MASTER OF SCIENCE
IN ENGINEERING

Module Description, available in: EN

Partial differential equations in engineering applications

General Information

Number of ECTS Credits

3

Module code

FTP_PartDiff

Valid for academic year

2020-21

Last modification

2020-01-12

Coordinator of the module

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Explanations regarding the language definitions for each location:

- Instruction is given in the language defined below for each location/each time the module is held.
- Documentation is available in the languages defined below. Where documents are in several languages, the percentage distribution is shown (100% = all the documentation).
- The examination is available 100% in the languages shown for each location/each time it is held.

	Lausanne			Lugano	Zurich		
Instruction					**X** E 100%		
Documentation					**X** E 100%		
Examination					**X** E 100%		

Module Category

FTP Fundamental theoretical principles

Lessons

2 lecture periods and 1 tutorial period per week

Entry level competences

Prerequisites, previous knowledge

The course links topics well known from bachelor mathematics courses and extends them, in particular linear algebra, analysis and numerical mathematics. Expected competences:

Linear algebra: systems of equations, matrices, numerical methods

Analysis: partial derivatives, gradient, concept of ordinary differential equation, linear differential equations, separable differential equation, concept of fourier series.

Brief course description of module objectives and content

Foundations of the theory of partial differential equations relevant in engineering applications and their numerical solution.

Aims, content, methods

Learning objectives and competencies to be acquired

The student knows the basic geometric, analytic and numeric aspects of partial differential equations. He/she knows the basic methods to successfully solve partial differential equations analytically and numerically as well as a set of typical examples that allow to better understand the theoretical concepts.

Module content with weighting of different components

Part 1: General theory

Goals of part 1:

- understand how partial differential equations naturally appear in applications
- be able to solve selected examples using the separation method
- understand the kinds of boundary conditions necessary, Dirichlet and Neumann boundary conditions
- create a collection of examples to illustrate the basic theoretical principles

Lesson plan for part 1:

1. From ordinary to partial differential equations: three applied examples: wave equation, Laplace equation and heat equation. Goal: understand how partial differential equations naturally appear in applications
2. Quasilinear partial differential equations of first order, solutions using characteristics.
3. Solution of partial differential equations using separation of variables.
4. Solution of partial differential equations using the Laplace- or Fourier-transforms.
5. Elliptic partial differential equation with the Laplace equation as the prime example. Poisson formula, maximum principle, uniqueness of solutions.
6. Parabolic differential equations with the heat equation as prime example. Maximum principle and kernel function, Green's function.
7. Hyperbolic partial differential equations with the wave equation as prime example. d'Alembert solution and method of characteristics.

Part 2: Numerical methods for partial differential equations

1. Analysis of finite difference methods in the example of the two point boundary problem:
    - condition
    - stability

   Analysis of finite difference methods in the model problem transport equation.
   Goal: understand some central ideas and concepts of the analysis of numerical methods in general and finite difference methods in particular.
2. Finite volume methods for the Poisson-equation:
    - Example of a cell centered finite volume difference method
    - Example of a node centered finite volume element method

   Boundary elements for the Laplace equation.ıkes
   Goal: construct a collection of numerical methods that represent the broadness of possible approximation techniques.
3. Finite element method in the example of the stationary heat equation:
    - differential, variational and integral formulation
    - global and local ansatz functions
    - elements and element types
4. General perspective: weighted residues.
   Goal: concise introduction into the methodology of finite elements.
5. Problems of finite element methods in the example of the beam equation. Solution strategies and their numerical background:
    - p-strategies
    - h-strategies

   Example based introduction to adaptive step size control.
   Goal: show limitations of finite element methods
6. Finite elements in the example of the nonstationary heat equation:
    - semidiscrete schemata
    - completely discrete schemata
7. Eigenvalue determination using finite elements in the example of the beam oscillation equation.
   Goal: illustrate additional fields of application for finite elements.

This module does not intend to teach the use of any particular software product for the solution of partial differential equations. Instead it strives to teach the foundations for their successful use. The students should become capable to judge the potential and limitations of such a software system und the precision and reliability of the results that can be expected from such a system.

Teaching and learning methods

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Literature

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Assessment

Certification requirements

Module does not use certification requirements

Basic principle for exams

As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.

Standard final exam for a module and written resit exam

Kind of exam

Written exam

Duration of exam

120 minutes

Permissible aids

Aids permitted as specified below:

Permissible electronic aids

Pocket calculator

Other permissible aids

Summary of 10 pages size A4 for each part of the course (total 20 pages).

Special case: Resit exam as oral exam

Kind of exam

Oral exam

Duration of exam

30 minutes

Permissible aids

No aids permitted