
# Mathematics MSc

VU University Amsterdam - Faculteit der Exacte Wetenschappen - M Mathematics - 2015-2016

The master programme Mathematics offers the student a wide range of advanced mathematics courses. The students have a variety of options to specialize in a (sub)field of fundamental mathematics, or to choose subjects more broadly either with an eye towards applications or focused at a profession.

Reflecting these possibilities, there are several variants of the programme. In the *Research* (R) and *Professional* (P) variants, the students choose courses for 84 EC and complete their studies with a master project (R variant) or an internship (P variant) for 36 EC. The same applies to the *Biomedical* (B) variant, but in this variant at least 30 EC of the courses are to be chosen from the area of life sciences. The *Education* (E), *Society oriented* (S) and the *Communication* (C) variants consist of 36 EC Mathematics courses, a master project of 24 EC, and 60 EC dedicated to variant specific courses, projects and/or internships. Details about the compulsory courses in the different variants can be found in the study guide. In the R, P and B variants at most 15 EC can be devoted to optional courses, while the optional courses in the E, S and C variants are restricted to 12 EC.

At the start of every semester, students discuss their programme with the master coordinator. Mathematics courses can be selected from the ‘local’ courses offered by VU University Amsterdam and the University of Amsterdam, but also from the MasterMath programme offered jointly by the nine Dutch Universities that have a master programme in Mathematics or Engineering Mathematics. Students in the R and P variants are expected to follow at least 30 EC of these courses.

The master project is carried out under the supervision of a staff member of VU University Amsterdam or the University of Amsterdam. In case of an internship the student has a local advisor at the company and a supervisor from one of the two institutes; please contact the internship office roughly half a year before the start of the internship. In the R, P and B variants the student can only start the master project or internship after obtaining at least 75 EC.

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# Analysis and Dynamical Systems track

• Thesis 36EC
• Seminar Mathematics (6EC); track A&DS
• Scientific Writing in English (3EC)
• Elective courses, possibly outside maths (15EC)

The other 60EC:
• Mandatory: at least 3 courses from the following list (in MasterMath):
- Functional Analysis
- Partial Differential Equations
- Dynamical Systems
- Numerical Linear Algebra
• At least two advanced courses in A&DS:
usually taken in the second year of the Master. These courses are mostly offered locally
in Amsterdam and may change from year to year. In 2014/15 these are
- Topological methods for Differential Equations (MasterMath/Wonder)
- Floer Theory (local, VU)
- Adaptive Finite Elements (local, UvA)
- Fourier Analysis and Distributions (MasterMath)
- Numerical Methods for Time-dependent PDEs (MasterMath)
• This leaves 24EC free to choose in mathematics:
There is freedom to choose any courses from the MasterMath and local offering in mathematics. Some (nonbinding) suggestions:!
- Numerical Methods for Stationary PDEs (spring 2016)!
- Introduction to Numerical Bifurcation Analysis (spring 2016)
- Asymptotic Methods for DEs
- Mathematical Biology (probably fall 2015)
- Representation Theory
- Ergodic Theory
- Measure Theoretic Probabilty
- Asymptotic Statistics
- Stochastic Processes
- Time Series
- Differential Geometry (fall 2015)
- Symplectic Geometry
- Infinite Dimensional Systems
- Stochastic Differential Equations
• In total at least 30EC have to be MasterMath courses.

Programme components:

- Compulsory Choice 2 out of 6 (advanced courses Analysis and Dynamical Systems)
- Suggested elective Courses (MasterMath and Local courses)
- Compulsary choice 3 out of 4
- Compulsory Courses

# Compulsory Choice 2 out of 6 (advanced courses Analysis and Dynamical Systems)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |

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|---|---|---|---|
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Suggested elective Courses (MasterMath and Local courses)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Finance | Period 4+5 | 6.0 | X_418045 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |

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|---|---|---|---|
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |
| Interest Rate Models | Period 1+2 | 6.0 | X_418091 |
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Portfolio Theory | Period 1+2 | 6.0 | X_400535 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Statistical Data Analysis | Period 1 | 6.0 | X_420067 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |

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| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |

## Compulsary choice 3 out of 4

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |

## Compulsory Courses

Beyond the compulsory courses mentioned in the list below, students have to choose at least 6 credits in academic skill (including the course Scientific Writing in English).

Note: Every programme, including the choice of optional courses, has to be discussed and agreed upon with the master coordinator or a personal mentor and approved by the Examination Board.

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Master Project Mathematics | Ac. Year (September) | 36.0 | X_400355 |
| Scientific Writing in English | Period 4 | 3.0 | X_400512 |
| Seminar Mathematics | Period 1+2 | 6.0 | X_405024 |

## Algebra and Geometry track

• Thesis 36 EC
• Seminar Mathematics (6EC); track A&G
• Scientific Writing in English (3EC)
• Elective courses, possibly outside maths (15EC)

The other 60EC:
• Mandatory: at least 3 courses from the following list (in MasterMath):
- Algebraic Topology
- Algebraic Geometry
- Symplectic Geometry
- Semisimple Lie Algebras
- Differential Geometry (fall 2015), Lie Groups (spring 2016), Riemann Surfaces (spring 2016), Operator Algebras (fall 2015)
• At least two advanced courses in A&G:
usually taken in the second year of the Master. These courses are mostly offered locally in Amsterdam and may change from year to year. In 2014/15 these are
- Abelian Varieties (MasterMath/Wonder)

- Advanced Algebraic Geometry (MasterMath/Wonder)
- Algebraic Number Theory (MasterMath)
- Commutative Algebra (MasterMath)
- Non-commutative Geometry (local, UvA)
- Mirror Symmetry (local, UvA)
- Introduction to Contact Topology (local, VU)
- Floer Theory (local, VU)
- Modular Forms (local, VU)

• This leaves 24EC free to choose in mathematics:
There is freedom to choose any courses from the MasterMath and local offering in mathematics. Some (nonbinding) suggestions:
- Functional Analysis
- Cryptology
- Analytic Methods in Discrete Mathematics

• In total at least 30EC have to be MasterMath courses.

Programme components:

- Compulsory Choic 2 out of 7 Advanced Courses Algebra and Geometry
- Suggested elective Courses (MasterMath and Local courses)
- Compulsary choice 3 out of 9 (Mastermath)
- Compulsory Courses

## Compulsory Choic 2 out of 7 Advanced Courses Algebra and Geometry

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |

## Suggested elective Courses (MasterMath and Local courses)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |

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|---|---|---|---|
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Computational Finance | Period 4+5 | 6.0 | X_418045 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |
| Interest Rate Models | Period 1+2 | 6.0 | X_418091 |
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Nonparametric Bayesian Statistics | Period 1+2 | 6.0 | X_418124 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Portfolio Theory | Period 1+2 | 6.0 | X_400535 |

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|---|---|---|---|
| Probabilistic and Extremal Combinatorics | Period 1+2 | 8.0 | X_418118 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Spatial Statistics | Period 4+5 | 6.0 | XMM_00001 |
| Statistical Data Analysis | Period 4+5 | 6.0 | X_401029 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Compulsary choice 3 out of 9 (Mastermath)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algebraic Topology | | 8.0 | X_400600 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Semisimple Lie Algebras | | 8.0 | X_418034 |
| Symplectic Geometry | | 8.0 | X_418036 |

## Compulsory Courses

Beyond the compulsory courses mentioned in the list below, students have to choose at least 6 credits in academic skill (including the course Scientific Writing in English).

Note: Every programme, including the choice of optional courses, has to be discussed and agreed upon with the master coordinator or a personal mentor and approved by the Examination Board.

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Master Project Mathematics | Ac. Year (September) | 36.0 | X_400355 |
| Scientific Writing in English | Period 4 | 3.0 | X_400512 |
| Seminar Mathematics | Period 1+2 | 6.0 | X_405024 |

## Biomedical Mathematics track

Programme components:

- Compulsory Choice
- Recommended Choice Life Science Courses (30 EC)
- Compulsory Courses

## Compulsory Choice

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |

| | | | |
|---|---|---|---|
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Probabilistic and Extremal Combinatorics | Period 1+2 | 8.0 | X_418118 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |

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|---|---|---|---|
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |
| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Recommended Choice Life Science Courses (30 EC)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced modelling in Systems Biology | Period 6 | 6.0 | X_418155 |
| Algorithms in Sequence Analysis | Period 2 | 6.0 | X_405050 |
| Basic Models of Biological Networks | Period 4 | 6.0 | X_418154 |
| Neurogenomics | Period 3 | 6.0 | AM_1007 |
| Physical Biology of the Cell | Period 2 | 6.0 | X_422589 |

## Compulsory Courses

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Master Project Mathematics | Ac. Year (September) | 36.0 | X_400355 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |

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|---|---|---|---|
| Scientific Writing in English | Period 4 | 3.0 | X_400512 |
| Seminar Mathematics | Period 1+2 | 6.0 | X_405024 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |

## Education track

Programme components:

- LVHO Wiskunde, overgangsregeling
- Master Leraar VHO Wiskunde vanaf 2015
- Leraar voorbereidend hoger onderwijs in Wiskunde - verplichte vakken
- Recommended Choice (masterMath and local Courses)
- Compulsory Course Mathematics

## LVHO Wiskunde, overgangsregeling

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Educational and Pedagogical Studies I | Period 1+2 | 6.0 | O_MLADEPI |
| Research I | Period 1+2+3 | 3.0 | O_MLVPOOI |
| Teaching Methodology Mathematics I | Period 1+2 | 3.0 | O_MLVDWII |
| Teaching Practice I | Period 1+2+3 | 15.0 | O_MLPRAKI |

## Master Leraar VHO Wiskunde vanaf 2015

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Didactiek 1 | Period 1, Period 4 | 6.0 | O_MLDIDAC_1 |
| Didactiek 2 | Period 2+3, Period 5+6 | 6.0 | O_MLDIDAC_2 |
| Didactiek 3 | Period 4+5+6 | 9.0 | O_MLDIDAC_3 |
| Peergroup 1 | Period 1+2+3, Period 4+5+6 | 0.0 | O_MLPEERGR_1 |
| Peergroup 2 | Period 3+4+5 | 0.0 | O_MLPEERGR_2 |
| Praktijk 1 | Period 1, Period 4 | 6.0 | O_MLPRAK_1 |
| Praktijk 2 | Period 2+3, Period 5+6 | 9.0 | O_MLPRAK_2 |
| Praktijk 3 | Period 4+5+6 | 15.0 | O_MLPRAK_3 |
| Praktijk onderzoek 1 | Period 3, Period 6 | 3.0 | O_MLPROZ_1 |
| Praktijk onderzoek 2 | Period 4+5+6 | 6.0 | O_MLPROZ_2 |

## Leraar voorbereidend hoger onderwijs in Wiskunde - verplichte vakken

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Educational and Pedagogical Studies II | Period 1+2 | 3.0 | O_MLADEPII |
| Research II | Period 1+2+3 | 6.0 | O_MLVPOOII |
| Specialisation | Period 2+3 | 3.0 | O_MLVERD |
| Teaching Methodology Mathematics II | Period 1+2 | 6.0 | O_MLVDWIII |
| Teaching Practice II | Period 1+2+3 | 15.0 | O_MLPRAKII |

## Recommended Choice (masterMath and local Courses)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |

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|---|---|---|---|
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Portfolio Theory | Period 1+2 | 6.0 | X_400535 |
| Probabilistic and Extremal Combinatorics | Period 1+2 | 8.0 | X_418118 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |

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|---|---|---|---|
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |
| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Compulsory Course Mathematics

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Master Project Mathematics (T,E track) | Ac. Year (September) | 24.0 | X_405037 |

## Stochastics track

• Thesis 36 EC
• Seminar Mathematics (6EC); track Stochastics
• Scientific Writing in English (3EC)
• Elective courses, possibly outside maths (15EC)

The other 60EC:
• Mandatory courses (in MasterMath):
- Measure Theoretic Probability
- Asymptotic Statistics
- Stochastic Processes
• At least two advanced courses in Stochastics/SFM:
usually taken in the second year of the Master. These courses are mostly offered locally in Amsterdam and may change from year to year. In 2014/15 these are
- Percolation (MasterMath/Wonder)
- Statistical Analysis of Networks (local, VU)
- Portfolio Theory (local, UvA)
- Simulation Methods in Statistics (local, UvA)
- Lévy Fluctuation Theory, with Applications in Finance and OR (local, UvA)
- Nonparametric Bayesian Statistics (local, UvA)
- Topics in Stochastic Networks (local, UvA)
- Interest Rate Models (local, UvA)
• This leaves 24EC free to choose in mathematics:
There is freedom to choose any courses from the MasterMath and local

offering in mathematics. Some (nonbinding) suggestions:
- Time Series
- Stochastic Optimization
- Applied Stochastic Modelling
- Statistical Models
- Project Optimization of Business Processes
- Functional Analysis
- Stochastic Differential Equations
- Ergodic Theory
- Fourier Analysis and Distributions
• In total at least 30EC have to be MasterMath courses.

Programme components:

- Suggested elective Courses (21 elective ec)
- Compulsory Choice 2 out of 6 Advanced Courses Stochastics
- Compulsory Courses

## Suggested elective Courses (21 elective ec)

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |

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|---|---|---|---|
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Probabilistic and Extremal Combinatorics | Period 1+2 | 8.0 | X_418118 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |

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|---|---|---|---|
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |
| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Compulsory Choice 2 out of 6 Advanced Courses Stochastics

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Interest Rate Models | Period 1+2 | 6.0 | X_418091 |
| Nonparametric Bayesian Statistics | Period 1+2 | 6.0 | X_418124 |
| Portfolio Theory | Period 1+2 | 6.0 | X_400535 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |

## Compulsory Courses

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Master Project Mathematics | Ac. Year (September) | 36.0 | X_400355 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Scientific Writing in English | Period 4 | 3.0 | X_400512 |
| Seminar Mathematics | Period 1+2 | 6.0 | X_405024 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |

## Teachers track

Programme components:

- Compulsory Choice

- Compulsory Courses

# Compulsory Choice

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Advanced Complex Analysis | Period 4+5 | 6.0 | X_418164 |
| Advanced Linear Programming | Period 4+5 | 6.0 | X_400326 |
| Algebraic Geometry | Period 4+5 | 8.0 | X_400456 |
| Algebraic Number Theory | Period 1+2 | 8.0 | X_400324 |
| Algorithms beyond the Worst Case | Period 4+5 | 8.0 | X_418159 |
| Applied Analysis: Financial Mathematics | Period 1+2 | 6.0 | X_400076 |
| Applied Finite Elements | Period 4+5 | 6.0 | X_400453 |
| Applied Statistics | Period 4+5 | 6.0 | X_400452 |
| Applied Stochastic Modeling | Period 1+2 | 6.0 | X_400392 |
| Asymptotic Statistics | Period 1+2 | 8.0 | X_400323 |
| Blowing ups and deformations: an introduction to the theory of singularities | Period 1+2 | 6.0 | X_418165 |
| Capita Selecta Analysis and Dynamics | Period 1+2 | 6.0 | X_418166 |
| Category Theory and Topos Theory | Period 4+5 | 8.0 | X_418114 |
| Coding and Cryptography | Period 1 | 6.0 | X_405041 |
| Coding Theory | Period 4+5 | 8.0 | X_418160 |
| Complex Networks | Period 1+2 | 8.0 | X_405125 |
| Computational Dynamics | Period 4+5 | 8.0 | X_405126 |
| Continuous Optimization | Period 1+2 | 6.0 | X_400446 |
| Continuum Mechanics | Period 4+5 | 8.0 | X_418115 |
| Differential geometry | Period 1+2 | 8.0 | X_400509 |
| Discrete Optimization | Period 1+2 | 6.0 | X_400445 |
| Dynamical Systems | Period 1+2 | 8.0 | X_400429 |
| Elliptic Curves | Period 1+2 | 8.0 | X_400505 |
| Fourier analysis with applications in medical imaging | Period 4+5 | 6.0 | X_418167 |
| Functional Analysis | Period 1+2 | 8.0 | X_400328 |
| Hamiltonian Dynamics | Period 1+2 | 8.0 | X_405127 |
| Heuristic Methods in Operations Research | Period 1+2 | 6.0 | X_418006 |
| Hypergeometric Functions | Period 1+2 | 8.0 | X_418161 |
| Infinite dimensional systems | Period 4+5 | 6.0 | X_418095 |

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|---|---|---|---|
| Introduction to Numerical Bifurcation Analysis of ODE's and Maps | Period 4+5 | 8.0 | X_418116 |
| Lie Groups | Period 4+5 | 8.0 | X_400350 |
| Mathematical Biology | Period 1+2 | 8.0 | X_400504 |
| Measure Theoretical Probability | Period 1+2 | 8.0 | X_400244 |
| Model Theory | Period 4+5 | 6.0 | X_437024 |
| Modular Forms | Period 4+5 | 8.0 | X_400599 |
| Numerical Linear Algebra | Period 1+2 | 8.0 | X_400329 |
| Numerical Methods for Stationary PDE's | Period 4+5 | 8.0 | X_418057 |
| Operator Algebras | Period 1+2 | 8.0 | X_418062 |
| Optimization of Business Processes | Period 4+5 | 6.0 | X_400422 |
| Parallel Algorithms | Period 1+2 | 8.0 | X_418011 |
| Partial Differential Equations | Period 4+5 | 8.0 | X_400330 |
| Portfolio Theory | Period 1+2 | 6.0 | X_400535 |
| Probabilistic and Extremal Combinatorics | Period 1+2 | 8.0 | X_418118 |
| Quantum Groups and Knot Theory | Period 1+2 | 6.0 | X_400343 |
| Queueing Theory | Period 4+5 | 6.0 | X_400397 |
| Queues & Levy Fluctuation Theory | Period 1+2 | 8.0 | X_405130 |
| Reflection Groups, Affine Hecke Algebras and Integrable Systems | Period 4+5 | 6.0 | X_418168 |
| Riemann Surfaces | Period 4+5 | 8.0 | X_400325 |
| Rigid Geometry | Period 1+2 | 8.0 | X_418162 |
| Scheduling | Period 4+5 | 6.0 | X_400396 |
| Semidefinite Optimization | Period 4+5 | 8.0 | X_418120 |
| Set Theory | Period 4+5 | 8.0 | X_418035 |
| Simulation Methods in Statistics | Period 1+2 | 6.0 | X_400258 |
| Statistical Models | Period 1+2 | 6.0 | X_400418 |
| Statistics for High-Dimensional Data | Period 4+5 | 6.0 | X_405113 |
| Stochastic Differential Equations | Period 4+5 | 6.0 | X_400454 |
| Stochastic Integration | Period 4+5 | 8.0 | X_400470 |
| Stochastic Optimization | Period 1+2 | 6.0 | X_400336 |
| Stochastic Processes | Period 4+5 | 8.0 | X_400339 |
| Stochastic Processes for Finance | Period 1+2 | 6.0 | X_400352 |
| Systems and Control | Period 1+2 | 6.0 | X_400332 |
| TFT and moduli spaces | Period 4+5 | 6.0 | X_418073 |
| Time series | Period 4+5 | 8.0 | X_400571 |

| | | | |
|---|---|---|---|
| Topics in Algebraic Surfaces | Period 4+5 | 8.0 | X_405128 |
| Tropical Geometry | Period 1+2 | 6.0 | X_418163 |
| Variational Methods | Period 4+5 | 8.0 | X_400598 |

## Compulsory Courses

Courses:

| Name | Period | Credits | Code |
|---|---|---|---|
| Analysis 3 | Period 1+2 | 6.0 | X_400627 |
| Complexe Analyse | Period 4+5 | 6.0 | X_400386 |
| Dynamical Systems | Period 1+2 | 6.0 | X_400637 |
| General Statistics | Period 1+2 | 6.0 | X_400004 |
| Master Project Mathematics (T,E track) | Ac. Year (September) | 24.0 | X_405037 |
| Measure Theory | Period 1+2 | 6.0 | X_401028 |
| Numerical Methods | Period 4+5 | 6.0 | X_401039 |
| Statistical Data Analysis | Period 4+5 | 6.0 | X_401029 |

## Advanced Complex Analysis

| | |
|---|---|
| **Course code** | X_418164 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/20510

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Advanced Linear Programming

| | |
|---|---|
| **Course code** | X_400326 (400326) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. L. Stougie |
| **Examinator** | prof. dr. L. Stougie |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Advanced modelling in Systems Biology

| | |
|---|---|
| **Course code** | X_418155 () |
| **Period** | Period 6 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. F.J. Bruggeman |
| **Examinator** | prof. dr. F.J. Bruggeman |
| **Teaching staff** | prof. dr. F.J. Bruggeman |
| **Teaching method(s)** | Lecture, Computer lab, Seminar |
| **Level** | 500 |

**Course objective**
To extend modelling techniques learnt in Basic models of biological networks and to get acquainted with more advanced aspects of modelling biological systems

**Course content**
In this course we will assume knowledge of Basic models of biological networks. We will go deeper into important issues in modelling biological systems. Issues that will be discussed are model validation (parameter estimation, experimental design), dynamic behaviour (instability, multistability), robustness and sensitivity analysis, more advanced Metabolic Control Analysis and stochastic modelling. After this course, students should be able to make a model, evaluate its dynamic behaviour and explore the structure and parameters of the model. This should provide enough background for students to apply modelling in their own research.

**Form of tuition**
Lectures, self-study, computer practical work, computer modelling tutorials

**Type of assessment**
Results of computer assignments, written exams

**Course reading**

A course syllabus with recent reviews and papers presented by the lecturers and guest researchers (max. 15 euros)

## Algebraic Geometry

| | |
|---|---|
| **Course code** | X_400456 (400456) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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## Algebraic Number Theory

| | |
|---|---|
| **Course code** | X_400324 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Target group**
mMath

**Registration procedure**
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## Algebraic Topology

| | |
|---|---|
| **Course code** | X_400600 () |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.J.B. van den Berg |
| **Examinator** | prof. dr. G.J.B. van den Berg |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Target group**
mMath

**Registration procedure**
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**Remarks**
The course is taught once every two years, the next opportunity will be in study year 2016-2017

## Algorithms beyond the Worst Case

| | |
|---|---|
| **Course code** | X_418159 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
"This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl ."

**Target group**
mMATH

**Registration procedure**
You have to register your participation in each Mastermath course via
http://www.mastermath.nl/registration/
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## Algorithms in Sequence Analysis

| | |
|---|---|
| **Course code** | X_405050 (405050) |
| **Period** | Period 2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. J. Heringa |
| **Examinator** | prof. dr. J. Heringa |
| **Teaching staff** | prof. dr. J. Heringa |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 400 |

**Course objective**
Have you ever wondered how we can track a gene across 3 billion years of evolution? Sequence alignment can be used to compare genes from humans and bacteria, using a dynamic programming algorithm. In this course we focus on
algorithms for biological sequences that can be applied to real scientific problems in biology.

Students will obtain in-depth knowledge about the theory of sequence analysis methods. They will also develop understanding and skills to apply the
algorithms to protein and DNA sequences. We would like to stress that no biological knowledge is required to enter this course.

Goals
- At the end of the course, the student will be aware of the major issues, methodology and available algorithms in sequence analysis.
- At the end of the course, the student will have hands-on experience in tackling biological problems using sequence analysis algorithms and applying the general statistical framework of Hidden Markov Models.
- At the end of the course, the student will be able to implement several of the most important algorithms in sequence analysis.

**Course content**
Theory:
- Dynamic programming, database searching, pairwise and multiple alignment, probabilistic methods including hidden markov models, pattern matching, entropy measures, evolutionary models, and phylogeny.

Practical:
- Programming own alignment algorithm based on dynamic programming
- Reverse translation and dynamic programming

- Homology searching and pattern recognition using biological and disease examples
- Multiple alignment of biological sequences
- Entropy-based functional residues prediction
- Programming own implementation of Hidden Markov Models and using it to predict protein domain structure

**Form of tuition**
13 Lectures: 2 two-hour lectures per week
11 Computer practicals and associated assignments: 2 two-hour hands-on sessions per week

**Type of assessment**
The final grade for this course will consist of 50% practical work (see above) and 50% theoretical assessment.
The theoretical assessment will be an oral and/or written exam (depending on number of students).

**Course reading**
Course material on bb.vu.nl
Books: Durbin, R., Eddy, S.R., Krogh, A., Mitchison, G.. Biological Sequence Analysis. Cambridge University Press, 1998, 350 pp., ISBN 0521629713.
Recommended reading: Marketa Zvelebil and Jeremy O. Baum Understanding Bioinformatics Garland Science 2008 ISBN-10: 0-8153-4024-9

**Entry requirements**
Bachelor in any science discipline (including medicine).
Basic programming skills and an interest in biological problems.

**Target group**
mAI, mBio, mCS

**Remarks**
Signing up via bb.vu.nl is mandatory.
The course is taught in English.

## Analysis 3

| | |
|---|---|
| **Course code** | X_400627 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. D.R.A.W. Notbohm |
| **Examinator** | dr. D.R.A.W. Notbohm |
| **Teaching staff** | dr. D.R.A.W. Notbohm |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 300 |

## Applied Analysis: Financial Mathematics

| | |
|---|---|
| **Course code** | X_400076 (400076) |

| | |
|---|---|
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. A.C.M. Ran |
| **Examinator** | prof. dr. A.C.M. Ran |
| **Teaching staff** | prof. dr. A.C.M. Ran |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
The course aims to introduce the student to several aspects of the mathematical theory of option pricing.

**Course content**
This course gives an introduction to financial mathematics.
The following subjects will be treated:
- introduction in the theory of options;
- the binomial method;
- introduction to partial differential equations;
- the heat equation;
- the Black-Scholes formula and applications;
- introduction to numerical methods, approximating the price of an (American) option.

**Form of tuition**
Lectures, exercises, discussion of exercises.

**Type of assessment**
Homework exercises and oral examination

**Course reading**
The Mathematics of Financial Derivatives, A Student Introduction, by Paul Wilmott, Sam Howison, Jeff Dewynne. Cambridge University Press.

In addition, lecture notes will be made available for several topics which are not treated in the book.

**Recommended background knowledge**
Calculus and Linear Algebra

**Target group**
3W, mMath, mBA, 3Ect

## Applied Finite Elements

| | |
|---|---|
| **Course code** | X_400453 (400453) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |

| | |
|---|---|
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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**Remarks**
Locatie: Universiteit Utrecht en Universiteit Twente.

Docent en eerste beoordelaar is Fred Vermolen (Technische Universiteit Delft).

## Applied Statistics

| | |
|---|---|
| **Course code** | X_400452 (400452) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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## Applied Stochastic Modeling

| | |
|---|---|
| **Course code** | X_400392 (400392) |
| **Period** | Period 1+2 |

| | |
|---|---|
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Bekker |
| **Examinator** | dr. R. Bekker |
| **Teaching staff** | dr. R. Bekker |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 400 |

**Course objective**
To learn the most often used stochastic models and how they are applied in practice. During the course you learn to handle such practically motivated problems as an independent researcher. This means that you:
- learn to determine the appropriate model
- are able to formulate the problem mathematically correct
- are able to solve the stochastic model
- know how to interpret the outcome.

**Course content**
This course deals with a number of stochastic modeling techniques that are often used in practice. They are motivated by showing the business context in which they are used. Topics we deal with are:
birth-death-processes, basic queueing models, inventory models, renewal theory and simulation. We also repeat and extend certain parts of probability theory.

**Form of tuition**
Hoor- en werkcollege.

**Type of assessment**
Written examination.

**Course reading**
Lecture notes of Ger Koole (made available via blackboard).
Additional material will be announced in due time.

**Target group**
mBA, mMath

## Asymptotic Statistics

| | |
|---|---|
| **Course code** | X_400323 (400323) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 500 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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## Basic Models of Biological Networks

| | |
|---|---|
| **Course code** | X_418154 () |
| **Period** | Period 4 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. F.J. Bruggeman |
| **Examinator** | prof. dr. F.J. Bruggeman |
| **Teaching staff** | dr. J.P. Bruggeman, prof. dr. F.J. Bruggeman |
| **Teaching method(s)** | Lecture, Seminar, Computer lab |
| **Level** | 400 |

**Course objective**
The aim of the course is to learn the basis of modelling of biological systems. Computer models of metabolic networks, signal transduction pathways and transcriptional regulation are becoming indispensible in modern (medical) biology. After this course, students have an understanding of the principles of modelling, have learned to work with modelling tools and have applied these tools to biological examples. This should provide enough background for students to communicate with modellers or read modelling papers.

**Course content**
In this course we will teach how to set up computer models of biological systems, and how such models can be programmed in common software tools. We will provide some basic theoretical concepts required for understanding how to make models and how to interpret the results. Topics will include: properties of cell components (such as enzyme kinetics), mass and energy balances, stoichiometry and constraint-based modelling, kinetic modelling, Metabolic Control Analysis, modelling software. Topics will be illustrated by computer practicals of biological examples.

**Form of tuition**
Lectures, self-study, computer practical work, computer modelling tutorials

**Type of assessment**
Results of computer assignments, written exams.

**Course reading**
A course syllabus with recent reviews and papers presented by the lecturers and guest researchers (max. 15 euros).

## Blowing ups and deformations: an introduction to the theory of singularities

| | |
|---|---|
| **Course code** | X_418165 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/1132224

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Capita Selecta Analysis and Dynamics

| | |
|---|---|
| **Course code** | X_418166 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/1132328

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Category Theory and Topos Theory

| | |
|---|---|
| **Course code** | X_418114 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.J.B. van den Berg |
| **Examinator** | prof. dr. G.J.B. van den Berg |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMATH

**Registration procedure**
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## Coding and Cryptography

| | |
|---|---|
| **Course code** | X_405041 (405041) |
| **Period** | Period 1 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. R.M.H. de Jeu |
| **Examinator** | prof. dr. R.M.H. de Jeu |
| **Teaching staff** | prof. dr. R.M.H. de Jeu |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course objective**
To give an introduction the theory of error correcting codes and to cryptography.

**Course content**
This course provides a thorough introduction to the theory of error correcting codes, and to cryptography. It is aimed especially at students of Computer Science. For error correcting codes we shall include cyclic codes, BCH codes, Reed-Solomon codes and burst error correction. For cryptography we discuss some modern public key cryptography (e.g., RSA, ElGamal, DSA).

**Form of tuition**
Lectures and exercise classes

**Type of assessment**
Written exam and homework. The written exam will count for 80 percent of the grade, the homework will count for 20 percent of the grade. If not both the written exam and the homework are at least 55 percent each, then the maximum score will be 54 percent (which constitutes a fail).

**Course reading**
We shall be working from "Coding theory and cryptography, the essentials" by Hankerson, Hoffman, Leonard, Lindner, Phelps, Rodger and Wall (second edition, revised and expanded).

**Recommended background knowledge**
Some knowledge on linear algebra, on the integers modulo n, and on polynomials.

**Target group**

mAI, mCS, mMath, mPDCS

## Coding Theory

| | |
|---|---|
| **Course code** | X_418160 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl .

**Target group**
mMATH

**Registration procedure**
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## Complex Networks

| | |
|---|---|
| **Course code** | X_405125 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching staff** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl .

**Target group**
mMATH

**Registration procedure**
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Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Complexe Analyse

| | |
|---|---|
| **Course code** | X_400386 (400386) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. R.C.A.M. van der Vorst |
| **Examinator** | prof. dr. R.C.A.M. van der Vorst |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 300 |

## Computational Dynamics

| | |
|---|---|
| **Course code** | X_405126 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl .
Registration required via http://www.mastermath.nl

**Target group**
mMATH

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

**Remarks**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Computational Finance

| | |
|---|---|
| **Course code** | X_418045 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |

| | |
|---|---|
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/16398

**Target group**
mSFM

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

## Continuous Optimization

| | |
|---|---|
| **Course code** | X_400446 (400446) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Bekker |
| **Examinator** | dr. R. Bekker |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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## Continuum Mechanics

| | |
|---|---|
| **Course code** | X_418115 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |

| | |
|---|---|
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Didactiek 1

| | |
|---|---|
| **Course code** | O_MLDIDAC_1 () |
| **Period** | Period 1, Period 4 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | C.L. Geraedts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, drs. L.J. van Well-van Grootheest, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Lecture, Study Group |
| **Level** | 400 |

## Didactiek 2

| | |
|---|---|
| **Course code** | O_MLDIDAC_2 () |
| **Period** | Period 2+3, Period 5+6 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | drs. B. Klein |
| **Examinator** | dr. A. Handelzalts |

| | |
|---|---|
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, drs. L.J. van Well-van Grootheest, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Study Group, Lecture |
| **Level** | 400 |

## Didactiek 3

| | |
|---|---|
| **Course code** | O_MLDIDAC_3 () |
| **Period** | Period 4+5+6 |
| **Credits** | 9.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | drs. K.L. Schaap |
| **Examinator** | drs. K.L. Schaap |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, drs. L.J. van Well-van Grootheest, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Lecture, Study Group |
| **Level** | 400 |

## Differential geometry

| | |
|---|---|
| **Course code** | X_400509 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl/

**Target group**

mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Discrete Optimization

| | |
|---|---|
| **Course code** | X_400445 (400445) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Bekker |
| **Examinator** | dr. R. Bekker |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Dynamical Systems

| | |
|---|---|
| **Course code** | X_400429 (400429) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching staff** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
The aim of this course is to introduce the student to concepts, examples, results and techniques for studying smooth dynamical systems generated by ordinary differential equations or maps.

The student learns to apply techniques from topology and analysis to study properties of dynamical systems.

**Course content**
We provide a broad introduction to the subject of dynamical systems. In particular we develop theory of topological dynamics, symbolic dynamics and hyperbolic dynamics. Several examples are used to illustrate the theory and clarify the development of the theory.

An aim of dynamical systems theory is to describe asymptotic properties of orbits for typical initial points. The strength and beauty of the theory lies herein that techniques to do so work not only for special examples but for large classes of dynamical systems. The focus of the course will always be on learning techniques to analyse dynamical systems without relying on explicit formulas for the dynamical system.

As an example, the hyperbolic torus automorphism $(x,y) \mapsto (2 1 // 1 1) (x,y) \mod 1$ on the torus $R^2/Z^2$ is a topologically transitive dynamical system for which most orbits lie dense in the torus. What makes the example relevant is that small perturbations of it share its relevant properties. The automorphism is for instance $C^1$-structurally stable, so that a $C^1$ small perturbation is also topologically transitive. To see this requires much more advanced techniques than needed to study the linear automorphism. These techniques rely on the construction of stable and unstable manifolds.

The stable manifold theorem is among the highlights of the course. Another central result we cover is the structural stability theorem for hyperbolic sets.

A topical description of contents

1. Topological dynamics. Notions to describe attractors, limit sets and chaotic dynamics such as recurrence, topological transitivity, topological mixing.

2. Symbolic dynamics and their use to study chaotic dynamics. Full shift. Subshift of finite type. Topological Markov chain.

3. Aspects of bifurcation theory

4. Examples of chaotic dynamical systems such as hyperbolic torus automorphisms, the Smale horseshoe map and the solenoid.

5. Hyperbolic dynamics. Stable manifolds. Shadowing (finding real orbits near approximate orbits).

6. Structural stability and its relation with hyperbolicity. Shadowing as a technique to study structural stability.

**Form of tuition**
Lectures (2x45 minutes) and exercise session (45 minutes) weekly.

**Type of assessment**
Two larger sets of homework exercises will be given. The end grade is determined from these homework sets and an individual written exam, both counting for half the grade.

**Course reading**
M. Brin and G. Stuck, "Introduction to Dynamical Systems", Cambridge University Press.

**Entry requirements**
Prerequisite is material covered in a standard bachelor program in mathematics, containing in particular a bachelor course on ordinary differential equations and topology.

**Recommended background knowledge**
In dynamical systems theory, results for dynamical systems generated by maps or differential equations are developed in parallel. Our focus will be on dynamical systems generated by maps. A bachelor course on differential equations treats how a differential equation gives rise to a flow, i.e. a dynamical system, and starts a study of its qualitative properties.

Notions and techniques from topological dynamical systems are used throughout the course and require knowledge of topology as taught in a bachelor programme.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

**Remarks**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration is also required via http://www.mastermath.nl.

## Dynamical Systems

| | |
|---|---|
| **Course code** | X_400637 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching staff** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 300 |

## Educational and Pedagogical Studies I

| | |
|---|---|
| **Course code** | O_MLADEPI () |
| **Period** | Period 1+2 |

| | |
|---|---|
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

## Educational and Pedagogical Studies II

| | |
|---|---|
| **Course code** | O_MLADEPII () |
| **Period** | Period 1+2 |
| **Credits** | 3.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, dr. T. Bosma, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 500 |

## Elliptic Curves

| | |
|---|---|
| **Course code** | X_400505 (400505) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via
http://www.mastermath.nl/registration/

Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

**Remarks**
This course will not be given in the year 2010/2011.
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

## Fourier analysis with applications in medical imaging

| | |
|---|---|
| **Course code** | X_418167 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/1132330

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Functional Analysis

| | |
|---|---|
| **Course code** | X_400328 (400328) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## General Statistics

| | |
|---|---|
| **Course code** | X_400004 (400004) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. F. Bijma |
| **Examinator** | dr. F. Bijma |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 200 |

## Hamiltonian Dynamics

| | |
|---|---|
| **Course code** | X_405127 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching staff** | dr. F. Pasquotto, dr. O. Fabert |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl .
Registration required via http://www.mastermath.nl

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Heuristic Methods in Operations Research

| | |
|---|---|
| **Course code** | X_418006 (418006) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.J.B. van den Berg |
| **Examinator** | prof. dr. G.J.B. van den Berg |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see

http://www.mastermath.nl.

**Target group**
mMath, mBA

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Hypergeometric Functions

| | |
|---|---|
| **Course code** | X_418161 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl .
Registration required via http://www.mastermath.nl

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Infinite dimensional systems

| | |
|---|---|
| **Course code** | X_418095 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. A.C.M. Ran |
| **Examinator** | prof. dr. A.C.M. Ran |
| **Level** | 500 |

**Course objective**
Introduction to the theory of infinite dimensional systems.

**Course content**
The course covers the largest part of the book
Linear Port-Hamiltonian Systems on Infinite-dimensional Spaces,
by Birgit Jacob and Hans J. Zwart. Birkhäuser, 2012.

First finite dimensional systems theory is repeated with a focus on introducing port-Hamiltonian systems, then the theory of strongly continuous semigroups is treated. The theory is applied to several important examples involving the modeling of boundary control problems for systems whose dynamics is governed by partial differential equations.

This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Form of tuition**
Lectures

**Type of assessment**
Homework only

**Course reading**
Linear Port-Hamiltonian Systems on Infinite-dimensional Spaces, by Birgit Jacob and Hans J. Zwart. Birkhäuser, 2012.

**Recommended background knowledge**
Analysis, differential equations, preferably also a first course in mathematical systems theory.

**Target group**
Master students in mathematics, physics, engineering.

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Interest Rate Models

| | |
|---|---|
| **Course code** | X_418091 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching staff** | prof. dr. G.J.B. van den Berg |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/21133

**Target group**
mSFM, mMath

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Introduction to Numerical Bifurcation Analysis of ODE's and Maps

| | |
|---|---|
| **Course code** | X_418116 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Lie Groups

| | |
|---|---|
| **Course code** | X_400350 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Master Project Mathematics

| | |
|---|---|
| **Course code** | X_400355 (400355) |
| **Period** | Ac. Year (September) |
| **Credits** | 36.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. C.M. Quant |
| **Examinator** | dr. C.M. Quant |
| **Level** | 600 |

**Course objective**
The objectives of the master project are:
- to explore a mathematical research problem or to distill a mathematical problem formulation from the context of the host organisation.
- to study relevant papers from the (mathematical) literature, to combine those, and to add an original contribution.
- to put the results and conclusions in proper perspective, also in relation to results obtained by others.
- to present the research both in writing and in an oral presentation.

**Course content**
The Master's programme is concluded by an internal or external master project. An external project ("internship") is carried out within a business, industry or research facility other than the departments of Mathematics.

For an internal research project, the student starts by identifying a research topic in consultation with his/her supervisor. This leads to a research plan, which is recorded on the form that can be downloaded here: http://www.few.vu.nl/en/current-students/study-guidance-and-contact/final-assessment-form/index.asp (a copy is given to the master coordinator). The project itself usually starts with a literature study, leads towards the boundaries of mathematical knowledge, and ideally culminates in original research by the student. The work is carried out by the student individually, while there are weekly or biweekly meetings with the supervisor to discuss progress and scientific questions. The work is presented both in a master thesis and in a colloquium talk (mandatory).

**Form of tuition**
Individual work; Either the student performs individual research or the student is an intern at a host organization.

**Type of assessment**
78 EC of the master program need to be completed before starting the final project.

**Course reading**
Assigned individually

**Entry requirements**
78 EC of the master program need to be completed before starting the final project.

**Target group**

mMath

**Remarks**
If you are planning to start your external project within four months, please make an appointment with Annemieke van Goor (vangoor@few.vu.nl) at the Internship Office. Additional information can be found at http://www.few.vu.nl/en/current-students/int-car/internships/index.asp

## Master Project Mathematics (T,E track)

| | |
|---|---|
| **Course code** | X_405037 (405037) |
| **Period** | Ac. Year (September) |
| **Credits** | 24.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. C.M. Quant |
| **Examinator** | dr. C.M. Quant |
| **Level** | 600 |

**Course objective**
The objectives of the master project are:
- to explore a mathematical research problem or to distill a mathematical problem formulation from the context of the host organisation.
- to study relevant papers from the (mathematical) literature, to combine those, and to add an original contribution.
- to put the results and conclusions in proper perspective, also in relation to results obtained by others.
- to present the research both in writing and in an oral presentation.

**Course content**
The Master's programme is concluded by an internal or external master project. An external project ("internship") is carried out within a business, industry or research facility other than the departments of Mathematics.

**Form of tuition**
Either the student performs individual research or the student is an intern at a host organization.

**Type of assessment**
Assessment is based on the research performed (level, quality, quantity, independence, etcetera), the written master thesis, and the colloquium talk. The form used for the assessment of a research project can be downloaded here: http://www.few.vu.nl/en/current-students/study-guidance-and-contact/final-assessment-form/

**Course reading**
assigned individually

**Entry requirements**
90 EC of the master program need to be completed before starting the final project.

**Target group**
mSFM, mMath

**Remarks**
If you are planning to start your external project within four months,
please make an appointment with Annemieke van Goor (vangoor@few.vu.nl)
at the Internship Office. Additional information can be found at
http://www.few.vu.nl/en/current-students/int-car/internships/index.asp

## Mathematical Biology

| | |
|---|---|
| **Course code** | X_400504 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Planque |
| **Examinator** | dr. R. Planque |
| **Teaching staff** | dr. R. Planque |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
This is a master course for math students about mathematical methods to gain insight in the mechanisms
underlying biological phenomena. In the course, a lot of attention is paid to "translation": how do we get from biological information to a mathematical formulation of questions? And what do the mathematical results tell us about biological phenomena?
In addition, the course aims to introduce general physical ideas about time scales and spatial scales and how these can be used to great advantage when performing a mathematical analysis.

**Course content**
1. Exploiting time scale differences : the quasi-steady-state-approximation
-- Michaelis Menten enzyme kinetics
-- Holling's functional response
-- excitable media: Fitzhugh-Nagumo

2. Phase plane analysis
Essentially an assignment : students work in couples through a series of exercises about prey-predator interaction. In a lecture we explain some key notions, such as linearized stability and Poincare-Bendixon.

3. Diffusion (mainly linear theory; partly in the form of assignments)

-- various derivations of the diffusion equation
-- the fundamental solution, superposition
-- transport by diffusion: what distance in how much time?
-- separation of variables, eigenfunctions/modes
-- the asymptotic speed of propagation

4. Reaction-Diffusion (nonlinearity)
-- travelling waves

-- scalar equations do NOT generate stable patterns (in convex domains)
-- Turing instability
-- bifurcation theory
-- transition layers (excitable systems)?

5. Age/size structured populations, cell cycle models

6. Chemotaxis

7. Branching processes, links to epidemiology

8. Adaptive Dynamics

9. Master equations and additional topics, as time permits.

**Form of tuition**
-- lectures (notes are in preparation and should be ready by the time the course is given) which explain and illustrate the methods while referring to other sources for detailed accounts of the underlying mathematical theory
-- assignments which provide training in modelling and in the use of the methods. Students work on assignments, using both pen and paper and computer tools (MatLab).

**Type of assessment**
Grades are to a large extent based on the handed in written texts and on oral presentations.

**Course reading**
Lecture notes will be provided by the instructors. See also the course website for the latest details:
http://www.few.vu.nl/~rplanque/Onderwijs/MathBio/

**Recommended background knowledge**
Basic knowledge about linear algebra, analysis, ODE, stochastic processes. (The key point, however, is the attitude: students should be willing to quickly fill in gaps in background knowledge.)

**Target group**
MSc Mathematics

**Registration procedure**
You have to register your participation in each Mastermath course via
http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Measure Theoretical Probability

| | |
|---|---|
| **Course code** | X_400244 (400244) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http:/www.mastermath.nl.
Registration required via http:/www.mastermath.nl.

**Target group**
mMath, mSFM

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Measure Theory

| | |
|---|---|
| **Course code** | X_401028 (401028) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. J. van den Berg |
| **Examinator** | prof. dr. J. van den Berg |
| **Teaching staff** | prof. dr. R.W.J. Meester |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 300 |

**Course objective**
Basics of measure theory and the Lebesgue integral

**Course content**
We motivate and introduce the notion of a measure, that is, a way to assign a size to as many subsets as possible in an abstract space. It turns out that it is in general not possible to measure all sets, at least if one insists on additivity of the measure. This leads to the notion of a sigma-algebra.
Once we have defined measure, we can introduce and discuss so called measurable functions which, roughly speaking, form the class of functions which we will be able to integrate. We then introduce and study integration of these measurable functions with respect to a measure. We discuss (among other things) the monotone and dominated convergence theorems concerning the interchangeability of limit and integral, the substitution rule, absolute continuity and the relation of this new integral to the Riemann integral. We also discuss multi-dimensional Lebesgue measures, product measures and Fubini’s theorem.
The theory leads to a new perspective on integration of functions, which is not only more general when working on the real line, but also allows one to work in an abstract setting. This is of crucial importance for the development of (for example) functional analysis and probability theory.

**Form of tuition**
Classical classes with exercise classes.

**Type of assessment**
Written final exam, with a written midterm exam after 7 weeks. The final exam will be 50% of the final grade, and the midterm exam will be 40%. The remaining 10% will be homework, but the homework only counts if the weighted average of the two exams is at least 5,50.

**Course reading**
Rene L. Schilling: Measures, Integrals and Martingales, Cambridge University Press.

**Entry requirements**
Basics of calculus.

**Target group**
3W, 3Ect, 3WN

## Model Theory

| | |
|---|---|
| **Course code** | X_437024 (437024) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course descriptions and locations see http://www.mastermath.nl

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Modular Forms

| | |
|---|---|
| **Course code** | X_400599 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. S.R. Dahmen |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl

**Target group**
mMATH

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

**Remarks**
Mastermath course, see:
http://www.mastermath.nl/program/spring2016/Master_courses_2016/ModularForms/

## Neurogenomics

| | |
|---|---|
| **Course code** | AM_1007 () |
| **Period** | Period 3 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Fac. der Aard- en Levenswetenschappen |
| **Coordinator** | prof. dr. A.B. Smit |
| **Examinator** | prof. dr. A.B. Smit |
| **Teaching method(s)** | Lecture, Study Group, Computer lab |
| **Level** | 500 |

**Course objective**
To provide the Master of Neuroscience students with a solid basis in understanding the genome and working mechanisms and function of genes in relation to the development and functioning of the nervous system.

**Course content**
The course will address the various aspects of functional analysis of the genome, by addressing the following topics:

• The search for genes and gene variants which are underlying neuronal physiology and pathology, including forward genetics an gene-hunting strategies
• Functional analysis of genes through reverse genetics
• Gene expression analysis of neuronal cells and brain areas (gene expression profiling)
• The analysis of proteins (proteomics) and complexes thereof.
• Simulation of genetic and protein networks
• The introduction of various model organisms relevant for neurogenomics research, such as, man, mouse, Drosophilla, C. elegans, and zebrafish.

**Form of tuition**

Lectures, experiments, workshops, student presentations, computer practicals

**Type of assessment**
Written examination, open end questions. Practical task, presentation and literature evaluation.

**Course reading**
To be announced on Blackboard

**Entry requirements**
Bachelor Biology, Biomedical Sciences, Psychology with profile Biological Psychology or Neurophysiology

**Registration procedure**
Students need to enroll via VUnet
Students not enrolled in the VU master's in Neurosciences, need to contact the course coordinator prior to enrollment

**Remarks**
Language: tuition in English

## Nonparametric Bayesian Statistics

| | |
|---|---|
| **Course code** | X_418124 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 500 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/19550

**Target group**
mMath, mSFM

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

## Numerical Linear Algebra

| | |
|---|---|
| **Course code** | X_400329 (400329) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Numerical Methods

| | |
|---|---|
| **Course code** | X_401039 (401039) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Castelli |
| **Examinator** | dr. R. Castelli |
| **Teaching staff** | dr. R. Castelli |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 300 |

**Course objective**
- Gain experience in numerically solving a variety of problems.
- Getting acquainted with methods from numerical analysis.
- Develop intuition for the reliability of numerical methods.
- Learn how to use matlab.

**Course content**
Numerical methods are used frequently in all areas of science, such as fluid dynamics, meteorology and financial risk management. Moreover, techniques from numerical analysis play an important role in mathematical research on differential equations, stochastics, optimization, etcetera.
We focus on the main numerical methods from modern-day analysis and scientific computing. The theory is implemented in hands-on practical assignments. Active participation is expected. The list of subjects includes: error analysis, systems of nonlinear equations, eigenvalue problems, least square methods, fast Fourier transform, ordinary and partial differential equations. Applications include phone number recognition, ranking algorithms, curve following and planet motions.

**Form of tuition**
Lectures alternated with practical work in the computer rooms.
A number of matlab assignments form an integral part of the course.

**Type of assessment**
Active participation is expected. The grade is determined on the basis of the assignment (matlab code and short reports).

**Course reading**
Numerical Analysis by Richard Burden and J. Douglas Faires
ISBN: 978-0538735643

**Entry requirements**
A basic course in linear algebra (e.g. X_400041, X_400042, X_400638 or X_400639)

**Recommended background knowledge**
A basic course in linear algebra.

**Target group**
2W, 2W-B, mBA, mBA-D

**Registration procedure**
Enroll on blackboard

## Numerical Methods for Stationary PDE's

| | |
|---|---|
| **Course code** | X_418057 (418057) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Operator Algebras

| | |
|---|---|
| **Course code** | X_418062 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |

| | |
|---|---|
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

## Optimization of Business Processes

| | |
|---|---|
| **Course code** | X_400422 (400422) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.M. Koole |
| **Examinator** | prof. dr. G.M. Koole |
| **Teaching staff** | prof. dr. G.M. Koole |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
To learn about applications of stochastic operations research in the context of a few application areas, especially in services.

**Course content**
We deal with a number of application areas of stochastic modeling: production logistics, call centers, health care and revenue management. For each area we present quantitative problems and discuss how they can be solved using mathematical models. We also discuss a number of new models. Several guest lectures are given by people from industry.

**Form of tuition**
Lectures and practical work.

**Type of assessment**
Written examination, individual assignments, and a book presentation.

**Course reading**
Lecture notes.

**Recommended background knowledge**
Applied Stochastic Modeling or equivalent knowledge

**Target group**
mBA, mBA-D, mMath

**Remarks**

Attendance mandatory.

## Parallel Algorithms

| | |
|---|---|
| **Course code** | X_418011 (418011) |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Partial Differential Equations

| | |
|---|---|
| **Course code** | X_400330 (400330) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. J. Hulshof |
| **Examinator** | prof. dr. J. Hulshof |
| **Teaching staff** | prof. dr. J. Hulshof |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**

You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Peergroup 1

| | |
|---|---|
| **Course code** | O_MLPEERGR_1 () |
| **Period** | Period 1+2+3, Period 4+5+6 |
| **Credits** | 0.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching method(s)** | Study Group |
| **Level** | 400 |

## Peergroup 2

| | |
|---|---|
| **Course code** | O_MLPEERGR_2 () |
| **Period** | Period 3+4+5 |
| **Credits** | 0.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching method(s)** | Study Group |

## Physical Biology of the Cell

| | |
|---|---|
| **Course code** | X_422589 () |
| **Period** | Period 2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. ir. E.J.G. Peterman |
| **Examinator** | prof. dr. ir. E.J.G. Peterman |
| **Teaching staff** | prof. dr. ir. E.J.G. Peterman, prof. dr. ir. G.J.L. Wuite |
| **Teaching method(s)** | Seminar |
| **Level** | 400 |

**Course objective**
- To provide insight in how the basic tools and knowledge of physics and physical chemistry (in particular mechanics, statistical physics and thermodynamics) and mathematics can be used to better understand biology on the cellular and molecular level.
- To be able to understand and build quantitative models that provide a

deeper insight in living systems.
- To provide insight in how quantitative data obtained from microscopic imaging methods can be used to increase the understanding of biological systems.

**Course content**
- Biology by Numbers
- Construction Plans for Cells and Organisms
- Mechanical and Chemical Equilibrium in the Living Cell
- Entropy Rules!
- Two-State Systems: From Ion Channels to Cooperative Binding
- Random Walks and the Structure of Macromolecules
- Beam Theory: Architecture for Cells and Skeletons
- The Mathematics of Water
- A Statistical View of Biological Dynamics
- Rate Equations and Dynamics in the Cell
- Dynamics of Molecular Motors

**Form of tuition**
Lectures & Tutorials

**Type of assessment**
Oral Presentation & written exams (2).

**Course reading**
Phillips, R., Kondev, J., and Theriot, J., Physical Biology of the Cell. 2nd Edition New York: Garland Science, 2012 (ISBN 0815344503). (1st edition is also fine)

**Recommended background knowledge**
Mathematics: Calculus & Mathematische Methoden (or comparable)
Physics: basics of mechanics & thermodynamics

**Target group**
3N, 3MNW mi-BB, 3WN

**Remarks**
This course is part of the Minors Biomedische Beeldvorming and Bioinformatics and Systems Biology.

## Portfolio Theory

| | |
|---|---|
| **Course code** | X_400535 (400535) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 500 |

**Course content**
The course description is available on:
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/18617

**Target group**
mSFM, mMath

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

## Praktijk 1

| | |
|---|---|
| **Course code** | O_MLPRAK_1 () |
| **Period** | Period 1, Period 4 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. L.J. van Well-van Grootheest, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Study Group |
| **Level** | 400 |

## Praktijk 2

| | |
|---|---|
| **Course code** | O_MLPRAK_2 () |
| **Period** | Period 2+3, Period 5+6 |
| **Credits** | 9.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Study Group |
| **Level** | 400 |

## Praktijk 3

| | |
|---|---|
| **Course code** | O_MLPRAK_3 () |
| **Period** | Period 4+5+6 |
| **Credits** | 15.0 |

| | |
|---|---|
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Level** | 400 |

## Praktijk onderzoek 1

| | |
|---|---|
| **Course code** | O_MLPROZ_1 () |
| **Period** | Period 3, Period 6 |
| **Credits** | 3.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. H.B. Westbroek |
| **Examinator** | dr. H.B. Westbroek |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, prof. dr. M. Meeter, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, drs. L.J. van Well-van Grootheest, dr. T. Bosma, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, dr. J.M.H. Swennen, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Study Group, Lecture |
| **Level** | 400 |

## Praktijk onderzoek 2

| | |
|---|---|
| **Course code** | O_MLPROZ_2 () |
| **Period** | Period 4+5+6 |
| **Credits** | 6.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. H.B. Westbroek |
| **Examinator** | dr. A. Handelzalts |

| | |
|---|---|
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, ir. E.J.F. Scheringa, prof. dr. M. Meeter, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. B. Klein, drs. W. Jongejan, drs. L.J. van Well-van Grootheest, dr. T. Bosma, dr. H.B. Westbroek, C.L. Geraedts, dr. J.M.H. Swennen, dr. A.A. Kaal, dr. A. Handelzalts, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 400 |

## Probabilistic and Extremal Combinatorics

| | |
|---|---|
| **Course code** | X_418118 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Quantum Groups and Knot Theory

| | |
|---|---|
| **Course code** | X_400343 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 600 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/17254

**Target group**
mMath

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Queueing Theory

| | |
|---|---|
| **Course code** | X_400397 (400397) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Queues & Levy Fluctuation Theory

| | |
|---|---|
| **Course code** | X_405130 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl .

**Target group**
mMATH, mSFM

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your

grades from Mastermath to the administration of your university.

## Reflection Groups, Affine Hecke Algebras and Integrable Systems

| | |
|---|---|
| **Course code** | X_418168 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/1132987

**Registration procedure**
Registration is required via https://www.sis.uva.nl during the registration term before the start of the semester.

## Research I

| | |
|---|---|
| **Course code** | O_MLVPOOI () |
| **Period** | Period 1+2+3 |
| **Credits** | 3.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, drs. I. Pauw, drs. W.S. Hoekstra, drs. C.D.P. van Oeveren, drs. S. Donszelmann, drs. W. Jongejan, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, prof. dr. J.J. Beishuizen, dr. A.A. Kaal, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 500 |

## Research II

| | |
|---|---|
| **Course code** | O_MLVPOOII () |
| **Period** | Period 1+2+3 |
| **Credits** | 6.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. H.B. Westbroek |
| **Examinator** | dr. H.B. Westbroek |
| **Teaching staff** | drs. W. Jongejan, dr. T. Bosma, dr. H.B. Westbroek, dr. A.A. Kaal, dr. A. Handelzalts, W. Maas |
| **Teaching method(s)** | Lecture, Seminar |
| **Level** | 500 |

## Riemann Surfaces

| | |
|---|---|
| **Course code** | X_400325 (400325) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Rigid Geometry

| | |
|---|---|
| **Course code** | X_418162 () |
| **Period** | Period 1+2 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. R.M.H. de Jeu |
| **Level** | 500 |

**Course objective**
Rigid geometry over a non-Archimedean valued field was introduced by J. Tate in order to define the analogues of complex analytic spaces. The theory was developed by many mathematicians and turned out to be a good language for problems on algebraic curves, Abelian varieties, Drinfeld' modules, Dwork cohomology, etc.

In this course we want to treat the basic properties of rigid spaces and then apply these to some topics described below.

**Course content**
We first treat the following basic material

Valued fields, local fields, Banach spaces over valued fields.
Analytic functions on the projective line over a valued field.

Affinoid algebras, affinoid spaces and rigid spaces.

We shall then proceed to applications, which may include the following topics:

The Tate curve
Stable reduction of curves
Abelian varieties with multiplicative reduction
Mumford curves and Schottky groups
Drinfeld modules
Counting points with Dwork cohomology according to Kedlaya
Coleman integration

Other topics may be covered as well.

**Form of tuition**
Each class consists of two 45 minute lectures and one 45 minute problem session. Homework will be assigned but not marked, it will be discussed during the problem session.

**Type of assessment**
The final grade will be based on either a final written exam, or a take-home exam with a follow-up oral exam, depending on the number of students.

The decision will be taken early in the course.

**Course reading**
[1] S. Bosch - Lectures on formal and rigid geometry - LNM 2105, 2014.
[2] J. Fresnel and M.van der Put - Rigid analytic geometry and its applications - Progress in Mathematics 218, 2004.
[3] L. Gerritzen and M.van der Put - Schottky groups and Mumford curves - LNM 817, 1980.
[4] Proceedings of the Workshop on Drinfeld modules, Modular schemes and Applications - World Scientific 1997. (Editors Gekeler, van der Put, Reversat, Van Geel); in particular lectures 6,7 and 10.

We shall follow the first few chapters of [2] for the basic material.
The relevant chapters will be made available as paper copies, but you are strongly advised to buy this text.

**Recommended background knowledge**
A standard course on commutative rings, ideals, prime ideals and maximal ideals, zero divisors, ring homomorphisms, quotient rings, subrings, polynomial rings, formal power series, finite fields, algebraically closed fields.
A standard course on complex analytic functions (of one variable).
Some knowledge of algebraic geometry is helpful.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

**Remarks**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions, see http://www.mastermath.nl
Registration required via http://www.mastermath.nl

## Scheduling

| | |
|---|---|
| **Course code** | X_400396 (400396) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. R. Bekker |
| **Examinator** | dr. R. Bekker |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath, mBA

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Scientific Writing in English

| | |
|---|---|
| **Course code** | X_400512 () |
| **Period** | Period 4 |
| **Credits** | 3.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | M. van den Hoorn |
| **Examinator** | M. van den Hoorn |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
The aim of this course is to provide Master's students with the essential linguistic know-how for writing a scientific article in English that is well organized, idiomatically and stylistically appropriate and grammatically correct.

At the end of the course students

- know how to structure a scientific article;
- know what the information elements are in parts of their scientific article;
- know how to produce clear and well-structured texts on complex subjects;
- know how to cite sources effectively;
- know how to write well-structured and coherent paragraphs;
- know how to construct effective sentences;
- know what collocations are and how to use them appropriately;
- know how to adopt the right style (formal style, cohesive style, conciseness, hedging)
- know how to avoid the pitfalls of English grammar;
- know how to use punctuation marks correctly;
- know what their own strengths and weaknesses are in writing;
- know how to give effective peer feedback.

Final texts may contain occasional spelling, grammatical or word choice errors, but these will not distract from the general effectiveness of the text.

**Course content**
The course will start with a general introduction to scientific writing in English. Taking a top-down approach, we will then analyse the structure of a scientific article in more detail. As we examine each section of an article, we will peel back the layers and discover how paragraphs are structured, what tools are available to ensure coherence within and among paragraphs, how to write effective and grammatically correct sentences and how to choose words carefully and use them effectively.

Topics addressed during the course include the following:
- Structuring a scientific article
- Considering reading strategies: who is your readership? How do they read your text? What do they expect? How does that affect your writing?
- Writing well-structured and coherent paragraphs
- Composing effective sentences (sophisticated word order, information distribution).
- Arguing convincingly – avoiding logical fallacies
- Academic tone and style: hedging – why, how, where?
- Using the passive effectively
- Understanding grammar (tenses, word order, etc.)
- Understanding punctuation
- Referring to sources: summarising, paraphrasing, quoting (how and when?)
- Avoiding plagiarism
- Vocabulary development: using appropriate vocabulary and collocations

**Form of tuition**
Scientific Writing in English is an eight-week course and consists of 2 contact hours a week. Students are required to spend at least 6 to 8 hours of homework per week. They will work through a phased series of exercises that conclude with the requirement to write several text parts (Introduction, Methods, Discussion and Abstract). Feedback on the writing assignments is given by the course teacher and by peers.

**Type of assessment**
Students will receive the three course credits when they meet the following requirements:
- Students hand in three writing assignments (Introduction, Methods,

Discussion)
- Students get a pass mark for all writing assignments;
- Students provide elaborate peer feedback (Introduction, Methods, Discussion, Abstract);
- Students attend at least 7 out of 8 sessions;
- Students are well prepared for each session (i.e. do all homework assignments);
- Students participate actively in class;
- Students do not plagiarise or self-plagiarise.

Writing assignments:
1. If students have a BSc thesis in a traditional thesis form (e.g., 20+ pages) and written in English, they may use this for the writing assignments.
2. If students have a BSc thesis in a traditional form (e.g., 20+ pages) written in another language than English, they may use this for the writing assignments.
3. If students have written a paper or report in English that's not already in article form, they may use this for the writing assignment.
4. If students are working on their MSc thesis or internship report when taking Scientific Writing in English, they may use this for the writing assignments. They will have to notify their supervisor to make sure that they won't be accused of self-plagiarism.
5. If students cannot or do not wish to use any of the above-mentioned texts for the writing assignments (1-4), they are expected to do a limited Literature Review on a topic in their field of research, using at least 5 articles.

Students are not allowed to use the following texts for the writing assignments:
1. A BSc thesis written in English that's already in article form.
2. A MSc thesis written in English that's already in article form (and that has already been marked).
3. An internship report written in English that's already in article form (and that has already been marked).
4. A paper or report written in English that's already in article form.

**Course reading**
Effective Scientific Writing: An Advanced Learner's guide to Better English, 3rd edition (June 2013) (A. Bolt & W. Bruins, ISBN 978 90 8659 617 1). VU bookstore: €27.95.

**Target group**
This course is only open to students of the two-year Master's programmes Business Analytics, Mathematics and Stochastics and Financial Mathematics of the Faculty of Sciences. These students are only eligible to the course if they have already conducted scientific research (e.g. for their Bachelor's thesis) or if they will be working on a research project when taking Scientific Writing in English.

**Remarks**
- To do well, students are expected to attend all lessons. Group schedules are to be found at VUnet and on Blackboard.
- A VUnet registration for this course automatically gives access to the corresponding Blackboard site. Group registration only takes place via Blackboard (general groups: registration by students following FEW programmes offering this course; groups assigned to specific studies: registration through programme and course coordinator).

- Make sure Scientific Writing in English does not overlap with another course.
- If you have registered for a group in Blackboard, you are expected to attend all sessions. If you decide to withdraw from the course, do so in time in VUnet. This all will avoid a 'fail' on your grade list for not taking part in this course and allows other students to fill in a possible very wanted group spot.
- For specific Blackboard matters concerning this course, please contact onderwijsbureau.beta@vu.nl.

## Semidefinite Optimization

| | |
|---|---|
| **Course code** | X_418120 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Seminar Mathematics

| | |
|---|---|
| **Course code** | X_405024 (405024) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. O. Fabert |
| **Examinator** | dr. O. Fabert |
| **Teaching staff** | dr. B.T. Knapik |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
The aim of this course is to learn to read papers at a research level, organise the material for the framework of a seminar talk, and practice

presentation skills for such a talk. At the end of the course, the student will be able to acquire the prerequisites for reading and understanding a paper by researching the literature on his own, understand the logic of a paper, and to critically evaluate a paper. He will be able to extract and condense the material for a talk of a fixed length.

**Course content**
We will read papers from a wide range of areas of mathematics. Students will have a choice from a list.

**Form of tuition**
Seminar talks by students, individual coaching, group discussion, self study.

**Type of assessment**
Seminar talk

**Course reading**
Various; will be announced in the seminar

**Target group**
mMath, mSFM

**Remarks**
This course will have three variants: 'Analysis' given by dr. O. Fabert (VU), 'Geometry' given by dr. H. Posthuma (UvA), and 'Stochastics' given by dr. B. Knapik (VU). More details at http://www.few.vu.nl/~bkk320/semmath.html. Course registration is compulsory. VU students register at the VU and UvA students at the UvA (https://www.sis.uva.nl). Note: presence at all meetings is compulsory.

## Semisimple Lie Algebras

| | |
|---|---|
| **Course code** | X_418034 (418034) |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

**Remarks**
The course is taught once every two years, the next opportunity will be in study year 2016-2017

## Set Theory

| | |
|---|---|
| **Course code** | X_418035 (418035) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Simulation Methods in Statistics

| | |
|---|---|
| **Course code** | X_400258 (400258) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/14991

**Target group**
mMath, mSFM

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

## Spatial Statistics

| | |
|---|---|
| **Course code** | XMM_00001 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl .
Registration required via http://www.mastermath.nl

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your university.

## Specialisation

| | |
|---|---|
| **Course code** | O_MLVERD () |
| **Period** | Period 2+3 |
| **Credits** | 3.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | dr. A. Handelzalts |
| **Examinator** | dr. A. Handelzalts |
| **Teaching staff** | drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, drs. W.S. Hoekstra, drs. S. Donszelmann, dr. H.B. Westbroek, C.L. Geraedts, drs. A. Krijgsman, drs. K.L. Schaap, W. Maas, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw, drs. C.D.P. van Oeveren |
| **Teaching method(s)** | Seminar, |
| **Level** | 500 |

## Statistical Data Analysis

| | |
|---|---|
| **Course code** | X_420067 (420067) |
| **Period** | Period 1 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/14976

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904,

servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

# Statistical Data Analysis

| | |
|---|---|
| **Course code** | X_401029 (401029) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Teaching method(s)** | Lecture, Seminar, |
| **Level** | 300 |

**Course objective**
This course acquaints the students with the theory and application of several widely used statistical analysis techniques. After completing this course the student knows the theory behind the different techniques and is able to verify which techniques are applicable to a given data set. Using the learned statistical tools, the student is able to summarize and analyze real data sets using the statistical software package R.

**Course content**
This is an advanced level statistical data analysis course that builds on an introductory course on statistics, e.g. Algemene Statistiek. The course introduces the students to several widely used statistical models and methods, and the students are taught how to apply these tools to real data with the use of the statistical software package R. The following subjects are covered:
- summarizing data;
- investigating the distribution of data;
- robust methods;
- non-parametric methods;
- bootstrap;
- two-sample problems;
- contingency tables;
- multiple linear regression.

The course is a combination of theory (in the lectures) and practice (in the computer classes). Since the solutions of the computer assignments are discussed during the lectures, the theory is explicitly linked to the practice of statistical data analysis.

**Form of tuition**
Lectures, computer classes.

**Type of assessment**
Weekly homework assignments in R and written exam.

**Course reading**
Lecture notes.

**Recommended background knowledge**
Students should have basic knowledge on statistics, e.g. Algemene Statistiek (X_400004).

**Target group**
2BA, 2W, 2W-B, 3W, 3W-B, 3Ect.

**Remarks**
Language of tuition: English

## Statistical Models

| | |
|---|---|
| **Course code** | X_400418 (400418) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. E.N. Belitser |
| **Examinator** | dr. E.N. Belitser |
| **Teaching staff** | prof. dr. M.C.M. de Gunst, dr. E.N. Belitser |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
The goals of this course are to get acquainted with some of the most commonly used statistical models, to learn how to apply these models in valid settings, and to understand the basic theory behind these models.

**Course content**
Analysis of Variance, Generalized Linear Models, Non-linear Models, Time Series.

**Form of tuition**
Course of lectures, exercises and tutorial
.

**Type of assessment**
Assignments and examination.

**Course reading**
Lecture notes "Statistical Models" by M.C.M. de Gunst.

**Recommended background knowledge**
Linear Algebra, Probability Theory and Statistics. Statistical Data Analysis (X_401029)

**Target group**
mBA, mBA-D, mMath

**Remarks**
Students will use statistical package R (www.r-project.org/) for data analysis.

## Statistics for High-Dimensional Data

| | |
|---|---|
| **Course code** | X_405113 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |

| | |
|---|---|
| **Language of tuition** | Dutch |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. M. van de Wiel |
| **Examinator** | dr. M. van de Wiel |
| **Teaching staff** | dr. M. van de Wiel |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
Teaching students the adjustments to classical statistical methodology, necessary to tackle high-dimensional data.

**Course content**
This course gives an overview of statistical methods that are used for analyzing high-dimensional data sets in which many variables (often thousands) have been measured for a limited number of subjects. This type of data arises in genomics, where genetic information is measured for many thousands of genes simultaneously, in functional MRI imaging of the brain, and also in economic applications. The course covers some of the most important statistical issues for high-dimensional data, including: a) initial processing of the data; b) model-based statistical inference for Gaussian and count data (classical and Bayesian methods); c) multiple testing (family-wise error rate and false discovery rate control); d) prediction of binary endpoints (e.g. recurrence of a tumor) and survival; e) clustering of samples (e.g. to find tumor subtypes). Several specific types of high-dimensional data will be discussed and used during the course. In terms of applications the course focuses on cancer genomics, but theoretical aspects will apply to other fields as well.

**Form of tuition**
Lectures + practical exercises

**Type of assessment**
Written exam

**Course reading**
Tutorial in biostatistics: multiple hypothesis testing in genomics" by Goeman & Solari (article in Statistics in Medicine) plus handouts provided by the lecturer

**Recommended background knowledge**
Algemene statistitiek, Statistical Data Analysis

**Target group**
mMath, mSFM

## Stochastic Differential Equations

| | |
|---|---|
| **Course code** | X_400454 (400454) |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |

| | |
|---|---|
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Level** | 500 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Stochastic Integration

| | |
|---|---|
| **Course code** | X_400470 (400470) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Level** | 400 |

**Course content**
The course description is available on:
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/14994

**Target group**
mMath, mSFM

**Remarks**
This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, servicedesk-esc-science@uva.nl, +31 (0)20 525 7100.
Enrolment via https://m.sis.uva.nl/vakaanmelden is required.

## Stochastic Optimization

| | |
|---|---|
| **Course code** | X_400336 (400336) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. S. Bhulai |
| **Examinator** | dr. S. Bhulai |
| **Teaching staff** | dr. S. Bhulai |
| **Teaching method(s)** | Lecture |

| | |
|---|---|
| **Level** | 400 |

**Course objective**
The goal of the course is to discuss techniques from the field of stochastic optimization and their applications.

**Course content**
This course deals with the theory and algorithms for stochastic optimization with an application to controlled stochastic systems (e.g., call center management, inventory control, optimal design of communication networks). We discuss aspects of semi-Markov decision theory and their applications in certain queueing systems. In a programming assignment, students learn to implement optimization algorithms and experiment with them. Experience with and insight into the more theoretical subject is obtained through homework exercises.

**Form of tuition**
Lectures.

**Type of assessment**
Programming and written exercises, final exam.

**Course reading**
Lecture notes will be posted on BlackBoard

**Entry requirements**
Stochastische Methoden (400391) or equivalent and a programming language.

**Recommended background knowledge**
Stochastische Processen (X_401026) and Wachtrijmodellen (X_401061) or equivalent courses on Stochastic Processes and Queueing Theory and a programming language.

**Target group**
mBA, mBa-D, mMath, mSFM

## Stochastic Processes

| | |
|---|---|
| **Course code** | X_400339 (400339) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
You have to register your participation in each Mastermath course via
http://www.mastermath.nl/registration/
Registration is mandatory and absolutely necessary for transferring your grades from Mastermath to the administration of your univesity.

## Stochastic Processes for Finance

| | |
|---|---|
| **Course code** | X_400352 (400352) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. E.N. Belitser |
| **Examinator** | dr. E.N. Belitser |
| **Teaching staff** | dr. E.N. Belitser |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course objective**
Learn basics of stochastic processes in continuous time, including the concepts of martingales and stochastic integration; apply these concepts to price options on stocks and interest rates by the no-arbitrage principle.

**Course content**
Financial institutions trade in risk, and it is therefore essential to measure and control such risks. Financial instruments such as options, swaps, forwards, etc. play an important role in risk management, and to handle them one needs to be able to price them. This course gives an introduction to the mathematical tools and theory behind risk management.
A "stochastic process" is a collection of random variables, indexed by a set T. In financial applications the elements of T model time, and T is the set of natural numbers (discrete time), or an interval in the positive real line (continuous time). "Martingales" are processes whose increments over an interval in the future have zero expectation given knowledge of the past history of the process. They play an important role in financial calculus, because the price of an option (on a stock or an interest rate) can be expressed as an expectation under a so-called martingale measure. In this course we develop this theory in discrete and continuous time. Most models for financial processes in continuous time are based on a special Gaussian process, called Brownian motion. We discuss some properties of this process and introduce "stochastic integrals" with Brownian motion as the integrator. Financial processes can next be modeled as solutions to "stochastic differential equations". After developing these mathematical tools we turn to finance by applying the concepts and results to the pricing of derivative instruments. Foremost, we develop the theory of no-arbitrage pricing of derivatives, which are basic tools for risk management.

**Form of tuition**
Lectures and exercises.

**Type of assessment**
Assignments and written examination.

**Course reading**
Lecture notes.
In addition, it is useful to have the following books:
Shreve, "Stochastic Calculus for Finance I: The Binomial Asset Pricing Model", Springer;
Shreve, "Stochastic Calculus for Finance II: Continuous-time models", Springer.

**Entry requirements**
Probability (X_400622) and Analysis 1 (X_400005), or their equivalents.

**Recommended background knowledge**
Measure Theory.

**Target group**
mBA, mBA-D, mMath, mSFM, master Econometrics.

**Remarks**
A significant part of the course is used to introduce mathematical subjects and techniques like Brownian motion, stochastic integration and Ito calculus. In view of this, the course is NOT meant for students who already followed the master course "Stochastic Integration". On the other hand, after completing this course, students may be motivated to follow the other one (Stochastic Integration) to study the above mentioned mathematical subjects in a deeper and more rigorous way.

## Symplectic Geometry

| | |
|---|---|
| **Course code** | X_418036 (418036) |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.J.B. van den Berg |
| **Examinator** | prof. dr. G.J.B. van den Berg |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl . Registration required via http://www.mastermath.nl .

**Target group**
mMath

**Registration procedure**

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**Remarks**
The course is taught once every two years, the next opportunity will be in study year 2016-2017

## Systems and Control

| | |
|---|---|
| **Course code** | X_400332 (400332) |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Examinator** | dr. B.W. Rink |
| **Level** | 400 |

**Course content**
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**Target group**
mMath

**Registration procedure**
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## Teaching Methodology Mathematics I

| | |
|---|---|
| **Course code** | O_MLVDWII () |
| **Period** | Period 1+2 |
| **Credits** | 3.0 |
| **Language of tuition** | Dutch |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | drs. W.S. Hoekstra |
| **Examinator** | drs. W.S. Hoekstra |
| **Teaching staff** | drs. W.S. Hoekstra |
| **Teaching method(s)** | Seminar |
| **Level** | 500 |

## Teaching Methodology Mathematics II

| | |
|---|---|
| **Course code** | O_MLVDWIII () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | drs. W.S. Hoekstra |
| **Examinator** | drs. W.S. Hoekstra |
| **Teaching staff** | drs. W.S. Hoekstra |
| **Teaching method(s)** | Seminar |
| **Level** | 500 |

## Teaching Practice I

| | |
|---|---|
| **Course code** | O_MLPRAKI () |
| **Period** | Period 1+2+3 |
| **Credits** | 15.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | ir. E.J.F. Scheringa |
| **Examinator** | ir. E.J.F. Scheringa |
| **Level** | 500 |

## Teaching Practice II

| | |
|---|---|
| **Course code** | O_MLPRAKII () |
| **Period** | Period 1+2+3 |
| **Credits** | 15.0 |
| **Faculty** | Fac. der Gedrags- en Bewegingswetensch. |
| **Coordinator** | ir. E.J.F. Scheringa |
| **Examinator** | ir. E.J.F. Scheringa |
| **Level** | 500 |

## TFT and moduli spaces

| | |
|---|---|
| **Course code** | X_418073 () |
| **Period** | Period 4+5 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. G.J.B. van den Berg |
| **Examinator** | prof. dr. G.J.B. van den Berg |
| **Level** | 600 |

**Course content**
http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/19428

**Target group**
mMath

**Remarks**
Course registration is compulsory via https://www.sis.uva.nl

## Time series

| | |
|---|---|
| **Course code** | X_400571 (400571) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course content**
This course is part of the Joint National Master Programme in Mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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## Topics in Algebraic Surfaces

| | |
|---|---|
| **Course code** | X_405128 () |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | dr. B.W. Rink |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
"This course is part of the joint national master programme in mathematics. For schedules, course locations and course descriptions see http://www.mastermath.nl. Registration required via http://www.mastermath.nl ."

**Target group**
mMath

**Registration procedure**
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## Tropical Geometry

| | |
|---|---|
| **Course code** | X_418163 () |
| **Period** | Period 1+2 |
| **Credits** | 6.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. ir. J. Draisma |
| **Examinator** | prof. dr. ir. J. Draisma |
| **Teaching method(s)** | Lecture |
| **Level** | 500 |

**Course objective**
Tropical geometry is a rapidly growing area at the interface between algebraic geometry and polyhedral combinatorics, with links to other areas such as statistics and optimisation (min-plus algebra). The goal is to bring the student up to speed in these developments.

**Course content**
- min-plus arithmetic
- tropical curves in the plane: characterisation and enumeration
- tropical hypersurfaces
- tropical varieties: the Bieri-Groves theorem, the tropical basis theorem, and the fundamental theorem of tropical geometry (Kapranov's theorem)
- tropical linear algebra, determinantal varieties, Grassmannians
- links to Berkovich spaces

**Form of tuition**
Lectures and occasional computer sessions with software packages macaulay and gfan.

**Type of assessment**
Written exam (60% of the grade) and assignments (40%).

**Course reading**
- Primary source: Diane Maclagan and Bernd Sturmfels, Introduction to Tropical Geometry, GSM 161, AMS, 2015.
- Secondary sources: Ilia Itenberg and Grigory Mikhalkin and Eugenii Shustin, Tropical algebraic geometry. 2nd ed. Oberwolfach Seminars 35.
- Material from various papers.

**Recommended background knowledge**
Algebra (fields, (polynomial) rings, ideals).

It helps to have some background on additional topics such as commutative algebra, Groebner bases, and the geometry of polyhedra, but we will build up all that is needed from scratch.

**Target group**
mMath

**Remarks**
Additional information will appear on the website:

http://www.win.tue.nl/~jdraisma/index.php?location=teaching&teachingloca

## Variational Methods

| | |
|---|---|
| **Course code** | X_400598 (400598) |
| **Period** | Period 4+5 |
| **Credits** | 8.0 |
| **Language of tuition** | English |
| **Faculty** | Faculteit der Exacte Wetenschappen |
| **Coordinator** | prof. dr. J. Hulshof |
| **Examinator** | prof. dr. J. Hulshof |
| **Teaching staff** | prof. dr. J. Hulshof |
| **Teaching method(s)** | Lecture |
| **Level** | 400 |

**Course content**
This course is part of the joint national master programme in mathematics.
For schedules, course locations and course descriptions see http://www.mastermath.nl.
Registration required via http://www.mastermath.nl.

**Target group**
mMath

**Registration procedure**
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