SD2175 Numerical Methods for Acoustics and Vibration 9.0 credits

Numeriska metoder för akustik och vibrationer

Course syllabus for SD2175 valid from Spring 19, edition 1.

Learning outcomes

After completing this course, students should be able to:

- *Explain* the key concepts behind numerical methods for acoustics and vibrations, such as finite element and finite difference methods, and *discuss* them in terms of simplifications, accuracy, performance and validation.
- *Apply* numerical theory to acoustics and vibrations problems by implementing it in numerical programs, and *perform* numerical calculations using computational software such as Matlab and Comsol Multiphysics.
- *Reflect* on numerical implementations, *choose* appropriate modelling approaches and *troubleshoot* problems that arise.
- *Evaluate* and critically judge numerical results in order to *suggest* improvements from both physical and numerical modelling perspectives.
- *Present* the outcome of their work in group discussions, formal oral presentations and written reports.

Course main content

Introduction to numerical methods in engineering. Mathematical models versus numerical models. Finite difference method. Galerkins method and method of weighted residuals. Simple elements. Stiffness method. Element formulations. Coordinate transformations. Isoparametry. Numerical interpolation. Convergence properties for dynamic problems. Hierarchical elements. Direct and iterative solvers. Eigenvalue analysis. Modal superposition. Integral equations. Examples of acoustic radiation and scattering using BEM. Simple fluid-structure interaction. Response analysis of a coupled problem. Modelling of damping and its effect on the response.

Eligibility

Basic courses in mathematics and mechanics.

Literature

Course compendium for Numerical Methods for Acoustics and Vibration.

Structure of the course

The course is structured into five modules:

1. FD Basics – This begins with a lecture with preparatory reading accompanied by quiz questions. Then Assignment 1 follows where the students work through a finite difference method computer exercise for a simple case and answer questions about the theory and implementation issues (e.g. errors, convergence, etc.). This assignment is then submitted as a written report and peer reviewed.
2. FE Core – As it takes some time to introduce the students to the core parts of the finite element method, this module consists of three lectures with preparatory read and quiz questions. There is no assessment in this module.
3. FE Implementation – This begins with a lecture with preparatory reading accompanied by quiz questions. Then Assignment 2 follows where the students work through a finite element method computer exercise for a simple case and answer questions about the theory and implementation issues (e.g. errors, convergence, etc.). This assignment is then submitted as a written report and peer reviewed.
4. FE Applications – This begins with a lecture with preparatory reading accompanied by quiz questions. Then Assignment 3 follows where the students work through a finite element method computer exercise for an applied case and answer questions about the theory and implementation issues (e.g. errors, convergence, etc.). This assignment is then submitted as a written report and peer reviewed.
5. Project – The students begin with refining their project proposals and then carry out a detailed numerical analysis and evaluation of their results. The present their result at the course seminar where they are questioned by the examiner and other participants. This assignment is then submitted as a written report and peer reviewed.

Schedule

Module	#	Date	Time	Code	Title	Preparation	Followup	Deadline
Intro	1	2019-03-20	13:00	L0.	Introduction	None		
FD Basics	2	2019-03-22	10:00	L1.	Finite Difference Method	LeVeque Ch 1	INLA-1	
	3	2019-03-27	13:00	E1.	Computer lab 1			
	4	2019-03-29	10:00	A1.	Homework lab 1			2019-04-02
FE Core	5	2019-04-01	08:00	L2.	Finite Element Method I	Burnett Ch 3	INLA-2	
	6	2019-04-03	13:00	L3.	Finite Element Method II	Burnett Ch 4		
	7	2019-04-05	10:00	L4.	Finite Element Method III	Burnett Ch 5		
FE Implementation	8	2019-04-10	13:00	L5.	Finite Element Method IV	Burnett Ch 8 + 13		
	9	2019-04-12	10:00	E2.	Computer lab 2			
	10	2019-04-23	08:00	A2.	Homework lab 2			2019-04-23
FE Application	11	2019-04-24	13:00	L6.	Finite Element V		INLA-3	
	12	2019-04-26	10:00	E3.	Computer lab 3			
	13	2019-04-29	08:00	A3.	Homework lab 3			2019-05-08
Project	14	2019-05-08	13:00	P1.	Project intro	Proposal	PROA	
	15	2019-05-10	10:00	P2.	Project lab			
	16	2019-05-15	13:00	P3.	Presentation of project			2019-05-22

Examination

- INLA – 3x Assignment & Written report, 6.0, grade scale: A, B, C, D, E, FX, F
- PROA – Project & Oral and Written Report, 3.0, grade scale: A, B, C, D, E, FX, F

Requirements for final grade

To achieve:

- Grade E – must have achieved all E criteria
- Grade D – must have achieved all E criteria plus a majority of C
- Grade C – must have achieved all E and C criteria
- Grade B – must have achieved all E and C criteria plus a majority of A
- Grade A – must have achieved all E, C and A criteria

#	ILO text	E	C	A
1	*Explain* the key concepts behind numerical methods for acoustics and vibrations	Main steps in solving a BVP	E + Principles and formulation steps of numerical methods	
1	*Discuss* them in terms of simplifications, accuracy, performance and validation	Main considerations and assumptions		
2	*Apply* numerical theory to acoustics and vibrations problems by implementing it in numerical programs	Alter existing codes to implement given formulas for simple problems		
2	*Perform* numerical calculations using computational software such as Matlab and Comsol Multiphysics	Set-up and run simple problems in commercial software environments	E + Complex problems	
3	*Reflect* on numerical implementations and *choose* appropriate modelling approaches	Pros and cons of different approaches, with valid choices for simple modelling problems	E + Complex modelling problems	C + With only the physical problem
3	*Troubleshoot* problems that arise	Step through configuration in software to ensure that settings are reasonable	E + Diagnose the cause of simple problems and solve using knowledge of relevant theory	C + Diagnose the cause of complex problems and solve using knowledge of relevant theory
4	*Evaluate* and critically *judge* numerical results	Compare results to given analytical/experimental / other numerical values.	E + Select criteria and find/derive the values for simple comparison	C + Select criteria and find/derive the values for complex comparison
4	*Suggest* improvements from both physical and numerical modelling perspectives	Standard increased resources approaches	E + Incorporate physical and numerical theory in improvement decisions	C + Numerical analysis to propose informed/targeted solutions to complex problems
5	*Present* their work in group discussions, formal oral presentations	Clear communication that can be followed		
5	*Present* their work in written reports.	Clear communication that can be followed		

Offered by

SCI/Aeronautical and Vehicle Engineering

Examiner

Peter Göransson <pege@kth.se>

Add-on studies

SD2165 Acoustical Measurements
SD2150 Experimental Structure Dynamics
SD2155 Flow Acoustics
SD2160 Sound and Vibration, Project Course
SD2170 Energy Methods
SD2180 Non-Linear Acoustics
SD2185 Ultrasonics
SD2190 Vehicle Acoustics and Vibration

Version

Course syllabus valid from: Spring 19.
Examination information valid from: Spring 19.