Mathematical Simulation Techniques — AR-308

Rota	Duration	Semester	SWS	Credit Points	Workload
annually WS or SS	1 Semester	2^{nd}/ 3^{rd}	3 SWS	5	150 h

1 Modul structure

Course (Abbreviation)	Type/ SWS	Presence	Self study	Credits
a) Mathematical Simulation Techniques (MST)	Lecture/ 2 SWS	30 h	70 h	3
b) Mathematical Simulation Techniques (MST)	Tutorial/ 1 SWS	15 h	35 h	2

2 Language: English

3 Content: Discretization and solution techniques for the numerical simulation of problems in continuum mechanics, as well as their efficient treatment on computer systems are introduced. The course Advanced Engineering Mathematics, a solid background in mathematics, and solid programming skills are assumed. Among the subjects are the following:

1. Practical finite elements: Variational formulation of partial differential equations, weak solutions, Ritz-Galerkin techniques, finite element approximation and analysis, numerical integration, boundary approximation, mesh generation, error control and reliability, solution of linear systems.
2. Computational aspects of fluid dynamics: Conservation laws, compressible and incompressible fluids, spatial discretization (FD, FV, FEM), stabilization techniques, explicit and implicit time stepping schemes, treatment of boundary conditions, projection- and operator-splitting -techniques.
3. High performance computing: Parallel computer architecture, performance-oriented programming, sparse numerical linear algebra, Krylov-subspace and multigrid solvers, preconditioning strategies, domain decomposition methods, shared and distributed memory parallelization with OpenMP and MPI, GPU Computing.
4. Approximation theory: Interpolation and approximation, polynomial spaces, splines and Bézier curves, existence and uniqueness, best-approximation properties, quasi-interpolation, quality assessment and error analysis.

Literature: References will be given in the courses.

4 Goals

This course provides students with fundamental mathematical simulation techniques that are essential to solve automation problems in robotics as well as in production and engineering processes of all kinds. The entire simulation pipeline is covered in theory and practice. Students are trained to solve real-life complex problems in “Numerics Labs”.

5 Examination Requirements

The final exam will be an oral (20 minutes) or written (1.5 hours) exam, depending on the number of participants (form will be announced in the second week of the course).

6 Formality of Examination

☒ Module Finals ☐ Accumulated Grade

7 Module Requirements (Prerequisites)

Course: “Advanced Engineering Mathematics”, solid programming skills

8 Allocation to Curriculum:

Program: Autom. & Robot., Field of study: Robotics, Process Automation, Cognitive Systems

9 Responsibility/ Lecturer

Dean of the Mathematics faculty / Lecturers of the Mathematics faculty