About this document

Goal
This document was written to assist VU students in choosing courses within the two mathematical master programs and their tracks:

• *Mathematics*, consisting of six tracks:
  – Algebra and Geometry
  – Analysis and Dynamical Systems
  – Stochastics
  – Biomedical Mathematics
  – Education
  – Teachers
• *Stochastics and Financial Mathematics*

This manual contains information on the overall structure of the Master programs, and lists courses offered in 2016/17 per track, indicating both their level and relevance. Also, several “suggested lines” are given. These are clusters of related courses that offer the possibility of going in depth into several specialisations.

We recommend that you discuss your program with the coordinator of the master programs (Corrie Quant) as early as possible.

Other sources of information
Detailed course descriptions can be found in the online UvA and VU study guides, and on the Mastermath website.

Non-standard programs
If you want to follow a non-standard program (e.g. a major/minor, a double master program, a free program, interdisciplinary program, or if you simply want to include certain courses that are not listed in the program below), then in most cases you will need to have your proposed program approved by the Examination Board. Contact the coordinator of the master program as soon as possible.

Legal disclaimer
No rights can be derived from this document, the only legally binding source regarding your master degree is the *Teaching and Examination Regulations* (commonly known by its Dutch abbreviation OER). You can find this on VUNET.
Mathematics: Algebra and Geometry Track

Program outline

- **6EC**: Master Seminar in Algebra and Geometry (year 1)
- **3EC**: Scientific Writing in English (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **60EC**: Mathematics courses, consisting of
  - At least three courses out of:
    - Algebraic Geometry 1
    - Algebraic Topology
    - Riemann Surfaces
    - Lie Groups and Lie Algebras
  - At least 2 advanced Algebra and Geometry courses
  - Remainder (about 30EC) mathematics courses (all tracks)
- **15EC**: Free (must be master level; can be math, literature, ...)

Fall 2016

Master Seminar

- Master Seminar in Algebra and Geometry (UvA)

Suggested basic courses

- Algebraic Number Theory (Mastermath)
- Algebraic Geometry 1 (Mastermath)
- Algebraic Topology (Mastermath)
- Coding and Cryptography (VU)
- Commutative Algebra (Mastermath)
- Differential Geometry (Mastermath)
- p-Adic Numbers and Applications (Mastermath, not every year)

Advanced courses

- Advanced Algebraic Geometry (Mastermath/WONDER, 17/18)
- Characteristic Classes (UvA, not every year)
- Complex Geometry (Mastermath/M2, not every year)
- Galois Representations and Automorphic Forms (Mastermath/WONDER, not every year)
- Mirror Symmetry (UvA, not every year)
Mathematics: Algebra and Geometry Track

Related courses

- Ergodic Theory (Mastermath)
- Functional Analysis (Mastermath)

Spring 2017

Master Seminar

- Master Seminar in Algebra and Geometry (UvA)

Suggested basic courses

- Cryptology (Mastermath)
- Elliptic Curves (Mastermath)
- Lie Groups and Lie Algebras (Mastermath)
- Operator Algebras (Mastermath)
- Riemann Surfaces (Mastermath)

Advanced courses

- Algebraic Geometry 2 (Mastermath/M2)
- Derived Categories (UvA, not every year)
- Non-Commutative Geometry (UvA, not every year)
- Symplectic Geometry (Mastermath/M2, not every year)

Suggested lines

Algebraic Geometry

- Basic: Algebraic Geometry 1, Commutative Algebra
- Advanced: Algebraic Geometry 2, Advanced Algebraic Geometry (17/18)
- Related: Complex Geometry, Algebraic Topology, Derived Categories

Manifolds

- Basic: Differential Geometry, Lie Groups and Lie Algebras, Riemann Surfaces
- Advanced: Complex Geometry, Symplectic Geometry
- Related: Algebraic Topology

Mathematical Physics

- Basic: Algebraic Topology, Differential Geometry, Lie Groups and Lie Algebras
- Advanced: Non-Commutative Geometry, Mirror Symmetry, TFT & Moduli Spaces (17/18)
- Related: Operator Algebras, Derived Categories, Algebraic Geometry 1
Number Theory

- Basic: Algebraic Number Theory, Elliptic Curves, Modular Forms (17/18), p-Adic Numbers and Applications
- Advanced: Galois Representations and Automorphic Forms
- Related: Commutative Algebra, Algebraic Geometry 1, Ergodic Theory

Research staff in Algebra and Geometry

UvA


VU

Sander Dahmen, Oliver Fabert, Rob de Jeu, Vincent Knibbeler, Dietrich Notbohm, Federica Pasquotto, Jan Sanders, Rob van der Vorst.
Mathematics: Analysis and Dynamical Systems
Track

Program outline

- **6EC**: Master Seminar in Analysis and Dynamical Systems (year 1)
- **3EC**: Scientific Writing in English (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **60EC**: Mathematics courses, consisting of
  - At least 3 courses out of
    * Functional Analysis
    * Partial Differential Equations
    * Dynamical Systems
    * Finite Element Methods for Partial Differential Equations (this course replaces Numerical Linear Algebra that was in this list until 15/16)
  - At least 2 advanced Analysis and Dynamical Systems courses
  - Remainder (about 30EC): mathematical courses (all tracks)
- **15EC**: Free (must be master level; can be math, literature, \ldots)

Fall 2016

Master Seminar
- Master Seminar in Analysis and Dynamical Systems (VU)

Suggested basic courses
- Differential Geometry (Mastermath)
- Dynamical Systems (Mastermath)
- Fourier Analysis and Distributions (Mastermath)
- Functional Analysis (Mastermath)
- Introduction to Numerical Bifurcation Analysis (Mastermath, 15/16)
- Parallel Algorithms (Mastermath)
- Numerical Linear Algebra (Mastermath)

Advanced courses
- Hamiltonian Mechanics (VU, not every year)

Related courses
- Complex Geometry (Mastermath)
- Ergodic Theory (Mastermath)
- Mathematical Biology (Mastermath, Fall 2017)
• Measure Theoretic Probability (Mastermath)

Spring 2017

Master Seminar
• Master Seminar in Analysis and Dynamical Systems (VU)

Suggested basic courses
• Finite Element Methods for Partial Differential Equations (UvA)
• Nonlinear Waves (Mastermath)
• Partial Differential Equations (Mastermath)
• Riemann Surfaces (Mastermath)
• Stochastic Differential Equations (Mastermath)

Advanced courses
• Numerical Methods for Time Dependent PDEs (Mastermath/WONDER, alternates with Num. Meth. for Stationary PDEs)
• Topological Methods for Nonlinear Differential Equations (Mastermath)
• Symplectic Geometry (Mastermath/M2, every year)

Related courses
• Lie Groups and Lie Algebras (Mastermath)
• Stochastic Differential Equations (Mastermath)

Suggested lines

Dynamical systems
• Basic: Dynamical Systems, Partial Differential Equations
• Advanced: Topological Methods for Nonlinear Differential Equations, Hamiltonian Mechanics, Symplectic Geometry
• Related: Ergodic Theory, Functional Analysis, Nonlinear Waves

Numerical Analysis
• Basic: Numerical Linear Algebra, Finite Element Methods for Partial Differential Equations
• Advanced: Numerical Methods for Time Dependent PDEs
• Related: Functional Analysis, Parallel Algorithms, Partial Differential Equations

Research staff in Analysis and Dynamical Systems

UvA
Jan Brandts, Daan Crommelin, Ale Jan Homburg, Han Peters, Rob Stevenson, Chris Stolk, Jan Wiegerinck.
VU
Jan Bouwe van den Berg, Frank Bruggeman, Roberto Castelli, Oliver Fabert, Ale Jan Homburg, Joost Hulshof, Rien Kaashoek, Vincent Knibbeler, Federica Pasquotto, Bob Planqué, André Ran, Bob Rink, Jan Sanders, Rob van der Vorst.
Mathematics: Stochastics Track

Program outline

- **6EC**: Master Seminar in Stochastics (two semesters, year 1)
- **3EC**: Scientific Writing in English (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **60EC**: Mathematics courses, consisting of
  - Compulsory courses:
    - Asymptotic Statistics
    - Measure Theoretic Probability
    - Stochastic Processes
  - At least 2 advanced Stochastics courses
  - Remainder (about 30C): mathematics courses (all tracks)
- **15EC**: Free (must be master courses; can be math, literature, . . .)

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Fall 2016

Master Seminar

- **Master Seminar in Stochastics** (UvA)

Suggested basic courses

- **Applied Stochastic Modelling** (VU)
- **Asymptotic Statistics** (Mastermath)
- **Functional Analysis** (Mastermath)
- **Measure Theoretic Probability** (Mastermath)
- **Simulation Methods in Statistics** (UvA)
- **Statistical Models** (VU)
- **Stochastic Optimization** (VU)
- **Stochastics Processes for Finance** (VU)

Advanced courses

- **Complex Networks** (Mastermath/WONDER)
- **Interest Rate Models** (UvA)
- **Portfolio Theory** (UvA)
- **Queues & Levy Fluctuation Theory** (Mastermath/WONDER)
- **Statistics for High-Dimensional Data** (VU, 17/18)
- **Statistics for Networks** (VU)
Related courses
- Mathematical Biology (Mastermath, 17/18)

Spring 2017

Master Seminar
- Master Seminar in Stochastics (VU)

Suggested basic courses
- Stochastic Differential Equations (Mastermath)
- Stochastic Integration (UvA)
- Stochastic Processes (Mastermath)
- Time Series (Mastermath)

Advanced courses
- Bayesian Statistics (Mastermath/WONDER, not every year)

Related courses
- Ergodic Theory (Mastermath)
- Optimization of Business Processes (VU)

Suggested lines

Probability
- Basic: Measure Theoretic Probability, Asymptotic Statistics
- Advanced: Queues & Levy Fluctuation Theory
- Related: Time Series, Stochastic Integration, Functional Analysis

Statistics
- Basic: Measure Theoretic Probability, Asymptotic Statistics
- Advanced: Bayesian Statistics, Time Series
- Related: Statistical Theory for High- and Infinite-Dimensional Models

Financial Mathematics
- Basic: Measure Theoretic Probability, Stochastics Processes for Finance, Portfolio Theory
- Advanced: Interest Rate Models
- Related: Functional Analysis, Partial Differential Equations
Research staff in Stochastics

UvA
Paulo de Andrade Serra, Arnoud den Boer, Sonja Cox, Daan Crommelin, Jan-Pieter Dorsman, Bert van Es, Asma Khedher, Chris Klaassen, Bas Kleijn, Michel Mandjes, Sindo Núñez Queija, Maria Remerova, Marjan Sjerps, Peter Spreij, Harry van Zanten.

VU
René Bekker, Eduard Belitser, Rob van den Berg, Sandjai Bhulai, Bram Gorissen, Mathisca de Gunst, Wouter Kager, Bartek Knapik, Ger Koole, Ronald Meester, Rob van der Mei, Klaas Sloot, Mark van de Wiel, Wessel van Wieringen.
Mathematics: Biomedical Mathematics Track

Program outline

- **6EC**: Master Seminar in Analysis and Dynamical Systems or Master Seminar in Stochastics (two semesters, year 1)
- **3EC**: Scientific Writing in English (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **30EC**: Minor Biomedical Mathematics
- **36EC**: Mathematics courses, consisting of
  - Compulsory courses:
    * Statistical Models
    * Dynamical Systems
    * Mathematical Biology (Fall 2017; Mastermath)
  - Remainder (about 30C): mathematics courses (all tracks)
- **9EC**: Free (must be master courses; can be math, literature, ...)

Minor Biomedical Mathematics

For this minor we suggest 5 life science courses (see below). The minor may also include an 18EC applied project for students who already followed the VU biomedical mathematics program in the bachelor.

The minor of the Master may include at most 18EC of the bachelor courses currently in the “Biomedische Wiskunde” variant of the bachelor at the VU, for students who did not yet follow those courses. Specifically: Biochemie, Medische Fysiologie, Principles of Systems Biology, Introductie Medische Beeldbewerking.

Fall 2016

Master Seminar

- **Master Seminar in Analysis and Dynamical Systems** (VU) or **Master Seminar in Stochastics** (UvA)

Suggested basic courses

- **Complex Networks** (Mastermath/WONDER)
- **Dynamical Systems** (Mastermath)
- **Functional Analysis** (Mastermath)
- Introduction to Numerical Bifurcation Analysis (Mastermath, not every year)
- **Mathematical Biology** (Mastermath, 17/18)
- **Statistical Models** (VU)
- **Statistics for High-Dimensional Data** (VU, 17/18)
- **Statistics for Networks** (VU)
Suggested life science courses in the Minor Biomedical Mathematics
- Algorithms in Sequence Analysis (VU, period 2)
- Mechanics and Thermodynamics in the Cell (VU, period 2)
- Neurogenomics (VU, period 3)

Spring 2017

Master Seminar
- Master Seminar in Analysis and Dynamical Systems (VU) or Master Seminar in Stochastics (VU)

Suggested basic courses
- Bayesian Statistics (Mastermath/WONDER)
- Numerical Methods for Time Dependent PDEs (Mastermath)
- Partial Differential Equations (Mastermath)
- Stochastic Differential Equations (Mastermath)
- Stochastic Processes (Mastermath)
- Time Series (Mastermath)

Suggested life science courses in the Minor Biomedical Mathematics
- Basic Models of Biological Networks (VU, period 4)
- Advanced Modeling in Systems Biology (VU, period 6)

Research staff in Mathematical Biology

VU
Jan Bouwe van den Berg, Frank Bruggeman, Mathisca de Gunst, Joost Hulshof, Bob Planqué, Mark van de Wiel, Wessel van Wieringen.
Mathematics: Education Track

Program outline

- **24EC**: Master Project Mathematics (T, E track) (year 2)
- **60EC**: Teaching qualification (including internship)
- **24EC**: Mathematics courses, from the MasterMath and local program. This excludes the MasterMath teacher courses.
- **12EC**: Free (must be master courses, but may include the MasterMath teacher courses; can be math, literature, ...)

Alternative program for students with an Education Minor (30EC obtained earlier in the Bachelor)

- **24EC**: Master Project Mathematics (T, E track) (year 2)
- **33EC**: Teaching qualification (reduced: didaktiek, praktijk en onderzoek)
- **51EC**: Mathematics courses, of which at most 27EC from the elective courses in the third year of the bachelor, and at least 24EC courses from the MasterMath and local master program. This excludes the MasterMath teacher courses.
- **12EC**: Free (must be master courses, but may include the MasterMath teacher courses; can be math, literature, ...)

Mathematics: Teachers Track

This track has a special entry requirement: HBO students from the “lerarenopleiding wiskunde” with a “tweedegraadsbevoegdheid” can enter this track after having followed a premaster program (consisting of a specific selection of 30EC of first year bachelor courses). In the Teacher track, they follow a lot of mandatory courses (42EC) and must reach the exit level of the Education track.

Program outline

- **24EC**: Master Project Mathematics (T, E track) (year 2)
- **30EC**: Teaching qualification (reduced, including internship)
- **66EC**: Mathematics courses, consisting of
  - Compulsory courses:
    - Analyse 3
    - Complexe Analyse
    - Dynamische Systemen
    - Measure Theory
    - Numerical Methods
    - Statistical Data Analysis
    - Statistics
  - Remainder (24C): mathematics courses from the MasterMath and local master program. This excludes the MasterMath teacher courses.
Mathematics: Discrete Mathematics

There is no track in discrete mathematics, but there are a few recommended courses open to students from all three tracks. Several staff members at VU and UvA work in Discrete Mathematics and can supervise a Master Project in this area.

Fall 2016

Suggested basic courses
- Probabilistic and Extremal Combinatorics (Mastermath)
- Discrete Optimization (Mastermath)

Advanced courses
- Advanced Combinatorics (Mastermath/WONDER)
- Complex Networks (Mastermath/WONDER)

Related courses
- Algebraic Topology (Mastermath)
- Commutative Algebra (Mastermath)
- Measure Theoretic Probability (Mastermath)
- Ergodic Theory (Mastermath)

Spring 2017

Suggested basic courses
- Algebraic Methods in Combinatorics (Mastermath)
- Coding Theory (Mastermath)
- Advanced Linear Programming (Mastermath)
- Computational Complexity (UvA, Master of Logic)

Advanced courses
- Advanced Topics in Semidefinite Programming (Mastermath)

Research staff in Discrete Mathematics

UvA
Jan Brandts, Viresh Patel, Guus Regts, Lex Schrijver, Jacob Turner.

VU
Bram Gorissen, Rob de Jeu.
Program outline

- **6EC**: Master Seminar in Stochastics (year 1)
- **3EC**: Scientific Writing in English (year 1)
- **36EC**: Master Project SFM (year 2)
- **63EC**: Designated SFM courses, consisting of
  - Measure Theoretic Probability (Mastermath)
  - at least 2 Financial Mathematics courses, out of
    - Computational Finance
    - Interest Rate Models
    - Portfolio Theory
    - Stochastics Processes for Finance
  - at least 2 advanced SFM courses
- **12EC**: Free (must be master courses; can be a designated SFM course, Math, literature, . . .)

Fall 2016

Master Seminar

- Master Seminar in Stochastics (UvA)

Designated SFM courses

- Applied Analysis: Financial Mathematics (VU)
- Applied Stochastic Modelling (VU)
- Asymptotic Statistics (Mastermath)
- Complex Networks (Mastermath/WONDER)
- Fourier Analysis and Distributions (Mastermath)
- Functional Analysis (Mastermath)
- Interest Rate Models (UvA)
- Measure Theoretic Probability (Mastermath)
- Portfolio Theory (UvA)
- Queues & Levy Fluctuation Theory (Mastermath/WONDER)
- Simulation Methods in Statistics (UvA)
- Statistical Models (VU)
- Statistics for Networks (VU)
- Stochastic Optimization (VU)
- Stochastics Processes for Finance (VU)
Advanced SFM courses
- Queues & Levy Fluctuation Theory (Mastermath/WONDER)
- Complex Networks (Mastermath/WONDER)
- Interest Rate Models (UvA)
- Portfolio Theory (UvA)
- Statistics for Networks (VU)

Spring 2017

Master Seminar
- Master Seminar in Stochastics (VU)

Designated SFM courses
- Bayesian Statistics (Mastermath/WONDER)
- Computational Finance (UvA)
- Optimization of Business Processes (VU)
- Partial Differential Equations (Mastermath)
- Queueing Theory (Mastermath)
- Statistical Theory for High- and Infinite-Dimensional Models (UvA)
- Stochastic Differential Equations (Mastermath)
- Stochastic Integration (UvA)
- Stochastic Processes (Mastermath)
- Time Series (Mastermath)

Advanced SFM courses
- Bayesian Statistics (Mastermath/WONDER)
- Statistical Theory for High- and Infinite-Dimensional Models (UvA)

Research staff in SFM

UvA
Paulo de Andrade Serra, Arnoud den Boer, Sonja Cox, Jan-Pieter Dorsman, Bert van Es, Asma Khedher, Chris Klaassen, Bas Kleijn, Michel Mandjes, Sindo Núñez Queija, Maria Remerova, Marjan Sjerps, Peter Spreij, Robin de Vilder, Erik Winands, Harry van Zanten.

VU
René Bekker, Eduard Belitser, Rob van den Berg, Sandjai Bhulai, Bram Gorissen, Mathisca de Gunst, Wouter Kager, Bartek Knapik, Ger Koole, Ronald Meester, Rob van der Mei.
Final remarks

Free Masters

As prescribed in part A of the OER, students may apply to the Board of Examiners to do a “free master”, in which they are not bound to a track. This is not generally advised, unless there is a focus on some research area not represented in the tracks, such as mathematical logic or discrete mathematics. The criteria roughly are:

- **6EC**: One of the three Master Seminars
- **3EC**: Scientific Writing in English
- **36EC**: Master Project Mathematics
- **36EC**: A coherent selection of Master courses in Mathematics or logic, offered in Amsterdam or in Mastermath. At least two of these should be advanced Master courses. The meaning of “coherent” is to be decided by the Board of Examiners.
- **24EC**: Other mathematics courses offered locally and in MasterMath.
- **15EC**: Free (must be master level; can be math, literature, . . . )

Interdisciplinary Masters

The Biomedical Mathematics track is an example of an interdisciplinary track. If a student would like to combine mathematics with another discipline, then the Board of Examiners can approve such a program. The criteria roughly are:

- **6EC**: One of the three Master Seminars
- **3EC**: Scientific Writing in English
- **36EC**: Master Project Mathematics
- **30EC**: A Minor, consisting of a coherent selection of Master courses in a field that is (loosely) related to Mathematics. The meaning of “coherent” is to be decided the Board of Examiners.
- **36EC**: Mathematics courses offered locally or in MasterMath. At least two of these should be advanced Master courses.
- **9EC**: Free (must be master level; can be math, literature, . . . )

Other courses

Several courses that may be followed in the Master Mathematics or as elective courses in the Master SFM, do not fall explicitly under a track and hence were not mentioned in this document. For more details we refer to the online UvA and VU study guides, and the Mastermath website.