AALBORG UNIVERSITET

MASTER OF SCIENCE IN ENGINEERING (MATHEMATICAL ENGINEERING), 2018

MASTER OF SCIENCE (MSC) IN ENGINEERING
AALBORG

MODULES INCLUDED IN THE CURRICULUM

TABLE OF CONTENTS

INFORMATION PROCESSING IN TECHNICAL SYSTEMS 2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• have knowledge about modern statistical signal processing and its application to information processing systems
• have knowledge about information and coding theory and their application to information and communication technology systems and/or machine learning and its applications to technical science

SKILLS

• must be able to perform an analysis of complex theoretical problems, where there is a need for tools from statistical signal processing, information theory or machine learning
• must be able to handle problems with noisy data and signals

• must be able to design algorithms solving a given technical problem

COMPETENCES

Competencies:
• must be able to discuss and reason at the given level using mathematical terms from modern signal processing, as well as information theory, coding theory or machine learning

• must be able to both orally and in writing to present precise and reproducible documentation for the solutions developed

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 15 ECTS project module and the work load is expected to be 450 hours for the student.

EXAM

EXAMS

Name of exam	Information Processing in Technical Systems
Type of exam	Oral exam based on a project
ECTS	15
Permitted aids	All written and all electronic aids
Assessment	7-point grading scale
Type of grading	Internal examination

Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Informationsbehandling i teknologiske systemer
Module code	F-MTK-K1-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	15
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Arildsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

INFORMATION AND CODING THEORY

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the modules Probability Theory and Linear Algebra on the Bachelor of Science (BSc) in Engineering (Mathematical Engineering).

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• knowledge of information theoretical concepts such as entropy, mutual information, divergence, the chain rule for entropy, empirical entropy
• knowledge of lossless data compression, entropy coding, lossy data compression (rate distortion theory)

• knowledge of channel capacity and error-correcting codes

• knowledge of joint source-channel coding and the separation principle

SKILLS

• are able to give a theoretical description of the entropy of a signal and in practice estimate the entropy of simple signals
• are able to design efficient entropy codes for simple signals

• are able to use information inequalities to provide bounds on optimal performance of simple systems

• arte able to construct error-correcting codes with good properties and parameters

• are able to decode error-correcting codes efficiently (e.g. Reed-Solomon codes)

• understand the interaction between bitrate and distortion (reconstruction error) in connection with source coding

• understand the interaction between bitrate and error probability in connection with channel coding

• are able to perform calculations in finite fields

COMPETENCES

• have a good intuition and understanding of the concept of entropy and its significance regarding the information within a signal
• be able to use mathematical tools to discover and investigate the fundamental mathematical tools that describes data transmission, data reduction and data storage

TYPE OF INSTRUCTION

Lectures with exercises.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- In order to participate in the course evaluation, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

EXAMS

Name of exam	Information and Coding Theory
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Information og kodningsteori
Module code	F-MTK-K1-2
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Petar Popovski, Ignacio Cascudo Pueyo

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

MACHINE LEARNING

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

Basic knowledge in probability theory, statistics, and linear algebra.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Objective
The course gives a comprehensive introduction to machine learning, which is a field concerned with learning from examples and has roots in computer science, statistics and pattern recognition. The objective is realized by presenting methods and tools proven valuable and by addressing specific application problems.

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about supervised learning methods including K-nearest neighbor's, decision trees, linear discriminant analysis, support vector machines and neural networks
- Must have knowledge about unsupervised learning methods including: K-means, Gaussian mixture model, hidden Markov model, EM algorithm, and principal component analysis
- Must have knowledge about probabilistic graphical models, variational Bayesian methods, belief propagation, and mean-field approximation
- Must have knowledge about Bayesian decision theory, bias and variance trade-off, and cross-validation.
- Must be able to understand reinforcement learning

SKILLS

- Must be able to apply the taught methods to solve concrete engineering problems
- Must be able to evaluate and compare the methods within a specific application problem

COMPETENCES

- Must have competencies in analyzing a given problem and identifying appropriate machine learning methods to the problem
- Must have competencies in understanding the strengths and weaknesses of the methods

TYPE OF INSTRUCTION

The program is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- Lectures
- Classroom instruction
- Project work
- Workshops
- Exercises (individually and in groups)
- Teacher feedback
- Reflection
- Portfolio work

EXTENT AND EXPECTED WORKLOAD

Since it is a 5 ECTS course module, the work load is expected to be 150 hours for the student

EXAM

EXAMS

Name of exam	Machine Learning
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/studieadministration/

ADDITIONAL INFORMATION

Elective course
On this semester two courses must be chosen out of three elective courses (total: 10 ECTS).

FACTS ABOUT THE MODULE

Danish title	Maskinlæring
Module code	N-IRS-K3-3
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Esbjerg
Responsible for the module	Birgitte Bak-Jensen

ORGANISATION

Study Board	Study Board of Energy
Department	Department of Energy Technology
Faculty	Faculty of Engineering and Science

ARRAY AND SENSOR SIGNAL PROCESSING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- Must have knowledge about the Cramér-Rao lower bound (CRLB) as well as (asymptotic) optimal unbiased estimators such as minimum variance unbiased estimator, maximum likelihood, and least-squares.
- Must have knowledge about 1- and 2-dimensional spectral estimation methods such as the period gram, the Yule-Walker equations, subspace-based methods (MUSIC and ESPRIT), and filter-bank methods (Capon's method and Amplitude and Phase EStimation (APES)).
- Must have knowledge about fundamental terms and methods applied for design and analysis of adaptive filter such as Steepest descent, least-mean-square (LMS), normalized LMS (NLMS), affine projections (AP), recursive least-squares (RLS), transient and steady-state performance.
- Must have knowledge about terms and methods applied for design and analysis of multi-rate signal processing systems, such as Hilbert transform, Noble identities, poly-phase decomposition, commutators, re-sampling, as well as up- and down-sampling.

SKILLS

- Must be able to compare the estimation performance of unbiased estimators by using the CRLB.
- Must be able to apply methods and algorithms for parametric and non-parametric spectral estimation on 1- and 2-dimensional signals.
- Must be able to implement fundamental adaptive filters such as the (normalized) least-mean-square filter, the affine projection filter, and the recursive least-squares filter.
- Must be able to apply fundamental methods for analysis, design, and implementation of poly-phase filters.

COMPETENCES

- Must have competencies in analyzing a given problem which in its solution requires advanced signal processing methodologies and next identify appropriate methods and algorithms to solve the problem.
- Must have competencies in understanding the strengths and weaknesses of the methods

TYPE OF INSTRUCTION

As described in the introduction to Chapter 3.

EXAM

EXAMS

Name of exam	Array and Sensor Signal Processing
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in Joint Programme Regulations http://www.en.tech.aau.dk/education-programmes/Education+and+Programmes/

FACTS ABOUT THE MODULE

Danish title	Array- og sensor signalbehandling
Module code	ESNSPAK3K1
Module type	Course
Duration	1 semester
Semester	Autumn
ECTS	5
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ove Kjeld Andersen

ORGANISATION

Study Board	Study Board of Electronics and IT
Department	Department of Electronic Systems
Faculty	Technical Faculty of IT and Design

SIGNAL/DATA PROCESSING SYSTEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

- must have knowledge about one- and two-dimensional signal/data representations
- must have knowledge about how sparse representations and/or statistical techniques influence real-world data/signals
- must have knowledge about at least one of the following aspects:
    - classical and Bayesian statistical methods for processing of noisy signals
    - simulation techniques and Markov chain and Monte Carlo methods
    - compressed signal/data representations

SKILLS

- Must be able to apply relevant theories, methods and techniques to ensure that at least one of the following requirements is satisfied:
    - is able to use Bayesian and/or hierarchical statistical methods to analyse time series and lattice data and to evaluate the validity of the results obtained
    - is able to use compressed signal/data representations on real or synthetic data and be able to evaluate the quality of the signal/data reconstruction

COMPETENCES

- must be able to communicate results of statistical analyses and/or sparse representation techniques to non-specialists within advanced signal processing
- must be able to develop statistical models and/or sparse representations suitable for analysis of real-world signals such as noisy digital images or communication signals
- must be able to use sparse representations and/or statistical methods to solve a given practical problem and, if needed, make minor adjustments to the methods to obtain the wanted functionality

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 15 ECTS project module and the work load is expected to be 450 hours for the student.

EXAM

EXAMS

Name of exam	Signal/Data Processing Systems
Type of exam	Oral exam based on a project
ECTS	15
Permitted aids	All written and all electronic aids

Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Signal/databehandlende systemer
Module code	F-MTK-K2-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	15
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jan Østergaard, Poul Svante Eriksen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

COMPRESSIVE SENSING

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• must have knowledge of compressed (sparse) representation of signals/data in one and two dimensions
• must have knowledge of the concepts measurement matrix and dictionary

• must have knowledge of hardware realizations at block level, which use compressive representation of signals/data (e.g. multi-coset and random demodulator architectures)

• must have knowledge of the relation between compressed representation and classical representation of signals/data

• must have knowledge of key concepts and methods within compressed signal/data representation

• must have knowledge of formulation of signal/data reconstruction as different types of optimization problems (e.g. Greedy Pursuit and Orthogonal Matching Pursuit)

SKILLS

• must be able to apply compressed signal/data representation in analysis- and/or synthesis-related applications
• must be able to simulate and assess the quality of signals/data which are represented in compressed form

COMPETENCES

• must be able to assess when compressed signal/data representation is appropriate
• must be able to formulate the basic elements for a given signal/data type and assess the signal/data quality in relation to the number of signal/data components

TYPE OF INSTRUCTION

As described in §17.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- In order to participate in the course evaluation, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

EXAMS

Name of exam	Compressive Sensing

Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Komprimeret signal-/dataanalyse og syntese
Module code	F-MTK-K2-2
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Morten Nielsen, Thomas Arildsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

LONG MASTER'S THESIS, 60 ECTS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The student has the possibility to write a Long Master's Thesis (over 2 semesters: 60 ECTS), if the thesis is of experimental character and approved by the study board. The amount of experimental work must reflect the allotted ECTS.

LEARNING OBJECTIVES

KNOWLEDGE

- have expert understanding within one or a few selected elements of a central mathematical or engineering science subject area based on international research on a high level, or has a broader insight into a central mathematical or engineering subject area regarding theories and methods as well as central elements and their interrelationships
- must be able to understand and on a scientific basis reflect upon the knowledge of the subject area and be able to identify scientific problems within mathematics and engineering science

SKILLS

- must be able to identify, formulate and to analyze a scientific mathematical technological problem independently, systematically and critically
- must be able to relate the problem to the mathematical and engineering subject area, including explaining the choices that have been made in connection to the delimitation of the problem
- must be able to independently make and justify the choice of mathematical theories and scientific theoretical and/or experimental methods
- must be able to independently and critically evaluate the chosen theories and methods as well as the analyses, results and conclusions in the project, both during and at the end of the project period
- must be able to evaluate and choose between the scientific theories, methods, tools, and general skills within the mathematical subject area

COMPETENCES

- must be able to control work and development situations which are complex, unpredictable and require new mathematical and/or engineering models or methods for solution
- must be able to initiate and complete mathematically and/or engineering oriented collaborations, and if relevant also interdisciplinary collaborations, as well as assume professional responsibility
- must be able to independently assume responsibility for own professional development and specialisation

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 60 ECTS project module and the work load is expected to be 1800 hours for the student.

EXAM

EXAMS

Name of exam	Long Master's Thesis, 60 ECTS

Type of exam	Oral exam based on a project
ECTS	60
Permitted aids	All written and all electronic aids
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Langt kandidatspeciale, 60 ECTS
Module code	F-MTK-K3-3
Module type	Project
Duration	2 semesters
Semester	Autumn
ECTS	60
Language of instruction	Danish and English
Location of the lecture	Campus Aalborg
Responsible for the module	Thomas Arildsen, Ignacio Cascudo Pueyo, Zheng-Hua Tan, Morten Nielsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

MASTER'S THESIS. 30 ECTS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

Students who have completed the module meet the following criteria within at least one central mathematical/statistical area:

LEARNING OBJECTIVES

KNOWLEDGE

• have expert understanding within one or a few selected elements of a central mathematical or engineering science subject area based on international research on a high level, or has a broader insight into a central mathematical or engineering subject area regarding theories and methods as well as central elements and their interrelationships
• must be able to understand and on a scientific basis reflect upon the knowledge of the subject area and be able to identify scientific problems within mathematics and engineering science

SKILLS

• must be able to identify, formulate and to analyze a scientific mathematical technological problem independently, systematically and critically
• must be able to relate the problem to the mathematical and engineering subject area, including explaining the choices that have been made in connection to the delimitation of the problem

• must be able to independently make and justify the choice of mathematical theories and scientific theoretical and/or experimental methods

• must be able to independently and critically evaluate the chosen theories and methods as well as the analyses, results and conclusions in the project, both during and at the end of the project period

• must be able to evaluate and choose between the scientific theories, methods, tools, and general skills within the mathematical subject area

COMPETENCES

• must be able to control work and development situations which are complex, unpredictable and require new mathematical and/or engineering models or methods for solution
• must be able to initiate and complete mathematically and/or engineering oriented collaborations, and if relevant also interdisciplinary collaborations, as well as assume professional responsibility

• must be able to independently assume responsibility for own professional development and specialisation

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 30 ECTS project module and the work load is expected to be 900 hours for the student.

EXAM

EXAMS

Name of exam	Master's Thesis. 30 ECTS
Type of exam	Oral exam based on a project
ECTS	30
Permitted aids	All written and all electronic aids
Assessment	7-point grading scale
Type of grading	External examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Kandidatspeciale. 30 ECTS
Module code	F-MTK-K4-1
Module type	Project
Duration	1 semester
Semester	Spring
ECTS	30
Language of instruction	Danish and English
Location of the lecture	Campus Aalborg
Responsible for the module	Morten Nielsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

TIME SERIES AND ECONOMETRICS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the module Statistical Inference for Linear Models from the Bachelor of Science (BSc) in Engineering (Mathematical Engineering).

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• know about conditioning in the multivariate normal distribution as well as ordinary and generalized least squares methods
• are able to understand a time series as a stochastic process and understand the connection between stochastic processes and dynamical systems, and in particular the Box-Jenkins models (ARMA-type models)

• know about various stationarity and non-stationarity concepts for Time Series: Weak and strong stationarity, causality, autocovariance- and autocorrelation functions, integrated models, long memory models, volatility models, and basic state-space models

• know about various modern time series and econometric models within financial econometrics and financial engineering in discrete time

SKILLS

• are able to interpret the statistical and possibly econometric properties of time series
• are able to implement all phases in a classical time series analysis: Identification, estimation, diagnostic checking, prediction, and statistical/econometric interpretation

• are able to use correlograms and other graphical tools in the identification phase

• are able to apply and make themselves acquainted with new statistical methods to analyse time series

COMPETENCES

• are able to apply the concepts from time series in an econometric or other broader context
• are able to perform qualified econometric analyses of financial and other data including estimation and prediction using available software

• are able to reflect on the discipline's approach to academic problems at a high level and the discipline's relationship to other subject areas

• are able to involve the knowledge area in solving complex problems and thus achieve a new understanding of a given subject area

TYPE OF INSTRUCTION

As described in §17.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- Only for students on master-level: In order to participate in the course evaluation, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

EXAMS

Name of exam	Time Series and Econometrics
Type of exam	Written or oral exam
ECTS	5
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Tidsrækkeanalyse og økonometri
Module code	F-MOK-B6-3
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Ege Holger Rubak

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

BAYESIAN INFERENCE AND MIXED MODELS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the module Statistical Inference for Linear Models from the Bachelor of Science (BSc) in Engineering (Mathematical Engineering.

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• have knowledge of the general linear model with random effects
• have knowledge of maximum likelihood inference for the general linear model with random effects

• have knowledge of prediction of random effects

• have knowledge of Bayesian inference

• have knowledge of prior distributions in Bayesian inference

• have knowledge of computational aspects of Bayesian inference

SKILLS

• can for a specific dataset identify possible sources of random variation and formulate a relevant model with random effects
• can perform maximum likelihood- and Bayesian inference for the formulated model

COMPETENCES

• can account for methodology and practical inference for different approaches to models with random effects

- Be able to reflect on the discipline's approach to academic problems at a high level and the discipline’s relationship to other subject areas.
- Be able to involve the knowledge area in solving complex problems and thus achieve a new understanding of a given subject area.

TYPE OF INSTRUCTION

As described in §17.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- In order to participate in the course evaluation, students on the master level must have actively participated in course progress by way of one or several independent oral and/or written contributions.

EXAMS

Name of exam	Bayesian Inference and Mixed Models
Type of exam	Written or oral exam
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Bayesiansk inferens og modeller med tilfældige effekter
Module code	F-MAT-K2-2
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Rasmus Plenge Waagepetersen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

SPATIAL STATISTICS AND MARKOV CHAIN MONTE CARLO METHODS

2018/2019

PREREQUISITE/RECOMMENDED PREREQUISITE FOR PARTICIPATION IN THE MODULE

The module builds on knowledge obtained by the module Statistical Inference for Linear Models from the Bachelor of Science (BSc) in Engineering (Mathematical Engineering)

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

The course deals with Markov chain Monte Carlo methods as well as one or more of the three main topics within spatial statistics.

LEARNING OBJECTIVES

KNOWLEDGE

- know the fundamental models and methods within the chosen main topics (geostatistics, lattice processes or spatial point processes) as well as Markov chain Monte Carlo.
- have knowledge about the following subjects within the chosen main topic(s)
    - Geostatistics:
      Theory for second order stationary processes, variograms/covariograms, prediction and kriging, as well as model based geostatistics
    - Lattice processes:
      Markov fields, Brook's factorisation and Hammersley-Clifford's theorem and likelihood based statistical analysis
    - Spatial point processes:
      Poisson processes, Cox processes and Markov point processes, as well as statistical analyses based on non-parametric methods (summary statistics) and likelihood based methods
    - Markov chain Monte Carlo:
      Fundamental theory of Markov chains with a view to simulation, Markov chain Monte Carlo methods for simulation of distributions, including the Metropolis-Hastings algorithm and the Gibbs sampler

SKILLS

- are able to explain the main theoretical results from the course
- are able to perform statistical analyses of concrete datasets
- are able to simulate the examined models

COMPETENCES

- are able to interpret a spatial statistical model in relation to a concrete dataset and give an account of the limitations of the model with respect to describing the variation in the dataset using the theoretical results within spatial statistics
- are able to simulate distributions using Markov chain Monte Carlo methods and evaluate the output of the Markov chain

TYPE OF INSTRUCTION

As described in §17.

EXTENT AND EXPECTED WORKLOAD

This is a 5 ECTS course module and the work load is expected to be 150 hours for the student.

EXAM

PREREQUISITE FOR ENROLLMENT FOR THE EXAM

- For students on the master level: In order to participate in the exam, students must have actively participated in course progress by way of one or several independent oral and/or written contributions.

EXAMS

Name of exam	Spatial Statistics and Markov Chain Monte Carlo Methods
Type of exam	Written or oral exam Individual oral or written exam, or individual ongoing evaluation.
ECTS	5
Assessment	Passed/Not Passed
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Rumlig statistik og markovkæde Monte Carlo metoder
Module code	F-MAT-B6-9
Module type	Course
Duration	1 semester
Semester	Spring
ECTS	5
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Jesper Møller

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

SELECTED ADVANCED TOPICS IN MATHEMATICS AND TECHNOLOGY WITH A FOCUS ON MATHEMATICAL PROBLEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• must have extensive knowledge of relevant theory and methods within one or more selected areas of mathematics, and to a lesser degree, knowledge about one or more areas within engineering science
• must have extensive knowledge about one or more applications of the theory and methods

• must be able to understand, and to reflect scientifically over knowledge within mathematics and engineering science and to be able to identify mathematical and technological problems

SKILLS

• are able to independently to apply relevant mathematical theory and methods to identification, statement and analysis of technological problems
• are able to communicate research based knowledge, and is able to discuss professional and scientific problems with peers both within mathematics and engineering science, as well as with non-specialists

COMPETENCES

• are able to independently to initiate and complete interdisciplinary development projects based on advanced mathematical modelling and methods from engineering science, and is able in that context, to professionally take charge of implementing derived models and methods
• are able to independently to take charge of self-development and one’s own professional development and specialization within mathematics and engineering science

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 30 ECTS project module and the work load is expected to be 900 hours for the student

EXAM

EXAMS

Name of exam	Selected Advanced Topics in Mathematics and Technology with a Focus on Mathematical Problems
Type of exam	Oral exam based on a project
ECTS	30

Permitted aids	All written and all electronic aids
Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Specialisering i videregående matematiske og teknologiske emner med fokus på matematiske problemstillinger
Module code	F-MTK-K3-1
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Morten Nielsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science

SELECTED ADVANCED TOPICS IN MATHEMATICS AND TECHNOLOGY WITH A FOCUS ON TECHNICAL PROBLEMS

2018/2019

CONTENT, PROGRESS AND PEDAGOGY OF THE MODULE

LEARNING OBJECTIVES

KNOWLEDGE

• must have extensive knowledge of relevant theory and methods within one or more selected areas of engineering science, and to a lesser degree, knowledge about one or more areas within mathematics
• must have extensive knowledge about one or more applications of the theory and methods

• must be able to understand, and to reflect scientifically over knowledge within mathematics and engineering science and to be able to identify mathematical and technological problems

SKILLS

• are able to independently to apply relevant mathematical theory and methods to identification, statement and analysis of technological problems
• are able to communicate research based knowledge, and is able to discuss professional and scientific problems with peers both within mathematics and engineering science, as well as with non-specialists

COMPETENCES

• are able to independently to initiate and complete interdisciplinary development projects based on advanced mathematical modelling and methods from engineering science, and is able in that context, to professionally take charge of implementing derived models and methods
• are able to independently to take charge of self-development and one’s own professional development and specialization within mathematics and engineering science

TYPE OF INSTRUCTION

Project work.

EXTENT AND EXPECTED WORKLOAD

This is a 30 ECTS project module and the work load is expected to be 900 hours for the student

EXAM

EXAMS

Name of exam	Selected Advanced Topics in Mathematics and Technology with a Focus on Technical Problems
Type of exam	Oral exam based on a project
ECTS	30

Assessment	7-point grading scale
Type of grading	Internal examination
Criteria of assessment	As stated in the Joint Programme Regulations. http://www.engineering.aau.dk/uddannelse/Studieadministration/

FACTS ABOUT THE MODULE

Danish title	Specialisering i videregående matematiske og teknologiske emner med fokus på teknologiske problemstillinger
Module code	F-MTK-K3-2
Module type	Project
Duration	1 semester
Semester	Autumn
ECTS	30
Language of instruction	Danish and English
Empty-place Scheme	Yes
Location of the lecture	Campus Aalborg
Responsible for the module	Morten Nielsen

ORGANISATION

Study Board	Study Board of Mathematics, Physics and Nanotechnology
Department	Department of Mathematical Sciences
Faculty	Faculty of Engineering and Science