UCLouvain

linma2720 — Mathematical modelling of physical systems

2021

5.00 credits	30.0 h + 22.5 h	Q2

Teacher(s)	Keunings Roland ;
Language :	English
Place of the course	Louvain-la-Neuve
Prerequisites	LFSAB1103, LFSAB1104, LMECA1901. Prerequisites: basic Physics and Applied Mathematics courses as offered in Bac 1-3.
Main themes	The focus is mainly set on the mathematical modeling of physical systems described by partial differential equations. Multi-scale modeling is also covered.
Learning outcomes	**At the end of this learning unit, the student is able to :** Contribution of the course to the program objectives : • AA1.1, AA1.2, AA1.3 • AA2.1 • AA5.2, AA5.3 The main objective of this course is to allow the student to gain understanding of mathematical modeling approaches for continuous physical systems. With this course, the student will be able to: 1 • Formulate a mathematical model of a complex physical problem using appropriate principles of Physics and suitable constitutive models; • Identify the main governing mechanisms by means of dimensional analysis, and, if relevant, apply adequate perturbation methods; • Understand in depth (for the generic example of diffusion processes covered in the lectures) the different available approaches to the modeling of a complex problem; • In the course of his/her project, analyse in a detailed and critical manner a sophisticated mathematical model; • Perform a critical scientific literature search; • Write a scientific report of quality and substance; • Deliver an efficient and clear oral presentation of a complex technical topic.
Evaluation methods	Evaluation: oral exam (open book; 50% of final mark), project (written report + 20 minute presentation to fellow students; 50% of final mark)
Teaching methods	Lectures and a project carried out in the course of the second semester (individually of by groups of two students). Students choose their project's topic, they identify and analyse the relevant scientific references (journal papers or books), present a summary of their project to fellow students, and write a report that will be discussed with the professor at the oral exam.
Content	Topics covered include: (i) dimensional analysis (Buckingham "Pi" Theorem, similarity solutions, scaling), (ii) perturbation methods (regular and singular perturbations, boundary layers, matched asymptotic expansions, multi-scale analysis), (iii) generic topic of diffusion processes (random walk and Brownian motion, diffusion equation, Fick's constitutive equation, Einstein and Langevin approaches), (iv) stochastic calculus and Fokker-Planck equation for Markov processes (Wiener process, Itô calculus, equivalence between stochastic differential equation and Fokker-Planck equation, numerical methods), (v) illustration of recent developments: micro-macro modeling of polymer dynamics (kinetic theory of polymer solutions, associated Fokker-Planck equation, closure approximations and derivation of constitutive equations, numerical solution of Fokker-Planck equation in configuration spaces of high dimension).
Inline resources	Various optional documents (slides, bibliographical and web references) are gathered at http://moodleucl.uclouvain.be/course/view.php?id=874
Bibliography	• M. H. Holmes (2009) Introduction to the Foundations of Applied Mathematics • E.J. Hinch (1991) Perturbation Methods • H.C. Öttinger (1996) Stochastic Processes in Polymeric Fluids
Other infos	--

Faculty or entity in charge	MAP

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Mathematical Engineering	MAP2M	5		🔍