Valid from 2024.HS

Module description: Numerics

Module Code	t.BA.XXM5.NUM.22HS
ECTS Credits	4
Language of Instruction/Examination	German
Organizational Unit	IAMP
Module Coordinator	Simon Iwan Stingelin
Legal Framework	The module description is part of the legal basis in addition to the general academic regulations. It is binding. During the first week of the semester a written and communicated supplement can specify the module description in more detail.
Module Characteristic	Type 3a 2 lecture lessons per semester week and class+ 2 lab bi-weekly lessons per semester and half-class
Module Description	Introduction to numerical methods for engineers.
Module Content	**Linear equations** • - Triangular matrices - LR decomposition - Cholesky method - Tridiagonal matrices **Nonlinear equations** • - Fixpoint iteration - Newton method **Linear least squares methods** • - Normal equation, condition - QR decomposition **Nonlinear least squares methods** • - Gauss-Newton method - Levenberg-Marquardt method **Numerical methods for differential equations** • - One-step methods for ordinary differential equations - Discretisation error, convergence - Explicit and implicit numerical methods - Explicit: Euler, Runge, Heun, classical Runge-Kutta - Implicit: trapezoid, center point rule - (optional) 4th order Gauss-Legendre - (optional) Semi-implicit methods - (optional) Step size control - Finite difference method for boundary value problems - One-dimensional boundary value problems - Time-dependent one-dimensional boundary value problems - Explicit, implicit Euler method **Splines** • - Introduction cubic splines - (optional) B-splines - (optional) data fit with (smoothing) B-splines
Prerequisite Knowledge	• Analysis I - III • Lineare Algebra I & II

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Learning Objectives (Competences)

Students...	Competencies	Taxonomies
Providing the analytical and numerical tools needed in engineering subjects. Introduction to the way of thinking of discrete and numerical mathematics. To convey the role of applied mathematics in science and technology.	F, M	K1
You know the terms consistency, convergence, local/global error, error order, stability. You can calculate and visualize both local and global errors for suitable examples.	F, M	K3
You know important algorithms and numerical parameters for solving linear systems of equations and apply them correctly using examples.	F, M	K3
You are able to solve linear least square problems with the help of QR decomposition and know the geometrical interpretation of the normal equation.	M, F	K3
You know important algorithms for solving nonlinear systems of equations and apply them correctly to examples.	F, M	K3
You can solve nonlinear least square problems using the Gauss-Newton or Levenberg Marquard method.	F, M	K3
You can approximate a function using cubic splines.	F, M	K3
You know common explicit as well as implicit one-step procedures, e.g. procedures according to Euler, Runge, Trapez, classical Runge-Kutta, Heun, and can use them for the approximate solution of initial value problems.	F, M	K3
You can use finite differences to solve one-dimensional boundary value problems.	M, F	K3

Performance Assessment

End-of-module exam	Assessment	Length (min.)	Weighting	Form
written exam	Grade	120	60	acc. to module agreement

Performance assessment during the semester	Assessment	Length (min.)	Weighting	Form
Practicum	Grade		20	acc. to module agreement
Project	Grade		20	acc. to module agreement

Classroom Attendance Requirement

None

Learning material

- Practica
- Interactive Jupyter-Notebooks
- Excercises
- Script

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Comments	The implementation of numerical methods on the computer is an integral part of the lecture.