Define and explain. 5

(*b*) The estimated construction cost of a hydro-power project is Rs. 90 crore. After Rs. 20 crore had been spent on the project, another location was found where the construction cost of a project, which will be able to deliver the same output, was found to be Rs. 60 crore. If all future costs and all benefits from the new plant will be the same, which location should be pursued ? Explain your answer. 9

(*c*) What do you understand by 'environment impact assessment' ? How does it help in protection of environment ? 6

7. (*a*) Estimates show that a reservoir having the capacity of 10,000 m^3 can be built for Rs. 1 crore and the present worth of its benefits would be Rs. 1.4 crore. Before construction begins, it was found that the storage capacity can be increased to 20,000 m^3 at a total cost of Rs. 1.5 crore and this will yield additional downstream flood control benefits whose present worth would be Rs. 0.6 crore. What course of action would you recommend and why ? 8

(*b*) Define and briefly explain sustainable water resources development. 7

(*c*) With the help of a diagram, briefly explain the concept of pumped storage schemes. 5

8. (*a*) Annual precipitation and run off data (in cm) for a catchment of 5 years (1985-89) are given in the table below :

Year	Precipitation, x	Run off, y
1985	47.67	15.17
1986	50.24	15.5
1987	43.28	14.22
1988	52.6	21.2
1989	31.06	7.7

Establish linear regression by using the above data and estimate run off for two years, 1983 and 1984, whose precipitation values are 42.4 cm and 33.5 cm, respectively. 15

(*b*) Define and explain reference evapotranspiration. 5

Group C

9. (*A*) Answer the following in brief : 4 × 3

(*i*) What are floats and for what purpose these are used in hydrologic measurements ?

(*ii*) A river basin has three rain gauges and the rainfall at a given day at these rain gauges was 10 mm, 15 mm and 20 mm. Find the average rainfall by the Thiessen polygon method, if the weights of first two stations are 0.25 and 0.35.

(*iii*) What is the 'top-down' approach of water resources planning ?

(*iv*) What are 'relation-oriented data' in water sector ? Give *two* examples.

(*B*) Give brief answer to the following : 4 × 2

(*i*) What do you understand by reservoir routing ?

(*ii*) What are 'layers' in a geographic information system ?

(*iii*) What is a run-of-river hydropower plant ? Draw a sketch.

(*iv*) What is a geostationary satellite ?

S'13 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks

Group A

1. (*a*) Explain the steps required for a successful system design. 10

(*b*) There are six rain gauge stations in an Indian city catchment. In the year 2012, the annual rainfalls recorded by these six rain gauges are as follows :

Station	Rainfall, cm	Station	Rainfall, cm
1	136.7	4	82.6
2	110.3	5	98.8
3	120.9	6	180.3

Assuming a 10% error in the estimation of the mean rainfall, calculate the optimum number of stations in the catchment. 5

(*c*) Enlist various applications of remote sensing in hydrology and water resources. 5

2. (*a*) A set of paired observations is represented by $(x_1, y_1), (x_2, y_2), ..., (x_i, y_i), ..., (x_n, y_n)$. Develop the required expressions to fit the observed data to a best-fit straight line in a step-by-step manner. 12

(*b*) Write a note on first order Kuhn-Tucker conditions. 8

3. (*a*) Discuss the common methods of converting the point rainfall values at various stations into an average value over a catchment. 8

(*b*) Write notes on the following : (*i*) Fitting a probability distribution by using (*ii*) method of moments, and (*iii*) method of maximum likelihood. Write your comment about the suitability of the two methods for hydrologic data analysis. 2 + 3 +2

(*c*) Write a note on testing the Goodness of Fit by using Chi-square test. 5

4. (*a*) Solve the following LPP problem by using traditional simplex tableau method : 12

Minimize $Z = x_1 + x_2 + x_3$

subject to $x_1 + x_4 - 2x_6 = 5$

$x_2 + 2x_4 - 3x_5 + x_6 = 3$

$x_3 + 2x_4 - 5x_5 + 6x_6 = 5$

$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0,$

$x_5 \geq 0, x_6 \geq 0$

(*b*) Why do we use simulation ? Give a general classification of simulation models. 4 + 4

Group B

5. (*a*) Write a note on planning horizons. 8

(*b*) Costs and revenues for a particular water resources project having alternate possible levels of investment have been estimated on an equivalent basis and found to be as follows :

Cost	39	83	117	155	194
Revenue	100	150	175	185	190

Which project level should be selected ? 12

6. (*a*) Write a note on the importance of forecasting municipal water demand ? 3

(*b*) Explain briefly the major forecasting approaches. 12

(*c*) Write a note on general form of water demand models. 5

7. (*a*) Write a note on present-worth method of discounting technique. 5

(*b*) A particular water resources project produces benefits which amount to Rs. 12,000 in year 1 and increase on a uniform gradient to Rs. 120,000 in year 10. Thereafter, they increase on another uniform gradient of 5000 per year to 200,000 in year 26, at which point they remain constant at Rs. 200,000 each year until the end of project life in year 50. What is the present worth of these benefits at a 4 percent discount rate ? 5

(*c*) Enumerate the typical environmental consequences of water resources projects. 10

8. (*a*) Compare between thermal and hydropower. 4

(*b*) Classify hydroelectric plants on the basis of hydraulic characteristics and operating heads on turbines. 4

(*c*) Name the component parts of a typical hydroelectric plant according to serial order of occurrence. 4

(*d*) A run-off river plant is to be constructed across a river at a site where a net head of 25 m is available on the turbines. The river carries a sustained minimum flow of 30 cumec as dry weather flow. Behind the power station, sufficient water pondage has been provided to supply daily peak load of demand with a load factor of 70%. Assuming the plant efficiency of 60%, determine the (*i*) maximum generating capacity of the generators to be installed at the power house, and (*ii*) volume of pondage to be provided to supply the daily demand, assuming that the daily load pattern consists of average load for 21 hr and of peak load for 3 hr. 4 + 4

Group C

9. Define/explain/solve the following : 10 × 2

(*i*) Define the term 'system'.

(*ii*) Enlist the factors that characterize a 'system'.

(*iii*) Explain the term 'variance'.

(*iv*) With m constraints and n variables ($n > m$), what will be the maximum number of basic solutions to the standard linear program ?

(*v*) What are the main features of the standard form of an LPP ?

(*vi*) 'For any water resource project, it is desirable to have physical life = construction horizon = economic life = period of analysis'. Write the correct statement.

(*vii*) Rs. 500 lakh have been spent on a hydropower installation ultimately costing Rs. 1000 lakh. A steam plant, costing an estimated Rs. 450 lakh, is subsequently found to be capable of supplying the same energy. Which facility should be selected, assuming all other future costs to be the same ?

(*viii*) Define the terms 'sinking fund' and 'amortization'.

(*ix*) What is catchment yield ?

(*x*) Define firm power and secondary power.

W'13 : 5 AN : CV 405 (1431)

WATER RESOURCES SYSTEMS

Time : Three hours

Maximum Marks : 100

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answer may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What are the major hydrosystem problems that must be solved by using systems approach ? 3

   (*b*) Briefly enumerate the factors that characterize a 'system'. 3

   (*c*) Explain the classification of systems in brief. 14

2. A simultaneously occurring rainfall covering the whole catchment is recorded in nine rain gauging stations within the catchment and is given below :

Station	Rainfall, cm	Thiessen area, km^2 km^2	Run-off Coefficient
A	3.2	4	0.80

Station	Rainfall, cm	Thiessen area, km^2	Run-off Coefficient
B	4.8	3	0.65
C	5.4	3	0.70
D	9.4	6	0.75
E	13.4	10	0.50
F	8.6	6	0.55
G	10.2	3	0.60
H	12.8	3	0.65
I	11.4	4	0.80

(*i*) Assuming a 10% error in the estimation of the mean rainfall, calculate the optimum number of stations required in the catchment. 5

(*ii*) Obtain the average precipitation in the catchment. 5

(*iii*) Will arithmetic averaging apply in this case ? Justify. 2

(*iv*) What are the stations – Thiessen areawise run-off (in m^3) and losses (in m^3) ? 2 + 2

(*v*) What are the total volume of run-off and losses ? 1 + 1

(*vi*) What are the average run-off (in cm) and average catchment losses (in cm) ? 1 + 1

3. (*a*) Explain the measures of the following : Central tendency, variance, and symmetry. 2 + 4 + 4

(*b*) Write a note on (*i*) linear regression, and (*ii*) testing the Goodness of fit by using Chi square test. 5 + 5

4. (*a*) Solve the following LPP by using traditional simplex tableau method : 12

$$\text{Minimize} \quad Z = 5x_1 + 2x_2 + 3x_3 - x_4 + x_5$$

$$\text{subject to} \quad x_1 + 2x_2 + 2x_3 + x_4 + 0x_5 = 8$$

$$3x_1 + 4x_2 + x_3 + 0x_4 + x_5 = 7$$

$$x_1 \geq 0, x_2 \geq 0, x_3 \geq 0, x_4 \geq 0, x_5 \geq 0$$

(*b*) Express the general symmetric primal-dual problems in algebraic representation. Also, give its matrix vector notation form. State the general rules for writing the dual of a linear programming problem in symmetric form. 8

Group B

5. (*a*) Write a note on the 'predictive uncertainties in engineering economy analysis'. 5

(*b*) State the general steps for structuring alternatives in engineering economy analysis. 5

(*c*) Enumerate various environmental impacts of water resources projects. 10

6. (*a*) State the important features of various classes of reservoirs. 7

(*b*) Explain the term 'reservoir yield' with an emphasis on the analysis of the relation between yield and capacity considering their importance in storage-reservoir design. 5

(*c*) Write a short note on reservoir losses. 8

7. (*a*) What are the advantages and disadvantages of benefit-cost ratio method, present worth method, rate-of-return method, and annual cost method of discounting ? 4 × 3

(*b*) Two mutually exclusive alternative water supply projects are described in the following table. Compare the alternatives using the present worth method of discounting:

Item	Project A	Project B
Construction cost	Rs. 40,000,000	Rs. 25,000,000 in first stage Rs. 30,000,000 in second stage
Operations and maintenance	Rs. 1,60,000 per year for 40 years	Rs. 100,1000 per year for first 20 years Rs. 220,000 per year for second 20 years
Economic life	40 years	40 years for each stage
Period of analysis	40 years	40 years
Annual benefits	Rs. 2,500,000	Rs. 2,500,000
Discont rate	5 percent	5 percent

8. (*a*) Write a note on development of linear programming model for reservoir capacity determination when the reservoir is intended solely for the purpose of water supply. 10

(*b*) Describe the level pool routing procedure of computing outflow hydrograph from a reservoir. 10

Group C

9. (*i*) Define 'system' and 'optimal system'. 1 + 1

(*ii*) A rectangular irrigation rank has 5 km^2 surface area. Storage on January 01, 2013 at 8.00 a.m. in the tank measures 20×10^6 m^3. A rivulet feeds the tank. The seepage through the tank has ceased completely because of long days of service. The rivulet carried water for 10 days at the rate of 10 m^3/sec during the early part of the month, and thereafter stopped flowing. No rainfall occurred during the period of consideration. The dead storage in the tank measures 10×10^6 m^3. Daily lake evaporation measures 4.0 cm. What will be the storage in the tank on February 01, 2013 at 8.00 a.m. ? Determine the volume of water that the irrigation authority can use from the tank during the period. 2 + 1

(*iii*) What are the standard form of a linear programming problem in algebraic and matrix-vector form ? 2 + 2

(*iv*) A community has spent Rs. 50,000 developing a new well and has not yet obtained water. The geological consultant estimates another Rs. 50,000 will be required to guarantee a good supply but admits sufficient water may be obtained after spending only Rs. 10,000. As an alternative, a spring exists several miles away from which an equivalent supply could be pumped for Rs. 40,000. What course of action would you recommend and why ? 3

(*v*) Enumerate the basic steps of economic analysis. 4

(*vi*) What are objectives of developing water resources projects of national interest ? 4