Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NCHD507	Advanced Modelling and Simulation	3	0	0	3

Course Objective

- To equip the learners with a host of tools of applied mathematics that are critical towards modelling and simulating a range of scenarios in science and engineering. Being a graduate-level elective course, the focus is on understanding and employing approximate methods such as scaling and asymptotics.

Learning Outcomes

- The students will
  1) learn the building blocks of modelling a process, i.e., formulating physicochemical processes.
  2) learn about the importance and utility of scaling analysis.
  3) get introduced to perturbation and asymptotic methods.
  4) learn how to use aforementioned methods for solving engineering problems of interest (mainly from transport and reaction processes).

Unit No.	Description of Lectures	Contact Hours	Learning Outcomes
1.	**Introduction to mathematical modelling:** Understanding the need and motivation to perform modelling; Types of mathematical models – finite, fuzzy, statistical, difference and differential equations, stochastic; Building blocks of a mathematical model - postulate, assumptions, equations, and closure conditions.	4	Students will able to appreciate the utility of mathematical models, learn about the various mathematical models, and also understand the building blocks of a mathematical model.
2.	**Introduction to scaling analysis:** motivation for using scaling analysis; mathematical basis for scaling analysis; order-of-one scaling analysis, scaling alternative for dimensional analysis	6	Students will learn the basics of scaling analysis and its advantages/limitations over dimensional analysis.
3.	**Introduction to asymptotic and perturbation methods:** motivation for using perturbation methods – advantages/limitations compared to exact methods; basic concepts – gauge functions, order symbols, asymptotic expansions and sequences; coordinate and parameter perturbation; regular and singular perturbation; method of matched asymptotic expansions; solving coupled equations; method of strained coordinates; method of multiple scales	10	Students will learn the fundamentals of asymptotic methods, and the various associated techniques for solving a wide range of algebraic, transcendental and differential equations.
4.	**Application of scaling and perturbation methods towards solving engineering problems:** applications in fluid mechanics; applications in heat transfer; applications in mass transfer	12	Students will learn and be able to appreciate the underlying importance and advantages of these approximate methods even in this age of sophisticated computing infrastructure.

4.	**Application of scaling and perturbation methods towards solving advanced engineering problems:** applications in mass transfer with chemical reaction	**10**	Students will learn and be able to appreciate the underlying importance and advantages of these approximate methods even in this age of sophisticated computing infrastructure.
	Total	**42**	

Textbooks:

1. Ali Hasan Nayfeh (2004), *Introduction to Perturbation Techniques,* Wiley VCH.
2. William B. Krantz (2007), *Scaling Analysis in Modeling Transport and Reaction Processes,* Wiley-Interscience.

Reference books:

1. Rutherford Aris (1999), *Mathematical Modeling – A Chemical Engineer's Perspective*, Academic Press.
2. Rutherford Aris (1978), *Mathematical Modeling Techniques*, Dover Publications.
3. Anders Rasmuson, Bengt Andersson, Louise Olsson, Ronnie Andersson (2014), *Mathematical Modeling in Chemical Engineering*, Cambridge University Press.