S.No.	Topic	No. of Practicals
4.	Use of various synthetic materials for drainage filter under the field condition	2
5.	Design of filter and envelop with synthetic materials	2
6.	Use of simulated models for drainage system	4
	Total	**16**

X. Suggested Reading

- Chauhan HS. 1999. *Mathematical Modeling of Agricultural Drainage, Ground Water and Seepage*. ICAR Publication New Delhi.
- Kirkham DL and Powers WL. 1972. *Advanced Soil Physics*. Inter Science, New York.
- Lambert K Smedema, Willem FV, Lotman and David Rycroft. 2004. *Modern Land Drainage: Planning, Design and Management of Agricultural Drainage Systems.* CRC Press.
- Ritzema HP. (Ed.). 1994. *Drainage Principles and Applications*. ILRI.
- Skaggs RW and Schilfgaarde Jan Van. 1999. *Agriculture Drainage*. Monograph No. 17. American Society of Agronomy Madison, Wisconsin, USA.

I. Course Title : Hydro-Mechanics and Groundwater Modeling

II. Course Code : IDE 603

III. Credit Hours : 3+0

IV. Aim of the course

To acquaint students about the concept of soil aquifer system, unsaturated flow models, numerical modeling of groundwater flow, theory of krigging and movement of groundwater in fractured and swelling porous media.

V. Theory

Unit I

Concept of soil aquifer system, flow of water in partially saturated soils. Partial differential equation of flow, pressure under curved water films, moisture characteristic functions.

Unit II

Physical models, Analog models, Mathematical modelling, Unsaturated flow models, Numerical modelling of groundwater flow, Finite difference equations and solutions. Successive over relaxation. Alternating direction implicit procedure. Crank Nicolson equation. Iterative methods. Direct methods. Inverse problem. Finite element method.

Unit III

Determination of unsaturated hydraulic conductivity and model for its estimation. Diffusivity and its measurement. Infiltration and exfiltration from soils in absence and presence of water table.

Unit IV

Fence diagram and aquifer mapping. Movement of groundwater in fractured and swelling porous media. Spatial variability, theory of krigging.

Unit V

Data requirements. Conceptual model design: Conceptualization of aquifer system. Parameters, Input-output stresses, Initial and Boundary conditions. Model design

and execution: Grid design, Setting boundaries, Time discretization and transient simulation. Model calibration: Steady state and unsteady state. Sensitivity analysis. Model validation and prediction. Uncertainty in the model prediction.

VI. Learning outcome

The students will be able to understand complex mechanics movement of water in soil systems and also able to estimate the statistical parameters for better understanding of soil aquifer system, model validation and prediction.

VII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Concept of soil aquifer system	1
2.	Flow of water in partially saturated soils	1
3.	Partial differential equation of flow	1
4.	pressure under curved water films, moisture characteristic functions	1
5.	Different types of Models used in hydrology and Groundwater	1
6.	Unsaturated flow models	1
7.	Numerical modelling of groundwater flow	1
8.	Finite difference equations and solutions, Finite difference equations and solutions, Alternating direction implicit procedure	4
9.	Crank Nicolson equation. Iterative methods	2
10.	Inverse problem. Finite element method	1
11.	Determination of unsaturated hydraulic conductivity and model for its estimation	2
12.	Diffusivity and its measurement	1
13.	Infiltration and exfiltration from soils in absence and presence of water table	2
14.	Fence diagram and aquifer mapping	2
15.	Movement of groundwater in fractured and swelling porous media, Spatial variability, theory of krigging	4
16.	Data requirements. Conceptual model design: Conceptualization of aquifer system. Parameters, Input-output stresses, Initial and Boundary conditions	4
17.	Model design and execution: Grid design, Setting boundaries, Time discretization and transient simulation	4
18.	Model calibration: Steady state and unsteady state. Sensitivity analysis. Model validation and prediction. Uncertainty in the model prediction	6
19.	Course Seminar	4
	Total	**43**

VIII. Suggested Reading

- Anderson MP and Woessner WW. 1992. *Applied Groundwater Modelling: Simulation of Flow and Advective Transport*. Academic Press, Inc.
- Elango L and Jayakumar R. 2001. *Modelling in Hydrology*. Allied Publishers Ltd.
- Fetter CW. 1999. *Contaminant Hydrogeology*. Prentice Hall.
- Kirkham and Powers. 1972. *Advanced Soil Physics*. John Wiley & Sons.
- Muskat M. 1937. *The Flow of Homogeneous Fluid through Porous Media*. McGraw Hill.
- Rushton KR. 2003.*Groundwater Hydrology: Conceptual and Computational Models. Wiley,*