Course title: Water Resources Optimization and Water Quality Modeling			
Course code: NRE 176	**No. of credits:** 3	**L-T-P:** 30-12-0	**Learning hours:** 42
Pre-requisite course code and title (if any): NRE 111 Applied mathematics			
Department: Department of Natural Resources			
Course coordinator:	**Course instructor:**		
Contact details:			
Course type: Elective	**Course offered in:** Semester 3		

Course Description

The course will deal with water resources systems analysis and systematic approaches to the mathematical modeling of various water resources issues, which helps decision-makers, allocate water effectively and efficiently. Students will gain an understanding of simulation, optimization, multi-criterion-decision-making and time series and spatial analysis, all necessary for successful water systems analysis. Course will explores recent developments in surface and groundwater systems optimization and modeling and it will relates these to real field applications and case studies supported by essential mathematical tools.

Course objectives

1. Introduction to modelling, identifying problems, conceptualization and using mathematical tools to solve surface water quality and ground water quality problems
2. To understand simulation, optimization techniques and multi objective programming including dynamic programming
3. To understand field applications by going through case studies which use algorithms as problem solving techniques

Course content

SNo	Topic	L	T	P
1.	**Water Resources System Modeling** Introduction to modeling; Definition and purpose of modeling; Types of models; Modeling protocol; Model development; Calibration and verification; Application of modeling techniques to water resource development and management	5		
2.	**Optimization of Water Resources System** Introduction to optimization and its application in water resources system management Problem formulation: decision variables, objective function Constraints, water resources planning process Systems analysis techniques: simulation, optimization, linear programming, dynamic programming, integer programming multi objective programming and nonlinear programming problems	4	3	
3.	**Linear Programming (LP): Application to Water Resources Problems** Assumptions, problems formulation and solutions, graphical methods, simplex algorithm, duality concept, sensitivity analysis Examples, reservoir for irrigation and power production, water resources systems River water quality optimization Water supply and drainage network optimization, Dynamic programming application	8	4	0

4.	**Surface Water Quality Modeling** Nature of problems; Modeling rivers, streams, eustaries and lakes, indicator bacteria, Dissolved oxygen eutrophication and toxic substances	6	3	0
5.	**Ground Water Quality Modeling** Nature of problems; Modeling ground water aquifers contamination, salt water intrusions; Major application of groundwater models; Numerical Modeling of groundwater systems; Numerical examples; Groundwater modeling by Finite element method (FEM) and Finite difference method (FD)	7	2	0
	Total	**30**	**12**	

Evaluation criteria

- 2 minor tests: 20% each
- Quizes and Tutorials: 20 %
- Major test: 40%

Learning outcomes

1. Identify problems, conceptualise, formulate a model using few basic parameters
2. Application of optimization techniques to water resources problems like water allocation from reservoir to different users
3. Ability to distinguish between various water quality models and optimization techniques and choose an appropriate one to suit the objectives to be satisfied.

Pedagogical approach

Materials

Required text

1. Douglas A.H (1982) *Environmental System Optimization*, John Wiley & Sons, New York.
2. Steven C.C. (1993) *Surface Water-Quality Modeling*, McGraw Hill Boston.
3. Vedula S. and Mujumdar P. P. (2005) *Water Resources Systems: Modeling Techniques and Analysis*, Tata MacGraw-Hill Publishing Company Limited.

Suggested readings

1. Douglas A.H. (1982) *Environmental System Optimization*, John Wiley & Sons, New York.
2. Rastogi A.K. (2008) *Numerical Groundwater Hydrology*, Penram International Publishing Pvt. Ltd., Bombay.
3. Robert V.T. and John A.M. (1987) *Principles of Surface Water Quality Modeling and Control*, Harper and Row Publisher, New York.
4. Steven C.C. (1993) *Surface Water-Quality Modeling*, McGraw Hill Boston.

Case studies

Websites

Journals

1. American Society of Civil Engineers Journal of Water Resources Planning
2. Management International Journal of Water Resources Development

Additional information (if any)

Student responsibilities

Attendance, feedback, discipline, guest faculty etc