MSc Applied Math. NU

Year One - Fall Semester	ECTS Credits	Year One - Spring Semester	ECTS Credits
MATH 510 Applied Measure Theory	6	Mathematics Elective II	6
MATH 519 Scientific Computing	6	Mathematics Elective III	6
MATH 540 Statistical Learning	6	Mathematics Elective IV	6
Mathematics Elective I	6	WCS 501 Science Communications	6
MATH 592 Research Seminar	6	MATH 691 Thesis Proposal	6
Summer		ECTS Credits	
MATH 599 Thesis Research Preparation		0	
Year Two - Fall Semester	ECTS Credits	Year Two - Spring Semester	ECTS Credits
Mathematics Elective V	6	MATH 692 Thesis	30
Mathematics Elective VI	6		
Mathematics Elective VII	6		
Mathematics Elective VIII	6		
Mathematics Elective IX	6		

Core Courses

MATH 510 Applied Measure Theory

This course is an introduction to the subject of measure theory and Lebesgue integration, and its applications in probability. The course begins with a discussion of the extended real number system, measurable sets and measurable functions. Measures are then introduced and used to construct the theory of Lebesgue Integration. After introducing the major theorems of Lebesgue integration, the course will conclude with applications of the theory to probability.

MATH 519 Scientific Computing

Algorithm design motivated by problems in physics, engineering, epidemiology, chemistry, and biology; implementation techniques in MATLAB; elements of shell programming under Unix/Linux and use of modern software packages for numerical computations; preparation of reports in the scientific style and maintain scientific software.

MATH 540 Statistical Learning

The course covers theoretical foundations and applications of machine learning models. Topics include supervised methods for regression and classification (linear models, trees, neural networks, ensemble methods, instance-based methods), Bayesian parametric learning, density estimation and clustering, sequential models. Programming projects covering a variety of real-world applications are assigned.

WCS 501 Science Communications

This course provides the graduate students with skills to write their research reports and scientific articles in English with proper use of style and grammar, as required in international conferences and journals. This course also trains the graduate students to deliver effective and appealing professional and scientific presentations, with attention to best practices in the use of technical English and vocal-gestural communication.

MATH 592 Research Seminar
This course provides graduate students with a broader view of the latest research in Mathematics. Seminar speakers are faculty members, PIs of research institutes and visiting academics. Students are required to attend all seminars, to participate in the weekly discussion sessions and to submit via TurnitIN reports on three of the seminars.

MATH 691 Thesis Proposal
This course is designed to monitor progress and develop understandings and skills to plan and conduct independent research at the MSc level. The student will develop under the guidance of the supervisor a research proposal that will state a research problem/question/hypothesis, its background, outline a research strategy and experimental approach, method of data collection, interpretation and validation. The thesis research proposal constitutes a partial fulfillment of the requirements Master's degree, and will be used in the course Thesis Research in part as a basis to monitor the research progress.

MATH 599 Thesis Research Preparation
This course is designed to facilitate during the Summer Term of the first Academic Year the preparation for the Thesis Proposal Research and Thesis Research in the second Academic Year. The course aims are: to provide students the opportunity to conduct feasibility studies and simulations; to practice methodologies required for their research; to collect data required for their research.

MATH 692 Thesis
This course is the last in the series of research courses for master students that leads to successful writing, completion and defense of the MSc thesis. The course main aim is to support the students in writing their thesis and regular monitoring of its progress. Secondly, the facilitation of the communication between course directors, supervisors and students and providing a framework for presenting and disseminate data and knowledge connected to the experimental and/or theoretical part done during the thesis. This is mostly done in form of two short presentations with discussion in the presence of supervisors, program directors, thesis defense committee and department staff. The basis of these presentations represents the basis for the presentation used during the thesis defense.

Elective Courses

MATH 512 Optimization Methods and Techniques

The course covers an introduction to optimization methods and techniques. Lectures will discuss the main theoretical results, the most relevant algorithms and show how to use them for solving real case studies. Relevant optimization software will be introduced as well.

MATH 514 Operations Research

Operations research helps in solving problems in different environments that need decisions. This course covers topics that include: mathematical programming, stochastic optimization, fuzzy optimization, dynamic programming, deterministic and stochastic optimal control, multi-criteria decision aid, and application to engineering, finance, management.

MATH 517 Mathematical Modeling and Simulation

This course will use scientific principles in physics, biology and engineering in combination with mathematical methods to formulate and design mathematical models to study real life problems.

MATH 518 Applied Finite Element Analysis

Initial/boundary value problems (IVP/BVP) in science and engineering with industrial applications, weak formulations for IVP/BVP, Sobolev spaces used in FEM, piecewise polynomial interpolations, basis shape functions in natural coordinates, local and global shape functions in spatial one, two and three dimensions, Galerkin method, Rayleigh-Ritz method, local and global finite element matrices, connectivity and nodal degrees of freedom, numerical integration, non-conforming FE, mixed FEM for Stokes problem, stabilized FEM for convection-dominated flow problems, FE error analysis, Superconvergence, quadrature error, discontinuous Galerkin methods, variational time discretizations and FE error analysis for parabolic problems, industrial applications of finite elements for heat transfer, structural, and fluid flow models, FE software package Comsol and Matlab PDE Toolbox, validation and presentation of simulation results.

MATH 541 Data Analysis and Statistical Learning

The course begins with the general formulation of the supervised learning problem and proceeds with the model assessment/selection issues, the comparison of models. We proceed to covering regularization, kernels, design of neural networks and, finally, based on Vapnik-Chervonenkis theory, we discuss how sample size affects the generalization power.

MATH 542 Statistical Programming
The course deals with data analysis using advanced statistical programming such as R or SAS. Students will learn syntax, how to read fixed and free format data, use built-in and user-written functions, optimization and graphical capabilities. The applied statistical problems considered include linear and nonlinear regression, experimental design, and others.

MATH 551 Advanced Numerical Methods
This course covers advanced numerical methods that are used in large scale scientific and engineering computations and simulations. The topics include Krylov subspace methods and preconditioning, conjugate gradient method and BiCGstab, iterative methods for eigenvalue computation, and advanced numerical methods for initial value problems.

MATH 571 Nonlinear Differential Equations
Advanced topics are presented concerning nonlinear ordinary and partial differential equations and their solutions. After a quick review of first-order (non) autonomous and (non) linear ordinary differential equations, higher order systems of nonlinear ordinary differential equations are examined from the viewpoint of their critical points, phase space trajectories, Poincare maps, periodic and quasiperiodic solutions. The Poincare-Bendixson theorem, Lyapunov stability, stability analysis by linearization, perturbation methods (Poincare-Lindstedt, multiple time scales, averaging method) and bifurcation theory are described. Singularity analysis of integrable and nonintegrable nonlinear differential equations in the complex domain, and applications to classical mechanics, solid state physics, nonlinear optics, water wave propagation, population dynamics and time evolution of epidemiological models are also introduced.

MATH 576 Numerical Methods for Partial Differential Equations
Finite difference, volume, and element methods; explicit/implicit methods for time integration; Convergence, consistency, stability; the Poisson equation, heat equation, wave equation, advection-diffusion equation, and Stokes equation.

MATH 577 Modelling and Numerical Analysis for Incompressible Fluids
This course will make students familiar with mathematical modeling and numerical schemes for problems related to incompressible fluids. The main focus in the numerical analysis will be on stable finite element discretizations for Stokes equations and stabilization methods for convection-dominated problems. The course is designed to teach students numerical analysis for scalar transport equations and Navier-Stokes equations. Students will also learn implementation aspects for presented schemes and modern multiphysics software package Comsol to carry out simulations for incompressible fluid flows.

MATH 582 Mathematical Biology

This course provides an introduction to the use of discrete and differential equations as well as PDEs in the biological sciences. Biological models will include single species and interacting population dynamics, modeling infectious and dynamic diseases, regulation of cell function, molecular interactions, neural and biological oscillators. Mathematical tools such as phase portraits, bifurcation diagrams, and parameter estimation techniques that are introduced to analyze and interpret biological models will also be covered.

MATH 601 Analytic Number Theory

This course delves more deeply into the theory of numbers and is a natural follow-up of Math 301 Introduction to Number Theory. Number theory in Z is explored here with the help of functions of a real and complex variable. Both multiplicative and additive theories are introduced, in the form of the Prime Number Theorem, Dirichlet's Theorem of primes in arithmetic progressions, examples of applications of the circle method and of methods of Diophantine approximation.

MATH 676 Advanced Partial Differential Equations with Applications

This course covers: Laplace and heat equations, wave equations, fundamental solutions, maximum principles, Sobolev spaces, embedding theorems, weak solutions, energy methods, regularity of solutions, existence and uniqueness of solutions, general linear elliptic, parabolic and hyperbolic equations, and applications.

MATH 680 Potential Theory and Polynomial Approximation

Numerical approximation with polynomials, both theory and practice. The emphasis is on Chebsyev polynomials on an interval, but some other topics will be covered. Expertise in numerical and theoretical sides of the topic will be expected (at the appropriate level).

MATH 682 Applied Functional Analysis

This course will make students familiar with mathematical tools: complete metric spaces, contraction mapping theorem, Banach spaces, completion, function spaces, linear operators, inverses, the Uniform Boundedness Principle and the Closed Graph Theorem, approximate solution to operator equations, Frechet derivatives, Newton-Kantorovich method, Schauder fixed point theorem, Hilbert spaces, projections, generalized Fourier series, Riesz representation theorem, Ritz method, generalized solutions, Sobolev spaces, Lax-Milgram theorem, Compact operators, Spectral theorem, Self-Adjoint Compact Operators. The course is designed to teach students how to apply functional analysis to solve real-world problems in mathematical physics and engineering.