Course Type	Course Code	Name of the Course	L	T	P	Credits
DE	NESD502	Groundwater Flow and Contaminant Transport Modelling	3	0	0	3

Course Objectives

- The course focuses on explaining the fundamental concepts of groundwater movement and contaminant transport in aquifers and the application of different numerical techniques in groundwater flow and contaminant transport modelling.

Overall Learning Outcomes

Upon successful completion of this course, students will be able to:

- Understand the fate and transport of contaminants in groundwater.
- Apply the finite difference and finite element methods to solve groundwater flow and contaminant transport equations.
- Develop skills for groundwater flow and contaminant transport modelling.

Unit No.	Topics to be covered	Contact Hr (L)	Learning outcomes
I	Groundwater in the Hydrological Cycle, Groundwater Exploration, Vertical Distribution of Groundwater, Aquifer, Types of Aquifers, Groundwater Contamination, Types of Groundwater Models	6	• To understand the importance of groundwater and know its sources of contamination • To get an idea of groundwater models
II	Groundwater Movement, Darcy's Law, Hydraulic Conductivity and its Determination, Derivation of Governing Groundwater flow Equation, One- and Two-Dimensional Groundwater Flow, Steady-State and Transient Groundwater Flow	8	• To understand the physics of groundwater flow • Derive the governing equation for groundwater flow
III	Contaminant Transport Processes, Advection, Diffusion, Dispersion, Derivation of Governing Contaminant Transport Equation, Advection-Dispersion Equation (ADE), Steady-State and Transient ADE for One- and Two-Dimensional Contaminant Transport, Contaminant Fate Processes, Sea Water Intrusion in Coastal Aquifers	7	• To understand the different contaminant transport processes in groundwater • Derive the governing contaminant transport equation • To learn about the sea water intrusion in coastal aquifers
IV	Numerical Modelling, Initial Condition, Boundary Conditions, Introduction to Finite Difference Method (FDM), Implicit and Explicit Methods, FDM Discretization of Groundwater Flow and Contaminant Transport Equations, Flow and Transport Modelling by FDM, Alternating Direction Implicit (ADI) Method and its Applications to Groundwater Problems	11	• Discretize the groundwater flow and contaminant transport equations using the FDM • To demonstrate the application of FDM in groundwater modelling
V	Introduction to Finite Element Method (FEM), Galerkin FEM Discretization of Groundwater Flow and Contaminant Transport Equations, Flow and Transport Modelling by FEM, Coupled Flow and Transport Modelling by FDM and FEM. MODFLOW and MT3DMS Models, Introduction to Meshfree Methods and their Advantages in Groundwater Modelling	10	• Discretize the flow and transport equations using the FEM • Demonstrate the application of FEM in groundwater modelling • Discuss MODFLOW and MT3DMS models for groundwater modelling
		42	

Text Books:

1. Rastogi, A. K. (2012). Numerical Groundwater Hydrology. Penram International Publishing Pvt. Ltd., Mumbai, India.
2. Todd, D. K., and Mays, L. W. (2004). Groundwater Hydrology. John Wiley & Sons.

Reference books:

1. Bedient, P. B., Rifai, H. S., and Newell, C. J. (1994). Ground Water Contamination: Transport and Remediation. Prentice-Hall International, Inc.
2. Wang, H. F., and Anderson, M. P. (1995). Introduction to Groundwater Modeling: Finite Difference and Finite Element Methods. Academic Press.
3. Anderson, J. D. JR. (1995). Computational Fluid Dynamics: The Basics with Applications. McGraw-Hill.
4. Bear, J., and Cheng, A. H. (2010). Modeling Groundwater Flow and Contaminant Transport. Germany: Springer Netherlands.
5. Istok, J. (1989). Groundwater Modeling by the Finite Element Method. American Geophysical Union, Washington, D.C.
6. Liu, G. R., and Gu, Y. T. (2005). An Introduction to Meshfree Methods and Their Programming. Springer Science & Business Media.