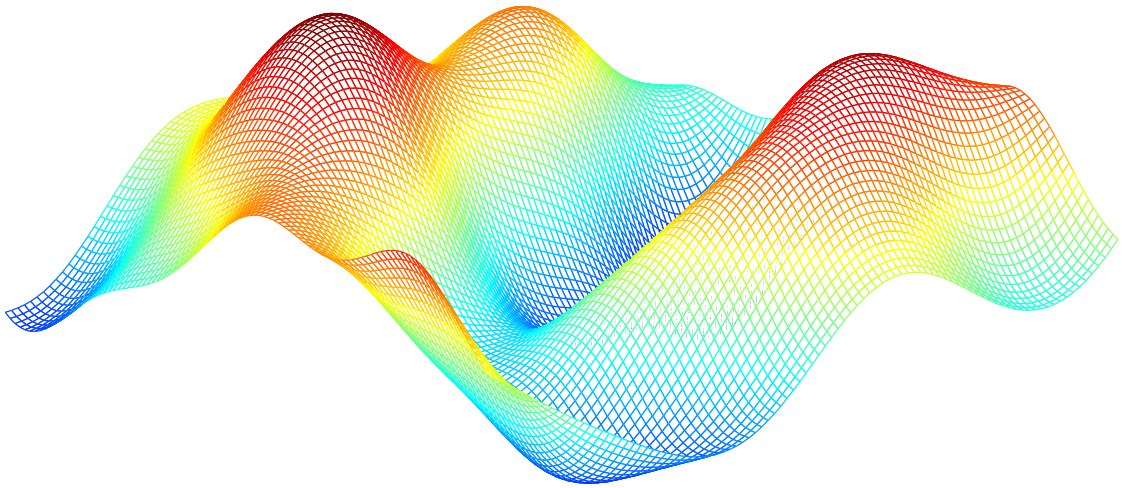
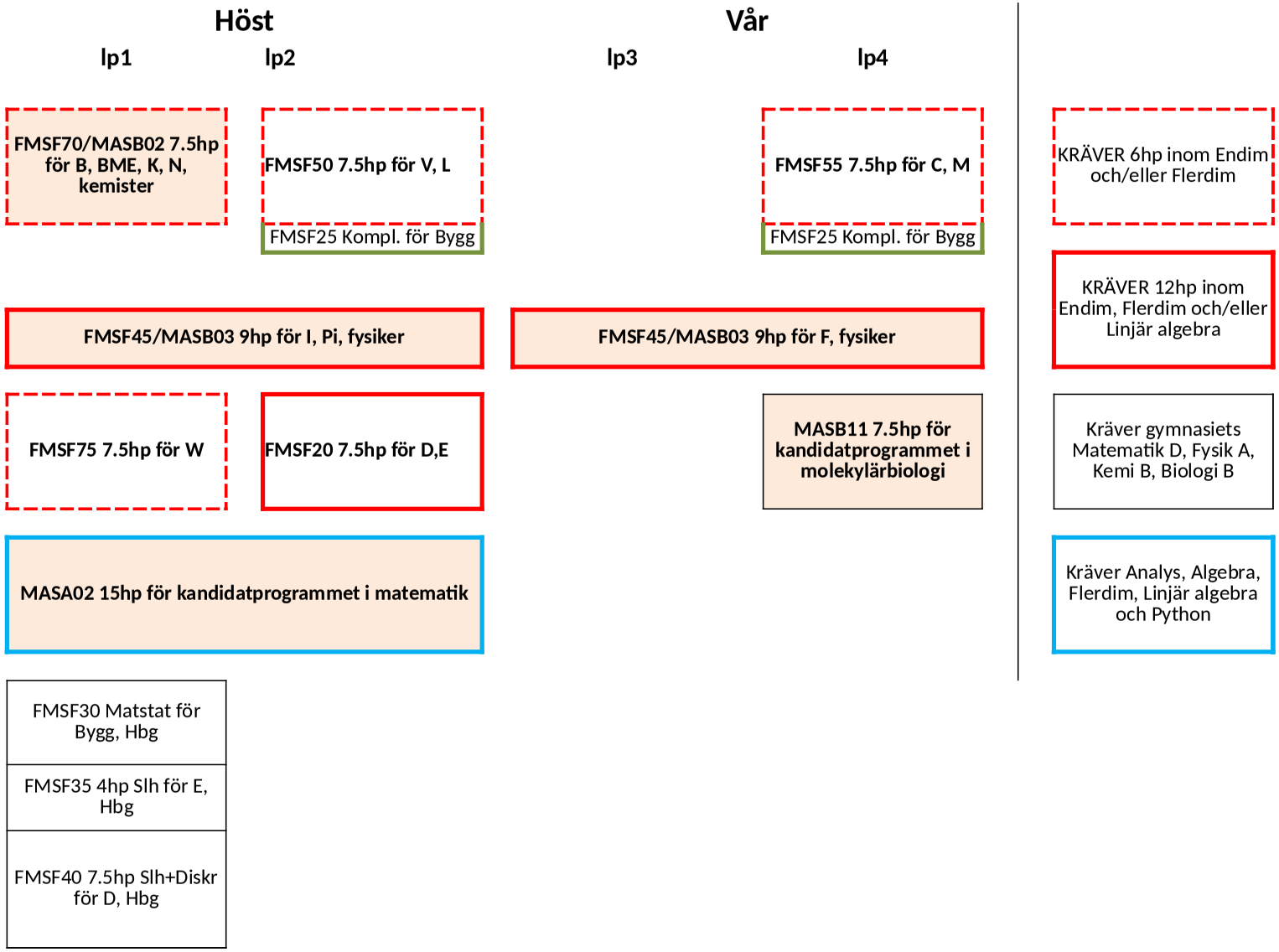
Courses in Mathematical statistics at Lund University Academic year 2020/2021



Grundkurser i Matematisk statistik läsåret 2019/20



Courses Academic Year 2020/21

Intermediate courses (G2)

FMSF05/MASC01: Probability theory, 7.5 ECTS Credits
Period: Spring semester, halftime 1st half.
Pre-requisites: *45 ECTS credits in mathematics and a basic course in mathematical statistics.*
LTH strict req.: *A basic course in Mathematical Statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140).*
LTH-programmes: BME, F, I, Pi.
Literature: *A. Gut, An Intermediate Course in Probability Theory, Springer 2nd ed. 2009.*
Description: Basic probability theory, random variables in one and several dimensions, multivariate Gaussian distribution, convergence of random variables and distributions, conditional distributions. Moment generating functions and characteristic functions.

MASC02: Inference theory, 7.5 ECTS Credits
Period: Spring semester, halftime 2nd half.
Pre-requisites: *45 ECTS credits in mathematics and a basic course in mathematical statistics.*
LTH-programmes: none.
Literature: *E.L. Lehman, G. Casella, Theory of Point Estimation, Springer 1998. E.L. Lehman, J.P. Romano, Testing Statistical Hypothesis, Springer 2005.*
Description: Factorization Theorem, exponential families, Rao-Blackwell's theorem, ancillary estimators, Cramér Rao's inequality, Neyman-Pearson's Lemma, permuation tests, interrelations between hypothesis testing and confidence intervals, asymptotic methods, maximum likelihood estimators, standard errors, marginal, conditional and penalized likelihood, likelihood ratio, Wald scores method, Baysian inference, sequential tests, inference for finite populations.

FMSF15/MASC03: Markov processes, 7.5 ECTS Credits
Period: Autumn semester, halftime 1st half.
Pre-requisites: *45 ECTS credits in mathematics and a basic course in mathematical statistics*
LTH strict req.: *A basic course in Mathematical statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140) or both Linear algebra and Calculus in several variables (FMAB20/420+FMAB30/430)*
LTH-programmes: BME, C, D, E, F, I, M, Pi.
Literature: *Rydén och Lindgren: Markovprocesser* or *Norris, J. R.: Markov Chains, Cambridge Series in Statistical and Probabilistic Mathematics*
Description: Markov chains Markov processes. Classification of states and Markov chains. Stationary distributions and asymptotic distributions. Asorbing states and time to absorption. Intensities, the Poisson process and spatial Poisson processes, Hidden Markov models.

FMSF10/MASC04: Stationary stochastic processes, 7.5 ECTS Credits
Period: Autumn semester, halftime 1st half.
Pre-requisites: *A basic course in mathematical statistics and knowledge in complex and linear analysis.*
LTH strict req.: *A basic course in Mathematical statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140) or both Linear algebra and Calculus in several variables (FMAB20/420+FMAB30/430)*
LTH-programmes: BME, C, D, E, F, I, M, MWIR, Pi.
Literature: *G. Lindgren, H. Rootzén, M. Sandsten:Stationary stochastic processes for scientists and engineers, CRC Press, 2013, ISBN-13: 978-1-4665-8618-5.*
Description: Models for stochastic dependence. Concepts of description of stationary stochastic processes in the time domain: expectation, covariance, and cross-covariance functions. Concepts of description of stationary stochastic processes in the frequency domain: effect spectrum, cross spectrum. Special processes: Gaussian process, Wiener process, white noise, Gaussian fields in time and space. Stochastic processes in linear filters: relationships between in- and out-signals, auto regression and moving average (AR, MA, ARMA), derivation and integration of stochastic processes. The basics in statistical signal processing: estimation of expectations,

covariance function, and spectrum. Application of linear filters: frequency analysis and optimal filters.

FMSF65/MASC05: Design of Experiments, 7.5 ECTS Credits
Period: Spring semester, halftime 2nd half.
Pre-requisites: *45 ECTS credits in mathematics and a basic course in mathematical statistics*
LTH strict req.: *A basic course in Mathematical statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140) or both Linear algebra and Calculus in several variables (FMAB20/420+FMAB30/430)*
LTH-programmes: BME, D, E, F, MLIV, MWIR, N, Pi, W.
Literature: *Box, Hunter and Hunter: Statistics for Experimenters ,Wiley, 2nd ed. (2005)*
Description: The course gives theory and methodology of how to model, design and evaluate experiments. Important concepts are: Simple comparative experiments. Analysis of variance; transformations, model validation and residual analysis. Factorial design with fixed, random and mixed effects. Additivity and interaction. Complete and incomplete designs. Randomized block designs. Latin squares and confounding. Regression analysis and analysis of covariance. Response surface methodology. Off-line quality control and Taguchi methods.

FMSF60: Statistical Methods for Safety Analysis, 7.5 ECTS Credits
Period: Autumn semester, halftime 1st half.
Pre-requisites: *a basic course in mathematical statistics or statistics*
LTH strict req.: *A basic course in statistics or mathematical statistics (EXTA60, TNX071, FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/240).*
LTH-programmes: BME, C, Pi, RH.
Literature: *Rychlik, I. och Rydén, J: Probability and Risk Analysis - An Introduction for Engineers. Springer, 2006, ISBN: 3-540-24223-6.*
Description: The course presents notions and ideas from the foundations of a statistical treatment of risks. The emphasis lies on an understanding of the theory and methods presented. Hence the focus is put on applications within the field of risk and safety analysis. A review of elementary concepts in probability and statistics;; maximum likelihood method, goodness of fit tests. Introduction to bootstrap and Bayesian statistics. Intensities, Poisson modelling and estimation. Some concepts from safety and reliability analysis. Estimation of quantiles. Introduction to extreme values statistics.

Advanced courses (A)

FMSN50/MASM11: Monte Carlo methods for stochastic inference, 7.5 ECTS Credits
Period: Spring semester, halftime 1st half.
Pre-requisites: *Stationary stochastic processes and Markov processes.*
LTH strict req.: *FMSF10 Stationary stochastic processes* or *FMSF15 Markov processes.*
LTH-programmes: BME, D, F, I, Pi.
Literature: *Geof H. Givens and Jennifer A.: Hoeting Computational Statistics Second Edition (2012)*
Description: Simulation based methods of integration and statistical analysis. Monte Carlomethods for sequential problems. Markov chain methods, e.g. Gibbs sampling andthe Metropolis-Hastings algorithm, for simulation and inference. Bayesian modellingand inference. The re-sampling principle, both non-parametric and parametric.Methods for constructing confidence intervals using re-sampling. Simulation basedtests as an alternative to asymptotic parametric tests.

MASM12: Non-linear Time Series Analysis, 7.5 ECTS Credits
Period: Autumn semester, quartertime whole semester.
Pre-Requisits: *Stationary stochastic processes, Times series analysis.*
LTH-programmes: none.
Literature: *H. Madsen, J. Holst & E. Lindström (2010): Modelling Non-Linear and Non-Stationary Time Series*
Description: The graduate course in Advanced Time Series Analysis has its target audience amongst students with technical or natural science background and with adequate basic knowledge in mathematical statistics. The primary goal to give a thorough knowledge on modeling dynamic systems. A special attention is paid to non-linear and non-stationary systems, and the use of stochastic differential equations for modeling physical systems.

The course is given in cooperation with DTU (Danish technical university, Lyngby)

MATM30: Mathematical Foundations of Probability, 7.5 ECTS Credits
Period: Autumn semester, halftime 2nd half.
Pre-requisites: *60 ECTS credits in mathematics. Knowledge of probability theory at the level of MASC01 is desirable.*
LTH-programmes: none.
Literature: *Shiryaev, A. N.: Probability, Springer 1996.*
Description: The course extends and deepens basic knowledge in Probability Theory. Central topics are existence and uniqueness of measures defined on sigma fields, integration theory, Radon-Nikodyn derivatives and conditional expectation, weak convergence of probability measures on metric spaces.

FMSN55/MASM15: Statistical Modelling of Extreme Values, 7.5 ECTS Credits
Period: Spring semester, halftime 2nd half.
Pre-requisites: *A basic course in mathematical statistics.*
LTH strict req.: *A basic course in Mathematical statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140).*
LTH-programmes: D, F, I, Pi.
Literature: *Coles, S.: An Introduction to Statistical Modelling of Extreme Values. Springer-Verlag, London, 2001. Lecture notes and articles.*
Description: Extreme value theory concerns mathematical modelling of extreme events. Recent developments have introduced very flexible and theoretically well-motivated semi-parametric models for extreme values which are now at the stage where they can be used to address important technological problems on handling risks in areas such as large insurance claims or large fluctuations in financial data (volatility), climatic changes, wind engineering, hydrology, flood monitoring and prediction and structural reliability. In many applications of extreme value theory, predictive inference for unobserved events in the main interest. One wishes to make inference about events over a time period much longer than for which data is available. Statistical modelling of extreme events has been the subject of much practical and theoretical work in the last few years. The course will give an overview of a number of different topics in modern extreme value theory including the following: (i) statistical methods for extreme event, (ii) some examples of applications of the theory in large insurance claims due to wind storms, flood monitoring and pit corrosion, (ii) exercises on detailed step-by-step use of extreme value modelling, and (iv) discussion of some open problems in the field.

FMSN45/MASM17: Time series analysis, 7.5 ECTS Credits
Period: Autumn semester, halftime 2nd half.
Pre-requisites: *A course in stationary stochastic processes.*
LTH strict req.: *FMSF10 Stationary stochastic processes* or *a basic course in Mathematical Statistics (FMSF20, F25, FF45/012, F50/032, F55/035, F70/086, F75/140).*
LTH-programmes: BME, C, D, E, F, I, Pi.
Literature: *Andreas Jakobsson, An Introduction to Time Series Modeling (2nd edition), Studentlitteratur, 2015.*
Description: Stationary and nonstationary processes, ARIMA processes, seasonal variation, prediction, filtering and reconstruction in transfer function models and state space models, parameter and structure estimation by least squares, maximum likelihood and predictive error methods, spectral analysis, recursive estimation, adaptive techniques, robustness and outlier detection, multivariate time series, spectral density estimation.

FMSN60/MASM18: Financial statistics, 7.5 ECTS Credits
Period: Autumn semester, halftime 2nd half.
Pre-requisites: *A course in Stationary stochastic processes and Time series analysis.*
LTH strict req.: *FMSF10 Stationary stochastic processes.*
LTH-programmes: F, I, Pi.
Literature: *Lindström, E., Madsen, H and Nielsen, J. N. (2015) , Statistics for Finance CRC Press/Chapman Hall*
Description: Modelling and estimation in nonlinear dynamical stochastic models for financial systems, models in in continuous and discrete time, GARCH-models, stochastic differential equations, prediction, optimization,

risk evaluation, maximum likelihood and moment methods for parameter estimation, kernel based estimation methods, nonlinear filters for filtering and prediction, bootstrap methods

FMSN30/MASM22:, Linear and Logistic Regression, 7.5 ECTS Credits
Period: Spring semester, halftime 2nd half.
Pre-requisites: *A basic course in mathematical statistics.*
LTH strict req.: *A basic course in Mathematical Statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140).*
LTH programmes: BME, D, F, I, L, M, Pi.
Literature: *Rawlings, J.O., Pantula, S.G., Dickey, D.A.: Applied Regression Analysis - A Research Tool, 2ed, Springer, available as e-book,*
Agresti, A.: An Introduction to Categorical Data Analysis, 2ed Springer, available as e-book.
Description: Least squares and maximum-likelihood-method; odds ratios; Multiple linear regression and logistic regression; Matrix formulation; Methods for model validation, residuals, outliers, influential observations, multi co-linearity, change of variables; Choice of regressors, F-test, likelihood-ratio-test; Confidence intervals and prediction. Introduction to: Poisson and Binomial regression.

FMSN40:, Linear and Logistic Regression with Data Gathering, 9 ECTS Credits
Period: Spring semester, halftime 2nd half.
Pre-requisites: *A basic course in mathematical statistics.*
LTH strict req.: *A basic course in Mathematical Statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140).*
LTH programmes: I.
Literature: *Rawlings, J.O., Pantula, S.G., Dickey, D.A.: Applied Regression Analysis - A Research Tool, 2ed, Springer, available as e-book,*
Agresti, A.: An Introduction to Categorical Data Analysis, 2ed Springer, available as e-book.
Description: Least squares and maximum-likelihood-method; odds ratios; Multiple linear regression and logistic regression; Matrix formulation; Methods for model validation, residuals, outliers, influential observations, multi co-linearity, change of variables; Choice of regressors, F-test, likelihood-ratio-test; Confidence intervals and prediction. Introduction to: Poisson and Binomial regression. As part of the course you should construct a questionaire or experimental plan for a problem of your choice, collect the data and analyse it using an suitable regression model.

FMSN15/MASM23: Statistical Modelling of Multivariate Extreme Values, 7.5 ECTS Credits
NOT GIVEN FALL 2018, RUNS AGAIN FALL 2019
Period: Autumn term, halftime 2nd half.
Pre-requisites: *Statistical Modelling of Extreme Values*
LTH strict req.: *FMSN55/155 Statistical Modelling of Extreme Values* or *FMSF60/065 Statistical Methods för Safety Analysis*
LTH programmes: F, I, Pi.
Literature: *Beirlant, Goegebeur, Segers, Teugels, with contributions from De Waal, Ferro: Statistics of Extremes: Theory and Applications*,
Roger B. Nelsen: An Introduction to Copulas.
Description: Weak convergence for normalized extreme values of stochastic vectors, different characterisations of multivariate extreme value distributions, peaks over threshold-model in the multivariate case, different definitions of multivariate generalized Pareto distributions, statistical inference for multivariate extreme values, parametric and semi-parametric methods for multivariate extreme values, use of copula in modelling extreme values, point process characterisation of extreme values, prediction of extreme values, examples of applications of the theory, e.g., estimation of operational risk, climate changes and wind insurances.

FMSN25/MASM24: Valuation of Derivative Assets, 7.5 ECTS Credits
Period: Autumn term, halftime 1st half.
Pre-requisites: *A course in stochastic processes*
LTH strict req.: *FMSF10 Stationary stochastic processes* or *FMSF15 Markov processes*
LTH programmes: F, I, Pi.
Literature: *Björk, T (2009): Arbitrage Theory in Continuous Time. Oxford University Press, Oxford.*
S. Åberg (2020) Derivative Pricing. Mathematical Statistics, Lund.
Description: The course consists of two related parts. In the first part we will look at option theory in discrete time. The purpose is to quickly introduce fundamental concepts of financial markets such as free of arbitrage and completeness as well as martingales and martingale measures. We will use tree structures to model time dynamics of stock prices and information flows. In the second part we will study alternative models formulated in continuous time. The models we focus on are formulated as stochastic differential equations (SDE:s). Most of the second part is devoted to the probability theory required to understand the SDE models. We go through the underlying theory of Brownian motion, stochastic integrals, Ito's formula, measure changes and numeraires. We here also apply the theory on valuation of derivatives both for the stock and interest rate market. We derive e.g. the Black-Scholes formula and how replicating portfolios for options are created.

FMSN20/MASM25: Spatial statistics with image analysis, 7.5 ECTS Credits
Period: Autumn semester, halftime 2nd half.
Pre-requisites: *One of the courses Markov processes (FMSF15/MASC03), Stationary Stochastic Processes (FMSF10/MASC04), Image analysis (FMA170) or equivalent.*
LTH strict req.: *FMSF10 Stationary stochastic processes* or *FMSF15 Markov processes* or *a basic course in mathematicsl statistics (FMSF20, F25, F45/012, F50/032, F55/035, F70/086, F75/140)*
LTH programmes: BME, C, D, E, F, Pi.
Literature: *A. Gelfand P. Diggle P. Guttorp M. Fuentes (Eds), Handbook of Spatial Statistics.*
Description: Bayesian methods for stochastic modelling, classification and reconstruction. Random fields, Gaussian random fields, Kriging, Markov fields, Gaussian Markov random fields, non-Gaussian observationer. Covariance functions, multivariate techniques. Simulation methods for stochastic inference (MCMC, etc.). Applications in climate, environmental statistics, remote sensing, and spatial statistics.

FMSN35/MASM26: Stationary and Non-stationary Spectral Analysis, 7.5 ECTS Credits
Period: Spring semester, halftime 1st half.
Pre-requisites: *Stationary stochastic processes, Time series analysis*
LTH strict req.: *FMSF10 Stationary stochastic processes*
LTH programmes: BME, C, D, E, F, I, Pi.
Literature: *Stoica & Moses, Spectral analysis of signals, Prentice-Hall, 2005.*
Description: Basic definitions. Continued study of AR (auto regressive), MA (moving average) and ARMA-processes. Line spectrum and parametric estimating methods. Sub space based techniques. Non-parametric spectral estimators, data-adaptive techniques and multi window techniques. Non-uniform sampling. Orientation about circular and non-circular processes. Spatial spectral analysis. Non-stationary signals. Spectrogram. Wigner-Ville distribution. Cohen's class. Ambiguity-spectrum. Doppler-spectrum. Multi-window techniques for non-stationary signals. Orientation about bi-spectrum.

MASM27: Nonparametric Inference, 7,5 ECTS Credits
Period: Spring semester, halftime 1st half, NOT GIVEN SPRING 2020.
Requirements: *MASA01 Matematical statistics basic course, 15 credits or MASC02 Inference theory, 7.5 credits, as well as the course MASC01 Probabilty theory 7.5 credits is required.*
LTH programmes: none
Literature: *A. W. van der Vaart, Asymptotic Statistics, Cambridge Series in Statistical and Probabilistic Mathematics, 1998.*
Description: Weak convergence on general function spaces. Non-measurable functionals (Hoffman-Jörgensen's theory). Characterization of tightness and convergence of finite dimensional distributions. Empirical processes. Covering numbers and bracketing numbers. VC-classes of functions. Functional differentiability (smooth

statistical functionals). Application to survival analysis (Nelson-Aalen and Kaplan-Meier estimators). Quantile estimators. Bootstrap methods, functional differentiability for bootstrap, bootstrap for empirical processes. Nonparametric estimation of densities. Limit distributions. Convergence rates. The partial sum process. Donsker's theorem for this. Nonparametric estimations of regression functions. M and Z estimators. Applications to maximum likelihood och least square estimators. Empirical processes and partial sum process results for weakly and strongly dependent stationary data. Kernel estimation of densities and regression functions. The empirical spectral process. Nonparametric estimation of spectral densities.

Contact Info

All our courses are described on the webpage:

In Swedish, both faculties:
`http://www.ctr.maths.lu.se/utbildning/matematisk-statistik-alla-kurser/`

In English, both faculties:
`http://www.maths.lth.se/education/mathematical-statistics-courses-lth-and-nf/`

If you have further questions you are welcome to contact the directors of studies:

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