CP515 Modelling and Simulation of Simultaneous Transport Phenomena with MATLAB® and COMSOL Multiphysics®"

Credit: 03 Credits

Prerequisites: Prior exposure to mathematical modelling using momentum, energy and mass transport phenomena; EM203 Numerical Methods in Chemical & Process Engineering or equivalent

Course type: Technical elective

Aim:

Chemical & process engineering undergraduates at University of Peradeniya learn the foundations in process modeling in independent course modules dealing with momentum, energy and mass transport phenomena. Successful application of what are learnt in the said independent course modules to deal with practical process engineering systems require the following skills in an undergraduate:

1. Modelling of practical process engineering systems in a unified framework where momentum, energy and mass transport phenomena often occur **simultaneously.**
2. Simulation of such complex systems modelled in a unified framework using **advanced simulation packages** such as MATLAB® and COMSOL Multiphysics® .

The proposed course module is designed to impart the aforementioned skills in the chemical and process engineering undergraduates.

Intended Learning Outcomes (ILOs):

Upon successful completion of this course module the student will be able to do the following:

ILO1: Derive mathematical models of practical process engineering systems in a unified framework where momentum, energy and mass transport phenomena occur simultaneously, supplemented by empirical relationships, where necessary

ILO2: Simulate published case studies where the coupling between different mathematical models is implemented using MATLAB® and COMSOL Multiphysics®

ILO3: Critically analyse the simulation results by carrying out error analysis, sensitivity analysis and uncertainty analysis and by benchmarking the solution

Course description:

Content	Time allocated / hours	
	Lecture	**Laboratory**
Mathematical modeling in a unified framework: Review of momentum, energy and mass transport phenomena; Process modeling using simultaneous momentum, energy and mass transport phenomena.	03	15
Introduction to COMSOL Multiphysics®	06	
Analysis of numerical solutions of ODEs and PDEs: Truncation and discretization errors in numerical analysis by the use of approximate functions in the different terms of the PDEs such as the order of a Lagrange polynomial to form a shape function in finite element and the size of the mesh elements; comparisons between analytical solutions and numerical solutions; grid convergence analysis; sensitivity analysis; effect of parameter uncertainty on the simulation results.	03	
Computational laboratory sessions with MATLAB® and COMSOL Multiphysics® in solving case studies	03	45
Total (equivalent hours)	**15**	**30**

Assessment scheme:

Method of assessment	**Marks assigned**
Viva-voce examinations on the laboratory performance	40%
Viva-voce examinations on the interim reports	10%
Oral presentations	20%
Final report	30%

Suggested texts:

1. Bird, R. B., W. E Stewart, and E. N. Lightfoot, Transport Phenomena, 2nd Ed., Wiley (2007)
2. Chandrupatla, T. R. and A. D. Belegundu, Introduction to Finite Elements Methods in Engineering, 3rd Ed., Prentice Hall (2002)
3. Chapra, S. C. and R. P. Canale, Numerical Methods for Engineers, 5th Ed., McGraw-Hill (2006)
4. COMSOL Multiphysics®, Version 4.4 to 5.2, documentation manuals
5. Slattery, J. C., Advanced Transport Phenomena, Cambridge University Press (1999)
6. Taylor, R., and Krishna, R., Multicomponent Mass Transfer, John Wiley, 1993.
7. Tosun, I., Modeling in Transport Phenomena A Conceptual Approach, 2nd Ed., Elsevier (2007)
8. Welty, J. R., C. E. Wicks, R. E. Wilson, and G. L. Rorrer, Fundamentals of Momentum, Heat, and Mass Transfer, 5th Ed., Wiley (2008)