About this document

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

- *Mathematics*, consisting of four specializations:
  - Algebra and Geometry
  - Analysis and Dynamical Systems
  - Mathematical Physics
  - Stochastics
- *Stochastics and Financial Mathematics*

This manual contains information on the overall structure of the Master programs, and lists courses offered in 2018/19 per specialization, indicating both their level and relevance. Also, we compile lists of courses per topic within the specialization direction. These are clusters of related courses that offer the possibility of going in depth into a specific topic.

We recommend that you discuss your programme with the coordinator of your master programme 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. The master guide book and the canvas page “*Mathematical Masters*” contains practical information regarding your programme, your Master Project, the PEP-form, the master room, etc. . .

Non-standard programmes
If you want to follow a non-standard programme (e.g. a major/minor, a double master programme, or a programme not in agreement with the requirements as below), then we advise you to contact your programme coordinator as soon as possible. The non-standard programme should be approved by the Examination Board as soon as possible. Also for standard programmes, approval of the Examination Board is required.

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* (TER). You can find this on the blackboard page “*Mathematical Masters*”.

For suggestions or corrections please contact Jasper Stokman (j.v.stokman@uva.nl).
MSc Mathematics: specialization Algebra and Geometry

Program outline

- **6EC**: Master Seminar in Algebra, Geometry and Mathematical Physics (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **66EC**: Mathematics courses, consisting of
  - At least three courses out of:
    * Algebraic Geometry 1
    * Algebraic Methods in Combinatorics
    * Algebraic Number Theory
    * Algebraic Topology
    * Differential Geometry
    * Lie Groups and Lie Algebras
    * Quivers
    * Riemann Surfaces
  - At least two from the following list of advanced courses:
    * Advanced Algebraic Geometry: Abelian Varieties
    * Algebraic Geometry 2
    * Algebraic Topology 2
    * Coding and Cryptography
    * Mirror Symmetry
    * Selected Areas in Cryptology
    * Symplectic Geometry
    * Topics in Number Theory
    * Topos Theory
  - Remainder (about 30EC): elective courses in mathematics (total list of elective courses can be found in appendix 2 of the TER B of Mathematics – see below for a selection related to the specialization)
- **12EC**: Free (must be master level; can be math, literature, . . . )

Elective Courses Related to the Specialization

*Note:* In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available). Please consider the study guide and the Mastermath ELO for details.

**Fall 2018**

- Advanced Algebraic Geometry: Abelian Varieties (Mastermath, recommended prerequisite: Algebraic Geometry 1)
• Algebraic Geometry 1 (Mastermath)
• Algebraic Number Theory (Mastermath)
• Algebraic Topology (Mastermath)
• Analytic Number Theory (Mastermath)
• Commutative Algebra (Mastermath)
• Cryptology (Mastermath)
• Differential Geometry (Mastermath)
• p-Adic Numbers (Mastermath)
• Quivers (UvA)
• Topos Theory (Mastermath)

Spring 2019
• Algebraic Geometry 2 (Mastermath)
• Algebraic Methods in Combinatorics (Mastermath)
• Algebraic Topology 2 (Mastermath)
• Coding and Cryptography (VU)
• Coding Theory (Mastermath)
• Elliptic Curves (Mastermath)
• Geometric PDE (Mastermath)
• Lie Groups and Lie Algebras (Mastermath)
• Mirror Symmetry (UvA)
• Multiple Zeta Functions (Mastermath)
• Riemann Surfaces (Mastermath)
• Selected Areas in Cryptology (Mastermath, recommended prerequisite: Cryptology)
• Symplectic Geometry (Mastermath)
• Topics in Number Theory (UvA, recommended prerequisite: Algebraic Number Theory)

Courses per topic

Note: We list now the courses that are related to specific topics within the specialisation direction. These lists are purely meant to guide the student in compiling a coherent programme. They do not have an official status; in particular, the specialisation requirements as given in the TER and outlined above, should always be fulfilled.

Algebraic Geometry
• Basic: Algebraic Geometry 1, Commutative Algebra
• Advanced: Advanced Algebraic Geometry: Abelian Varieties, Algebraic Geometry 2
• Related: Elliptic Curves, Riemann Surfaces

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

**Number Theory**
- Basic: Algebraic Number Theory, Analytic Number Theory, Elliptic Curves, p-Adic Numbers
- Advanced: Multiple Zeta Functions, Topics in Number Theory
- Related: Algebraic Geometry 1, Commutative Algebra

**Representation Theory**
- Basic: Lie Groups and Lie Algebras, Quivers
- Advanced: Mirror Symmetry, Operator Algebras
- Related: Algebraic Geometry 1, Algebraic Topology, Differential Geometry, Quantum Information Theory, Symmetries and Conservation Laws of Nonlinear PDE

**Cryptography**
- Basic: Coding Theory, Elliptic Curves
- Advanced: Algebraic Number Theory, Coding and Cryptography, Selected Areas in Cryptology, Quantum Information Theory

**Discrete Mathematics**
- Basic: Advanced Linear Programming, Algebraic Methods in Combinatorics, Coding Theory
- Advanced: Coding and Cryptography, Selected Areas in Cryptology
- Related: Additive Combinatorics, Commutative Algebra, Discrete Optimization, Parallel Algorithms, Probabilistic and Extremal Combinatorics

**Note:** for more probabilistic courses in discrete mathematics, also consider the Possible Specialization Path of discrete mathematics in the specialization Stochastics.

**Mathematical and Quantum Logic**
- Basic: Set Theory, Model Theory, Quantum Computing
- Advanced: Topos Theory, Quantum Information Theory
- Related: Machine Learning Theory

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**Research staff in Algebra and Geometry**

**UvA**

**VU**
Sander Dahmen, Oliver Fabert, Rob de Jeu, Federica Pasquotto, Jan Sanders, Rob van der Vorst.
MSc Mathematics: specialization Analysis and Dynamical Systems

Program outline

- **6EC**: Master Seminar in Analysis and Dynamical Systems (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **66EC**: Mathematics courses, consisting of
  - At least three courses out of
    * Control of Infinite Dimensional Systems
    * Differential Geometry
    * Dynamical Systems
    * Functional Analysis
    * Numerical Linear Algebra
    * Numerical Methods for Time Dependent PDEs
    * Partial Differential Equations
    * Uncertainty Quantification and Data Assimilation
  - At least two from the following list of advanced courses:
    * Advanced Complex Analysis
    * Advanced Topics in Stochastic Analysis
    * Algebraic Topology in Dynamical Systems
    * Geometric Functional Analysis and its Applications
    * Nonlinear Waves
    * Operator Algebras
    * Symplectic Geometry
  - Remainder (about 30EC): elective courses in mathematics (the total list of elective courses can be found in appendix 2 of the TER B of Mathematics – see below for a selection related to the specialization)
- **12EC**: Free (must be master level; can be math, literature, ...)
• Differential Geometry (Mastermath)
• Dynamical Systems (Mastermath)
• Ergodic Theory (Mastermath)
• Functional Analysis (Mastermath)
• Measure Theoretic Probability (Mastermath)
• Numerical Linear Algebra (Mastermath)
• Partial Differential Equations (Mastermath)
• Symmetries and Conservation Laws of Nonlinear PDE (Mastermath)
• Uncertainty Quantification and Data Assimilation (UvA)

Spring 2019
• Applied Finite Elements (Mastermath)
• Algebraic Topology in Dynamical Systems (Mastermath)
• Geometric Functional Analysis and its Applications (Mastermath)
• Geometric PDE (Mastermath)
• Inverse Problems in Imaging (Mastermath)
• Lie Groups and Lie Algebras (Mastermath)
• Nonlinear Waves (Mastermath)
• Numerical Bifurcation Analysis of Large-Scale Systems (Mastermath)
• Numerical Methods for Time Dependent PDEs (Mastermath)
• Operator Algebras (Mastermath, recommended prerequisite: Functional Analysis)
• Riemann Surfaces (Mastermath)
• Symplectic Geometry (Mastermath)

Courses per topic

Note: We list now the courses that are related to specific topics within the specialisation direction. These lists are purely meant to guide the student in compiling a coherent programme. They do not have an official status; in particular, the specialisation requirements as given in the TER and outlined above, should always be fulfilled.

Dynamical systems
• Basic: Dynamical Systems, Partial Differential Equations, Numerical Bifurcation Analysis of Large-Scale Systems
• Advanced: Algebraic Topology in Dynamical Systems, Nonlinear Waves
• Related: Ergodic Theory, Functional Analysis, Advanced Complex Analysis

Numerical Analysis
• Basic: Advanced Linear Programming, Applied Finite Elements, Inverse Problems in Imaging, Numerical Linear Algebra, Numerical Methods for Time Dependent PDEs, Partial Differential Equations
• Related: Functional Analysis, Parallel Algorithms
Geometric Analysis

- Basic: Differential Geometry, Functional Analysis, Lie Groups and Lie Algebras
- Advanced: Geometric Functional Analysis and its Applications, Geometric PDE, Symplectic Geometry
- Related: Riemann Surfaces, Symmetries and Conservation Laws of Nonlinear PDE, Advanced Complex Analysis

Functional Analysis

- Basic: Differential Geometry, Functional Analysis
- Advanced: Geometric Functional Analysis and its Applications, Operator Algebras
- Related: Partial Differential Equations

Stochastic Analysis

- Basic: Measure Theoretic Probability, Uncertainty Quantification and Data Assimilation
- Advanced: Advanced Topics in Stochastic Analysis, Ergodic Theory
- Related: Functional Analysis

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, Oliver Fabert, Ale Jan Homburg, Joost Hulshof, Rien Kaashoek, Federica Pasquotto, Bob Planqué, André Ran, Bob Rink, Jan Sanders, Rob van der Vorst.
MSc Mathematics: specialization Mathematical Physics

Note: this is the programme for the specialization. Students that enrolled in the MSc Mathematical Physics before 2017 follow the programme at the end of this document.

Programme outline

- **6EC**: Master Seminar in Algebra, Geometry and Mathematical Physics (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **60EC**: Mathematics courses, consisting of
  - At least three courses out of:
    * Algebraic Geometry 1
    * Algebraic Topology
    * Differential Geometry
    * Lie Groups and Lie Algebras
    * Riemann Surfaces
    * Quantum Computing
  - At least two from the following list of advanced courses:
    * Geometric PDE
    * Mirror Symmetry
    * Operator Algebras
    * Quantum Information Theory
    * Symmetries and Conservation Laws of Nonlinear PDE
    * Symplectic Geometry
    * Topology in Physics
  - Remainder (about 20EC): elective courses in mathematics (total list of elective courses can be found in appendix 2 of the TER B of Mathematics – see below for a selection related to the specialization)
- **6EC**: At least one physics course out of
  - Quantum Field Theory
  - Statistical Physics and Condensed Matter Theory 1
  - String Theory (recommended prerequisites: General Relativity, Quantum Field Theory)
- **12EC**: Free (must be master level; can be math, literature, . . .)

Elective Courses Related to the Specialization

Note: In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available). Please consider the study guide and the Mastermath ELO for details.
MSc Mathematics: specialization Mathematical Physics

Fall 2018
- **Algebraic Geometry 1** (Mastermath)
- **Algebraic Topology** (Mastermath)
- **Differential Geometry** (Mastermath)
- **Functional Analysis** (Mastermath)
- **Quivers** (UvA)
- **Symmetries and Conservation Laws of Nonlinear PDE** (Mastermath)

Spring 2019
- **Algebraic Geometry 2** (Mastermath)
- **Algebraic Topology 2** (Mastermath)
- **Advanced Algebraic Geometry: Abelian Varieties** (Mastermath)
- **Geometric PDE** (Mastermath)
- **Lie Groups and Lie Algebras** (Mastermath)
- **Mirror Symmetry** (UvA)
- **Operator Algebras** (Mastermath, recommended prerequisite: Functional Analysis)
- **Quantum Computing** (Mastermath)
- **Quantum Information Theory** (Mastermath)
- **Riemann Surfaces** (Mastermath)
- **Symplectic Geometry** (Mastermath)
- **Topology in Physics** (Mastermath)

Courses per topic

**Note:** We list now the courses that are related to specific topics within the specialisation direction. These lists are purely meant to guide the student in compiling a coherent programme. They do not have an official status; in particular, the specialisation requirements as given in the TER and outlined above, should always be fullfilled.

**Topological and Geometric Aspects**
- Basic: Algebraic Geometry 1, Algebraic Topology, Differential Geometry
- Advanced: Geometric PDE, Mirror Symmetry, Symplectic Geometry, Topology in Physics
- Related: Lie Groups and Lie Algebras, Riemann Surfaces, String Theory

**Analytic Aspects**
- Basic: Differential Geometry, Functional Analysis, Riemann Surfaces
- Advanced: Operator Algebras, Symplectic Geometry
- Related: Algebraic Topology, Lie Groups and Lie Algebras

**Quantum Theory**
- Basic: Differential Geometry, Lie Groups and Lie Algebras, Statistical Physics and Condensed Matter Theory 1
• Advanced: Interacting Particle Systems: Theory and applications, Operator Algebras, Symmetries and Conservation Laws of Nonlinear PDE, Symplectic Geometry, Quantum Field Theory
• Related: Algebraic Topology, Partial Differential Equations, Riemann Surfaces

Quantum Computing & Quantum Information
• Basic: Machine Learning Theory, Quantum Computing, Statistical Physics and Condensed Matter Theory 1
• Advanced: Geometric Functional Analysis and its Applications, Quantum Information Theory
• Related: Advanced Machine Learning, Coding Theory, Computational Complexity

Note: by including courses in quantum computing & quantum information theory in your study programme, it might be possible to do a master project at the research institute QuSoft, see also the QuSoft programme

Research staff in Mathematical Physics

UvA

VU
Oliver Fabert, Federica Pasquotto, Jan Sanders, Rob van der Vorst.
MSc Mathematics: specialization Stochastics

Note: Because of significant overlap in content, students cannot take both the courses Stochastic Integration (UvA) and Stochastic Differential Equations (Mastermath).

Program outline

- **6EC**: Master Seminar in Stochastics (year 1)
- **36EC**: Master Project Mathematics (year 2)
- **66EC**: Mathematics courses, consisting of
  - Measure Theoretic Probability (Mastermath)
  - At least two courses out of:
    - Asymptotic Statistics
    - Machine Learning Theory
    - Simulation Methods in Statistics
    - Stochastic Networks
    - Stochastic Processes
    - Stochastic Simulation
  - At least two from the following list of advanced courses:
    - Advanced Topics in Stochastic Analysis
    - Bayesian Statistics
    - Data-Driven Decision Making in Operations Research
    - Interacting Particle Systems: Theory and applications
    - Portfolio Theory
    - Queues & Levy Fluctuation Theory
    - Statistical Theory for High- and Infinite-Dimensional Models
    - Interest Rate Models
  - Remainder (about 30EC): elective courses in mathematics (total list of elective courses can be found in appendix 2 of the TER B of Mathematics – see below for a selection related to the specialization)
- **12EC**: Free (must be master courses; can be math, literature, . . . )

Elective Courses Related to the Specialization

Note: In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available). Please consider the study guide and the Mastermath ELO for details.

Fall 2018
- Advanced Topics in Stochastic Analysis (UvA)
- Applied Stochastic Modelling (VU)
- Asymptotic Statistics (Mastermath)
- Ergodic Theory (Mastermath, recommended prerequisite: Measure Theoretic Probability)
- Forensic Probability and Statistics (Mastermath)
- Functional Analysis (Mastermath)
- Heuristic Methods in Operations Research (Mastermath)
- Interacting Particle Systems: Theory and applications (Mastermath)
- Interest Rate Models (UvA, recommended prerequisites: Measure Theoretic Probability, Stochastic Processes for Finance and Stochastic Integration)
- Machine Learning Theory (Mastermath)
- Probabilistic and Extremal Combinatorics (Mastermath)
- Portfolio Theory (UvA, recommended prerequisite: Measure Theoretic Probability)
- Simulation Methods in Statistics (UvA, recommended prerequisite: Measure Theoretic Probability)
- Statistical Models (VU)
- Stochastic Networks (UvA)
- Stochastic Optimization (VU)
- Stochastic Processes for Finance (VU)
- Stochastic Simulation (UvA)
- Uncertainty Quantification and Data Assimilation (UvA)

Spring 2019
- Bayesian Statistics (Mastermath, recommended prerequisite: Measure Theoretic Probability)
- Applied Statistics (Mastermath)
- Data-Driven Decision Making in Operations Research (UvA)
- Queues & Levy Fluctuation Theory (UvA)
- Queueing Theory (Mastermath)
- Scheduling (Mastermath)
- Statistics for Networks (VU)
- Stochastic Integration (UvA, recommended prerequisite: Measure Theoretic Probability)
- Stochastic Processes (Mastermath, recommended prerequisite: Measure Theoretic Probability)

Courses per topic

**Note:** We list now the courses that are related to specific topics within the specialisation direction. These lists are purely meant to guide the student in compiling a coherent programme. They do not have an official status; in particular, the specialisation requirements as given in the TER and outlined above, should always be fulfilled.
MSc Mathematics: specialization Stochastics

Stochastics & Probability
- Basic: Stochastic Integration, Stochastic Simulation, Stochastic Processes
- Advanced: Advanced Topics in Stochastic Analysis, Queues & Levy Fluctuation Theory
- Related: Ergodic Theory, Forensic Probability and Statistics,

Statistics
- Advanced: Advanced Machine Learning, Bayesian Statistics, Statistical Theory for High- and Infinite-Dimensional Models
- Related: Forensic Probability and Statistics, Functional Analysis

Networks
- Advanced: Queues & Levy Fluctuation Theory
- Related: Probabilistic and Extremal Combinatorics, Queueing Theory

Applied Stochastics & Operations Research
- Related: Advanced Linear Programming, Forensic Probability and Statistics, Queueing Theory, Scheduling

Discrete Mathematics
- Basic: Discrete Optimization, Probabilistic and Extremal Combinatorics, Stochastic Networks
- Related: Advanced Linear Programming, Computational Complexity (jointly with MSc Logic), Scheduling

Note: for more algebraic courses in discrete mathematics, also consider the Possible Specialization Path of discrete mathematics in the specialization Algebra & Geometry.

Research staff in Stochastics

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

VU
René Bekker, Eduard Belitser, Rob van den Berg, Sandjai Bhulai, Federico Camia, Elena Dugundji, Bram Gorissen, Mathisca de Gunst, Wouter Kager, Ger Koole, Ronald Meester, Rob van der Mei, Klaas Slooten, Mark van de Wiel, Wessel van Wieringen.
MSc Stochastics and Financial Mathematics

Note: Because of significant overlap in content, students can only take one out the two courses Stochastic Integration (UvA) and Stochastic Differential Equations (Mastermath) and one out of Applied Analysis: Financial Mathematics and Stochastic Processes for Finance.

Note: It is possible to follow an Internship Stochastics & Financial Mathematics in the beginning of the summer for 3EC.

Program outline

• 3EC: Master Seminar Stochastics and Financial Mathematics (year 1)
• 36EC: Master Project Stochastics and Financial Mathematics (year 2)
• 69EC: Mathematics and SFM courses, consisting of
  – Measure Theoretic Probability (Mastermath)
  – at least two courses out of the following list of courses in financial mathematics:
    * Computational Finance (UvA MSc Computational Science)
    * Interest Rate Models (UvA, recommended prerequisites: Measure Theoretic Probability, Stochastic Processes for Finance and Stochastic Integration)
    * Portfolio Theory (UvA, recommended prerequisite: Measure Theoretic Probability)
    * Stochastic Processes for Finance (VU)
  – At least two from the following list of advanced courses:
    * Advanced Machine Learning
    * Advanced Topics in Stochastic Analysis
    * Data-Driven Decision Making in Operations Research
    * Interest Rate Models
    * Portfolio Theory
    * Queues & Levy Fluctuation Theory
    * Statistical Theory for High- and Infinite-Dimensional Models
    * Stochastic Networks
    * Stochastic Simulation
  – Remainder (about 35EC): elective courses in SFM (list can be found in appendix 2 of the TER B of Stochastics and Financial Mathematics, see also below)
• 12EC: Free (must be master courses; can be a designated SFM course, Math, literature, . . . )

Elective Courses in the master SFM

Note: In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available. Please consider the study guide and the Mastermath ELO for details.
Fall 2018

- **Advanced Machine Learning** (VU)
- **Advanced Topics in Stochastic Analysis** (UvA)
- **Applied Stochastic Modelling** (VU)
- **Asymptotic Statistics** (Mastermath)
- **Forensic Probability and Statistics** (Mastermath)
- **Interest Rate Models** (UvA, recommended prerequisites: Measure Theoretic Probability, Stochastic Processes for Finance and Stochastic Integration)
- **Machine Learning Theory** (Mastermath)
- **Portfolio Theory** (UvA, recommended prerequisite: Measure Theoretic Probability)
- **Simulation Methods in Statistics** (UvA, recommended prerequisite: Measure Theoretic Probability)
- **Statistical Models** (VU)
- **Stochastic Networks** (UvA)
- **Stochastic Optimization** (VU)
- **Stochastic Simulation** (UvA)
- **Stochastic Processes for Finance** (VU)

Spring 2019

- **Applied Statistics** (Mastermath)
- **Bayesian Statistics** (Mastermath, recommended prerequisite: Measure Theoretic Probability)
- **Computational Finance** (UvA, MSc Computational Science)
- **Data-Driven Decision Making in Operations Research** (UvA)
- **Queues & Levy Fluctuation Theory** (UvA)
- **Queueing Theory** (Mastermath)
- **Optimization of Business Processes** (VU, recommended prerequisite: Applied Stochastic Modelling)
- **Statistics for Networks** (VU)
- **Statistical Theory for High- and Infinite-Dimensional Models** (Mastermath, recommended prerequisites: Measure Theoretic Probability, Asymptotic Statistics, Stochastic Processes, Functional Analysis)
- **Stochastic Integration** (UvA, recommended prerequisite: Measure Theoretic Probability)

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**Research staff in SFM**

**UvA**

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

**VU**

René Bekker, Eduard Belitser, Rob van den Berg, Sandjai Bhulai, Federico Camia, Elenna Dugundji, Bram Gorissen, Mathisca de Gunst, Wouter Kager, Ger Koole,
Double Master Programmes

It is possible to combine two master programmes in order to be awarded two Master's degrees - one in Mathematics or SFM and one in a different field. Generically, the following requirements must be met:

1. the total programme of the candidate should amount to at least 180 EC credits;
2. the two master programmes may not show too much similarity;
3. the candidate's work for the programme (lectures, research work, etc.), must be of such a standard that all the exit qualifications of each of the two programmes have been met;
4. the candidate must have conducted separate research work for both Master's degrees. This may consist of two separate research projects with supervisors from the respective study programmes. In the case of an integrated research project, this must be supervised by two staff members appointed from the two study programmes. Both staff members must assess the work as a pass, according to the standards for a research project in the respective master degrees. The total number of credits given for an integrated research project is 3/4 of the sum of the credits given for two independent research projects;
5. in addition to 1-4, the other study programme may impose further requirements;
6. the Examinations Boards of both study programmes must approve the student's double Master's programme before the student commences on the double Master's programme.

There are three double master programmes that are conducted quite often:

- Econometrics and Mathematics
- Econometrics and SFM
- Mathematics and Theoretical Physics

For the two double master programmes with Econometrics different rules apply, since the master Econometrics is a one-year Master programme (60EC):

1. the total study load of the programme of the candidate should amount to at least 150 EC;
2. the candidate’s work for the Master’s programme (lectures, research work etc.) is of such a standard that all exit qualifications of each of the two programmes have been met;
3. the candidate has conducted an integrated research project Master Project Econometrics and Mathematics (36 EC), replacing Master Project Mathematics. This must be supervised by staff members from the two study programmes; both staff members must assess the work as a pass, according to the standards for a research project in their respective master degrees;
4. the Examinations Boards of both study programmes must approve the student's double Master’s programme before the student commences on the double Master's programme.
Mathematics and Theoretical Physics

The double master programme with Theoretical Physics has a detailed curriculum, including the special Math-Phys course "Topology in Physics":

- **6EC**: Student Seminar Theoretical Physics
- **6EC**: Master Seminar in Algebra, Geometry and Mathematical Physics
- **72EC**: Master Project Mathematics & Theoretical Physics
- **8EC**: Topology in Physics
- **12EC**: Compulsory physics courses:
  - Quantum Field Theory
  - Statistical Physics and Condensed Matter Theory 1
- **16EC**: Compulsory mathematics courses:
  - Differential Geometry
  - Lie Groups and Lie Algebras
- **12EC**: Elective courses in Physics & Astronomy (as in appendix 2 of the TER of Physics & Astronomy) different from Group Theory and Mathematical Methods in Theoretical Physics, at least **6EC** from the track Theoretical Physics
- **36EC**: Elective courses in mathematics (as in appendix 2 of the TER of Mathematics) constraint as follows:
  - At least four courses from the Algebra & Geometry or Mathematical Physics specializations
  - At least one out of
    - Algebraic Geometry 1
    - Algebraic Topology
    - Riemann Surfaces
- **12EC**: Free (must be master level; can be math, literature, . . .)

Elective Courses Related to the Double Master Mathematics & Theoretical Physics

**Note**: In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available). Please consider the study guide and the Mastermath ELO for details. For the complete list of elective courses in Mathematics and Theoretical Physics please consult the TER’s of both programmes (for Mathematics they are also listed in the appendix of the mini-manual).

Fall 2018

Courses in Mathematics

- **Algebraic Geometry 1** (Mastermath)
- **Algebraic Topology** (Mastermath)
- **Functional Analysis** (Mastermath)
- **Quivers** (UvA)
Courses in Theoretical Physics

- Advanced Topics in Theoretical Physics 1 (UvA, recommended prerequisites: Quantum Field Theory, Statistical Physics and Condensed Matter Theory 1)
- General Relativity (UvA)
- Particle Physics I (UvA)

Spring 2019

Courses in Mathematics

- Algebraic Geometry 2 (Mastermath)
- Algebraic Topology 2 (Mastermath)
- Geometric PDE (Mastermath)
- Mirror Symmetry (UvA)
- Operator Algebras (Mastermath, recommended prerequisite: Functional Analysis)
- Quantum Computing (Mastermath)
- Quantum Information Theory (Mastermath)
- Riemann Surfaces (Mastermath)
- Symplectic Geometry (Mastermath)

Courses in Theoretical Physics

- Advanced Quantum Field Theory (UvA)
- Advanced Topics in Theoretical Physics 2 (UvA)
- Particle Physics II (UvA)
- String Theory (UvA, recommended prerequisites: General Relativity, Quantum Field Theory)

Research staff in Mathematical Physics

UvA

VU
Oliver Fabert, Federica Pasquotto, Jan Sanders, Rob van der Vorst.
Major programmes

There are three possible majors:

- Teaching
- Science in Society
- Science Communication

The generic programme outline is as follows:

Programme outline

- **36EC**: Constraint electives in Mathematics (year 1)
- **24EC**: Master Project Mathematics (year 1)
- **60EC**: Major programme as below (year 2)

**Major Teaching programme outline**

Note: This major programme is given in Dutch. Successful completion results in a ‘eerstegraads lesbevoegdheid’.

- Compulsory courses:
  - Pedagogiek en Algemene Didactiek A (3EC, period 1)
  - Onderwijspraktijk A (6EC, period 1)
  - Pedagogiek en Algemene Didactiek B (3EC, period 2)
  - Onderwijspraktijk B (9EC, period 2 and 3)
  - Vakdidactiek 1 (9EC, semester 1)
  - Onderwijspraktijk C (15EC, semester 2)
  - Educatief Ontwerpen (9EC, semester 2)
  - Vakdidactiek 2 (3EC, period 5)
- One elective courses out of
  - Pedagogische Ethiek (3EC, period 4)
  - Leerling-Leerkracht Interactie (3EC, period 4)
  - Leerlingbegeleiding en Passend Onderwijs (3EC, period 4)
  - Sociale Veiligheid en Pesten (3EC, period 4)

**Major Science Communication programme outline**

Note: This major programme is given at the VU.

- Compulsory courses:
  - Research Methods for Analyzing Complex Problems (6EC, period 1)
  - Science and Communication (6EC, period 2)
Major and minor programmes

- One out of two possible internships:
  - Reflective Practice Internship Science Communication (30EC, all year)
  - Research Internship Science Communication (30EC, all year)

- Elective courses: 18 EC out of
  - Communication, Organization and Management (6EC, period 2)
  - Science in Dialogue (6EC, period 2)
  - Science Journalism (6EC, period 2, in Dutch)
  - Science Museology (6EC, period 3)

**Major Science in Society Programme outline**

**Note:** This major programme is given at the VU.

- Compulsory courses:
  - Research Methods for Analyzing Complex Problems (6EC, period 1)
  - Analysis of Government Policy (6EC, period 1)
  - Communication, Organization and Management (6EC, period 2)
  - Internship Science in Society (30EC, all year)

- Elective courses: 12 EC out of
  - Business Management in Health and Life Sciences (6EC, period 2)
  - Disability and Development (6EC, period 2)
  - Health, Globalisation and Human Rights (6EC, period 2)
  - Management of innovative technologies in CBH (6EC, period 2)
  - Policy, Politics and Participation (6EC, period 2)
  - Science in Dialogue (6EC, period 2)
  - Clinical Development and Clinical Trials (3EC, period 3)
  - Epidemiology (3EC, period 3)
  - Ethics in Life Sciences (3EC, period 3)
  - Innovation Behavior and Economy (3EC, period 3)
  - International Comparative Analysis of Health Care Systems (6EC, period 3)
  - Science Museology (6EC, period 3)

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**Minor programmes**

There are three possible minors:

- Tesla
- Teaching (in Dutch)
- Science for Sustainability

For more details on the exact programme content of a specific minor, please press the links in the list above. The generic programme outline is as follows:

**Programme outline**

- **6EC:** Master seminar mathematics (year 1)
- **48EC:** Constraint electives
• **24EC**: Master Project Mathematics (year 2)
• **12EC**: Free (must be master level; can be math, literature, . . .)
• **30EC**: Minor programme (year 2)
MSc Mathematical Physics (old style)

Note: this is the programme for students that enrolled the master Mathematical Physics before 2017. This is not the programme for master Mathematics students following the specialization Mathematical Physics.

Programme outline

- **6EC**: Master Seminar in Algebra, Geometry and Mathematical Physics (year 1)
- **48EC**: Master Project in Mathematical Physics (year 2)
- **38EC**: Compulsory mathematics courses:
  - Algebraic Topology
  - Differential Geometry
  - Lie Groups and Lie Algebras
  - Mirror Symmetry
  - Topology in Physics
- **12EC**: At least 2 physics courses out of
  - Quantum Field Theory
  - Statistical Physics and Condensed Matter Theory 1
  - String Theory (recommended prerequisites: General Relativity, Quantum Field Theory)
- **16EC**: Mathematics or physics courses from the list of elective courses (total list of elective courses can be found in appendix 2 of the TER B of Mathematical Physics, see also below)

Elective Courses in the master Mathematical Physics

Note: In the following list of courses the prerequisites are only given if they are of master level and explicitly mentioned in the course description (if available. Please consider the study guide and the Mastermath ELO for details.

Fall 2018
- Algebraic Geometry 1 (Mastermath)
- Functional Analysis (Mastermath)
- Quantum Field Theory (UvA)
- Quantum Field Theory extension (UvA)
- Quivers (UvA)
- Statistical Physics and Condensed Matter Theory 1 (UvA)
- Symmetries and Conservation Laws of Nonlinear PDE (Mastermath)

Spring 2019
- Algebraic Geometry 2 (Mastermath)
- Algebraic Topology 2 (Mastermath)
• Advanced Algebraic Geometry: Abelian Varieties (Mastermath)
• Geometric PDE (Mastermath)
• Operator Algebras (Mastermath, recommended prerequisite: Functional Analysis)
• Quantum Computing (Mastermath)
• Quantum Information Theory (Mastermath)
• Riemann Surfaces (Mastermath)
• Statistical Physics and Condensed Matter Theory II (UvA)
• String Theory (UvA, recommended prerequisites: General Relativity, Quantum Field Theory)
• Symplectic Geometry (Mastermath)

Research staff in Mathematical Physics

UvA

VU
Oliver Fabert, Federica Pasquotto, Jan Sanders, Rob van der Vorst.
Appendix: Elective Courses in Mathematics

Fall 2018

- Advanced Algebraic Geometry: Abelian Varieties
- Advanced Machine Learning
- Advanced Topics in Stochastic Analysis
- Algebraic Geometry 1
- Algebraic Number Theory
- Algebraic Topology
- Analytic Number Theory
- Applied Stochastic Modelling
- Asymptotic Statistics
- Commutative Algebra
- Continuous Optimization
- Control of Infinite Dimensional Systems
- Cryptology
- Differential Geometry
- Discrete Optimization
- Dynamical Systems
- Ergodic Theory
- Forensic Probability and Statistics
- Functional Analysis
- Heuristic Methods in Operations Research
- Interacting Particle Systems: Theory and applications
- Interest Rate Models
- Machine Learning Theory
- Measure Theoretic Probability
- Numerical Linear Algebra
- p-Adic Numbers
- Parallel Algorithms
- Partial Differential Equations
- Portfolio Theory
- Probabilistic and Extremal Combinatorics
- Quivers
- Reading Course Mathematics
- Set Theory
- Simulation Methods in Statistics
- Statistical Models
- Stochastic Networks
- Stochastic Optimization
- Stochastic Processes for Finance
- Stochastic Simulation
- Symmetries and Conservation Laws of Nonlinear PDE
- Systems and Control
- Topos Theory
- Uncertainty Quantification and Data Assimilation
Appendix: Elective Courses in Mathematics

Spring 2019

- Additive Combinatorics
- Advanced Complex Analysis
- Advanced Linear Programming
- Algebraic Geometry 2
- Algebraic Methods in Combinatorics
- Algebraic Topology 2
- Algebraic Topology in Dynamical Systems
- Applied Analysis: Financial Mathematics
- Applied Finite Elements
- Applied Statistics
- Bayesian Statistics
- Coding and Cryptography
- Coding Theory
- Computational Complexity
- Data-Driven Decision Making in Operations Research
- Elliptic Curves
- Entrepreneurship in Data Science and Analytics
- Geometric Functional Analysis and its Applications
- Geometric PDE
- History and Philosophy of Mathematics
- Inverse Problems in Imaging
- Lie Groups and Lie Algebras
- Mirror Symmetry
- Model Theory
- Multiple Zeta Functions
- Nonlinear Waves
- Numerical Bifurcation Analysis of Large-Scale Systems
- Numerical Methods for Time Dependent PDEs
- Operator Algebras
- Optimization of Business Processes
- Performance of Networked Systems
- Quantum Computing
- Quantum Information Theory
- Queueing Theory
- Queues & Levy Fluctuation Theory
- Reading Course Mathematics
- Riemann Surfaces
- Scheduling
- Selected Areas in Cryptology
- Statistical Theory for High- and Infinite-Dimensional Models
- Statistics for Networks
- Stochastic Differential Equations
- Stochastic Integration
- Stochastic Processes
- Symplectic Geometry
• Topics in Number Theory
• Topology in Physics