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Faculty of Health, Science and Technology  
Mathematics

# Syllabus

## Foundations of Mathematical Design Optimization

<b>Course code:</b>	7MAT009
<b>Course Title:</b>	Foundations of Mathematical Design Optimization Grunderna för matematisk konstruktionsoptimering
<b>Subject:</b>	Mathematics
<b>Credits:</b>	7.5 ECTS
<b>Degree Level:</b>	Doctoral

### Course approval

The syllabus was approved by the Faculty of Health, Science and Technology, 8 November 2023 and is valid from the autumn semester 2023 at Karlstad University.

### Language of instruction

Teaching is mainly in English.

### Prerequisites and selection

The course is open to students admitted to research education in mathematics, computational science and engineering, or a closely related subject. The course is primarily for research education students admitted at Karlstad University and secondarily for research education students admitted at other universities.

### Learning outcomes

After completed course the research education student should know:

- Perform sensitivity analysis and implement state-of-the-art methods for topology or shape optimization and solve standard model problems.
- Integrate knowledge from various parts of the course and use appropriate methods in connection with problem-solving. Explain the solution in speech and writing.
- Carry out extensive numerical tests and compare various solution strategies, for example, different regularization and restriction approaches.

**Course content**

The course is based on individual study of literature on selected key topics in mathematical design optimization. The course provides a comprehensive understanding of boundary shape and topology optimization fundamentals. As a first topic, we look at a classic (academic) example of minimizing compliance; depending on the student's background, we consider heat conduction or linear elasticity; from a mathematical viewpoint, the optimization problem is constrained by a partial differential equation, where the unknown either enters as a coefficient field in the equation or is the domain on which the equation is cast. Through theoretical exploration, practical implementation, and extensive testing with diverse solution strategies, the students will gain expertise in creating appropriate mathematical descriptions and simulation models for various design problems.

Throughout the course, students will learn to formulate objective and constraint functions based on these models, conduct sensitivity analysis, and implement optimization methods and computational tools to solve design optimization problems effectively.

**Reading list**

See separate document.

**Examination**

For a passing grade, the students must study the course literature and discuss the content with the instructor(s). Each student must also give a presentation that summarises the studies and the key theorems at a seminar.

**Grades**

One of the grades Fail (U) or Pass (G) is awarded in the examination of the course.

**Quality assurance**

A written evaluation is carried out at the conclusion of the course. The result of the evaluation is collated in accordance with *The Higher Education Ordinance*, Chapter 1, § 14.

**Course Certificate**

Course certificate is issued on request.

## Goal matrix

Goals that, after completing the course, are fulfilled for the doctoral or licentiate degree are marked with an X.

	Doctoral			Licentiate	
	Knowledge and understanding			Knowledge and understanding	
1a	- demonstrate broad knowledge and systematic understanding of the research field and	X		1a demonstrate knowledge and understanding in the field of research including	X
1b	advanced and up-to-date specialised knowledge in a limited area of this field, and	X		1b current specialist knowledge in a limited area of this field as well as	X
1c	familiarity with research methodology in general and the methods of the specific field of research in particular.	X		1c specialised knowledge of research methodology in general and the methods of the specific field of research in particular	X
	Competence and skills			Competence and skills	
2a	- demonstrate capacity for scholarly analysis and synthesis as well as	X		2a demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively and to	X
2b	to review and assess new and complex phenomena, issues and situations autonomously and critically			2b plan and use appropriate methods to undertake a limited piece of research and other qualified tasks within predetermined time frames in order to contribute to the formation of knowledge	X
3a	- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to	X		2c as well as to evaluate this work	
3b	plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work	X		3a demonstrate the ability in both national and international contexts to present and discuss research and research findings in speech and writing and in dialogue with the academic community and	
4	- demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research			3b society in general	

5a	- demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and	X	4	demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity.	X
5b	society in general				
6	- demonstrate the ability to identify the need for further knowledge and	X			
7	- demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity.				
<b>Judgement and approach</b>				<b>Judgement and approach</b>	
8a	- demonstrate intellectual autonomy and disciplinary rectitude as well as		5	demonstrate the ability to make assessments of ethical aspects of his or her own research	
8b	the ability to make assessments of research ethics, and		6	demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used	
9	- demonstrate specialised insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used.		7	demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning.	