EPFL

MSE-369

Introduction to numerical modelling

Derlet Peter

Cursus	Sem.	Type
Materials Science and Engineering	BA5	Obl.

Language of teaching	English
Credits	1
Session	Winter
Semester	Fall
Exam	Oral
Workload	30h
Weeks	14
Hours	**1 weekly**
Courses	1 weekly
Number of positions	

Summary

This course aims to give a broad introduction to the basic numerical methods used to model physical phenomenon such as diffusion, heat transport, elasticity and the wave equation, and incompressible fluid dynamics. Computational examples will be given within the python framework.

Content

Recap on the ordinary differential equations (ODE) initial value problem

- the initial value (Cauchy) boundary condition
- numerical integration methods (Euler and Runge–Kutta, implicit trapezoidal)
- reduction of higher order ODEs to a system of 1st order ODEs
- truncation error, stability, stiffness, and propagation of error

The ODE boundary value problem

- General formulation of the ODE boundary value problem (Dirchlet/Neumann boundary conditions)
- numerical solution methods (shooting and finite difference)
- 1D solution examples

Partial differential equations (PDE)

- general definition of PDEs and their boundary conditions
- differential operators – their physical origin, continuity, flux conservation, material derivative
- development of well known examples (diffusion, heat and wave equation, the Navier-Stokes equation, and solid mechanics (elasticity
- numerical solution methods (finite difference and finite element)

Keywords

Numerical methods, Ordinary Differential Equations, Partial Differential Equations, Finite difference methods, Finite element methods

Learning Prerequisites

Important concepts to start the course

- finite difference representation of derivatives
- numerical integration – quadrature (Newton-Coates)

- basic linear algebra – solution of linear systems
- numerical solution of non-linear equations

Learning Outcomes

By the end of the course, the student must be able to:

- Model some common physical phenomenon
- Propose the appropriate numerical solution strategy for a variety of different physical models

Transversal skills

- Use a work methodology appropriate to the task.
- Communicate effectively with professionals from other disciplines.
- Demonstrate the capacity for critical thinking
- Take feedback (critique) and respond in an appropriate manner.

Teaching methods

A weekly lecture will be given covering all theoretical concepts. Included in these lectures will be numerical solution examples using python

Expected student activities

Attendance to lectures

Assessment methods

Assessment is via an oral exam