

Syllabus

Engineering Systems Design Analytics and AI Design Analytics och AI för tekniska system

Credits

6.0 ECTS credits

Course level

Post graduate level (Science Master, and PhD students)

Target group

PhD students with an interest in model-based systems engineering, design analytics, and the application of artificial intelligence in engineering design and analysis.

Prerequisites

Basic background in engineering. Prior experience in Python programming is advantageous but not required.

Examiner

Petter Krus, Linköping University (LiU)

Contact

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Aim

The course aims to provide doctoral students with advanced analytical methods for evaluation and design of complex engineering systems. Emphasis is placed on statistical modelling, machine learning, sensitivity analysis, functional modelling, system complexity, and information-theoretic measures. The course prepares participants to critically and productively integrate modern machine learning techniques and large language models into engineering research and industrial development projects.

Intended learning outcomes

After successful completion of the course, the student shall be able to:

- Apply functional modelling, decomposition, and systematic methods for engineering system concept generation.
- Develop data-driven models capturing relationships between system requirements and component or system characteristics.

- Perform sensitivity and robustness analyses and interpret system coupling effects.
- Estimate and analyse system complexity, including computational complexity aspects.
- Use Generative AI tools to generate, evaluate, and refine analysis-oriented software code for system design, modelling, and design analytics, with critical assessment of correctness and applicability.

Course contents

Design analytics (8 hours)

- Axiomatic design
- Sensitivity analysis
- Robustness
- Functional correlation

Machine learning and design space generation (8 hours)

- Introduction to machine learning in design contexts
- Multiple regression analysis
- Principal component analysis (PCA) using singular value decomposition (SVD)
- Neural networks
- Design space representation and parametrization

System structures and modelling (4 hours)

- Use of large language models (LLMs) for analysis, modelling, and simulation
- Requirement and functional modelling (UML/SysML)
- Dependency structure matrices
- System concept generation supported by LLMs

Information entropy in engineering design (4 hours)

- Shannon's information theory
- Information entropy as a measure of system complexity
- Design space quantification
- Axiomatic design and complexity
- System optimisation and information entropy

Throughout the course, large language models are treated as design-support and analysis tools, with emphasis on critical evaluation, validation, and integration into engineering workflows.

Teaching and learning activities

The course is delivered online and consists of lectures, supervised exercises, project work, and an examination presentation meeting. Each scheduled teaching occasion typically includes approximately two hours of lectures and two hours of supervised exercises.

The main project is conducted individually or in small groups and is closely aligned with each participant's doctoral research topic.

Examination

The primary examination component is a written project report. The report shall demonstrate the application of course methods to a well-defined engineering system problem relevant to the student's doctoral research.

Additional compulsory assignments, including oral presentations, are included during the course.

Grading scale: Pass / Fail.

Literature

Course compendium and selected scientific journal and conference papers.

Course offering

The course is offered as an online doctoral-level course. It is normally scheduled to start in March and run over two months. Exact dates and times are announced well in advance.

Preliminary Schedule 2026

March 10. 13-17 (CET). Design analytics I, Axiomatic design, Machine learning in design.

March 17. 13-17 (CET). Design analytics II. Sensitivity Analysis, Robustness and functional correlation.

March 31. 13-17 (CET). Machine learning and design space generation I: Subsystem modelling. Regression analysis and Principal Component Analysis

April 7. 13-17 (CET). Machine learning and design space generation II. Principal Component Analysis and Neural Networks. System structures and modelling

April 14. 13-17 (CET). Invited talks (TBD).

April 21 13-17 (CET). Information entropy in Design and Optimization.

May 5. 13-17 (CET). Project presentation.

Schedule is preliminary and may be subject to change.