Valid from 2024.HS

Module description: Finite Elemente Methode

Module Code	t.BA.MT.FEM.19HS
ECTS Credits	4
Language of Instruction/Examination	German
Organizational Unit	IMES
Module Coordinator	Ralf Pfrommer
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	Participants are introduced to the structural mechanics and mathematical foundations of the finite element method and learn to work on linear strength problems with the FE code Abaqus.

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Module Content	**1. Introduction to the FE code Abaqus** • 1.1 Overview, development, economic benefits of the FE method • 1.2 Practical examples • 1.3 Practical exercises with the FE code Abaqus • 1.3.1 Different modeling techniques of a tension bar • 1.3.2 Calculation of an impeller • 1.3.3 Calculation of a piston with connecting rod • 1.3.4 Calculation of a steam turbine blade **2. One-dimensional FE problems** • 2.1 Principle of the FEM using the example of a framework • 2.1.1 Stiffness matrix of the tensile/compression bar in the local system • 2.1.2 Transformation of the local stiffness matrix to the global system • 2.1.3 Compilation of the overall stiffness matrix • 2.1.4 Consideration of boundary conditions and loads • 2.1.5 Calculation of stresses and deformations • 2.2 The stiffness matrix of the bending beam • 2.2.1 The Euler-Bernoulli beam with distributed load • 2.2.2 Superposition of the truss element and the beam element **3. Mathematical foundations of the FE method** • 3.1 Basic equations of the linear theory of elasticity • 3.2 Strong and weak form using the example of the tensile bar problem • 3.3 Differentiability requirements for displacement functions • 3.4 Galerkin's method • 3.5 Ansatz and shape functions • 3.6 Numerical integration according to Gauss • 3.7 Construction of element stiffness matrices based on the weak form **4. Two-dimensional FE problems** • 4.1 Membrane problems • 4.1.1 Strong and weak form of the membrane problem • 4.1.2 Stiffness matrix of the 3-node membrane element • 4.1.3 Stiffness matrix of the rotationally symmetrical membrane element • 4.2 Plane problems • 4.2.1 Strong and weak form of the plane problem • 4.2.2 The isoparametric concept • 4.2.3 The 4-node isoparametric element • 4.2.3.1 Stiffness matrix of the 4-node element for the plane stress state • 4.2.3.2 Stiffness matrix of the 4-node element for the plane strain state • 4.3 Numerical effects • 4.3.1 Hourglassing • 4.3.2 Shear locking • 4.4 Element selection criteria
Prerequisite Knowledge	The contents of this module require a good command of the material of Analysis 1 and 2, Algebra and Statistics 1 and 2 as well as statics and mechanics of materials.

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Learning Objectives (Competences)

Students...	Competencies	Taxonomies
Incorporate the boundary conditions into the overall stiffness matrix	F, M	K4
Form the stiffness matrix in the local system of single dimensional elements of rods and beams and transform it to the global system	F, M	K4
Explain and recognize various undesirable numerical effects in FE calculations	M, F	K4
Describe the concept of isoparametric elements and the numerical calculation of their element matrices	F, M	K4
Specify displacement approaches for two-dimensional elements and criteria that a displacement approach must meet	F, M	K4
Knows the mathematical foundations of the FE method and can derive the weak form from the strong form of one- and two-dimensional problems	M, F	K4
Carry out, plausibilise and evaluate linear calculations with the FE code Abaqus without help	F, M	K4

Performance Assessment

End-of-module exam	Assessment	Length (min.)	Weighting	Form
written exam	Grade	90	80	acc. to module agreement

Performance assessment during the semester	Assessment	Length (min.)	Weighting	Form
written exam	Grade	45	20	acc. to module agreement

Classroom Attendance Requirement

None

Learning material

- Skriptum "Die Methode der Finiten Elemente – Eine Einführung", Folien, eigene Mitschrift.
- J. Fish, T. Belytschko: A First Course in Finite Elements. John Wiley & Sons, 2007.
- M. Hahn, M. Reck: Kompaktkurs Finite Elemente für Einsteiger. Springer Vieweg, 2018.

Comments