



## Mathematics MSc

Vrije Universiteit Amsterdam - Faculteit der Exacte Wetenschappen - M Mathematics - 2014-2015

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 Probability
- 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.

Opleidingsdelen:

- [Courses in the Joint National Programme Mastermath \(30 ec compulsory\)](#)
- [Suggested elective Courses \(21 elective ec\)](#)
- [Compulsory choice 3 out of 4](#)
- [Compulsory Courses](#)

## Courses in the Joint National Programme Mastermath (30 ec compulsory)

Vakken:

Naam	Periode	Credits	Code
<a href="#">Abelian Varieties</a>	Periode 1+2	8.0	X_418134

Advanced Algebraic Geometry	Periode 1+2	8.0	X_418083
Advanced Combinatorics	Periode 1+2	8.0	X_418135
Advanced Linear Programming	Periode 4+5	6.0	X_400326
Advanced Modelling in Science	Periode 4+5	6.0	X_400451
Algebraic Geometry	Periode 4+5	8.0	X_400456
Algebraic Number Theory	Periode 1+2	8.0	X_400324
Algebraic Topology	Periode 1+2	8.0	X_400600
Applied Finite Elements	Periode 4+5	6.0	X_400453
Applied Statistics	Periode 4+5	6.0	X_400452
Asymptotic Methods for Differential Equations	Periode 4+5	8.0	X_418137
Asymptotic Statistics	Periode 1+2	8.0	X_400323
Commutative Algebra	Periode 4+5	8.0	X_418136
Computability theory	Periode 1+2	8.0	X_418094
Continuous Optimization	Periode 1+2	6.0	X_400446
Cryptography	Periode 4+5	8.0	X_400506
Discrete Optimization	Periode 1+2	6.0	X_400445
Dynamical Systems	Periode 1+2	8.0	X_400429
Ergodic Theory	Periode 1+2	8.0	X_418138
Fourier Analysis and Distributions	Periode 1+2	8.0	X_418007
Functional Analysis	Periode 1+2	8.0	X_400328
Goedel's Incompleteness Theorem	Periode 4+5	8.0	X_418005
Heuristic Methods in Operations Research	Periode 1+2	6.0	X_418006
Infinite dimensional systems	Periode 4+5	6.0	X_418095
Measure Theoretical Probability	Periode 1+2	8.0	X_400244
Numerical Linear Algebra	Periode 1+2	8.0	X_400329
Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Queueing Theory	Periode 4+5	6.0	X_400397
Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Stochastic Differential Equations	Periode 4+5	6.0	X_400454
Stochastic Processes	Periode 4+5	8.0	X_400339
Symplectic Geometry	Periode 1+2	8.0	X_418036
Systems and Control	Periode 1+2	6.0	X_400332
Time series	Periode 4+5	8.0	X_400571

Topological Methods for Differential Equations	Periode 1+2	8.0	X_418140
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## Suggested elective Courses (21 elective ec)

Vakken:

Naam	Periode	Credits	Code
<a href="#">Adaptive Finite Elements</a>	Periode 4+5	6.0	X_418141
<a href="#">Applied Analysis: Financial Mathematics</a>	Periode 1+2	6.0	X_400076
<a href="#">Applied Stochastic Modeling</a>	Periode 1+2	6.0	X_400392
<a href="#">Coding and Cryptography</a>	Periode 1	6.0	X_405041
<a href="#">Floer Theory</a>	Periode 4+5	6.0	X_405112
<a href="#">Interest Rate Models</a>	Periode 1+2	6.0	X_418091
<a href="#">Levy fluctuation theory, with applications in finance and OR</a>	Periode 1+2	6.0	X_418077
<a href="#">Mirror Symmetry</a>	Periode 4+5	6.0	X_418142
<a href="#">Modular Forms</a>	Periode 4+5	6.0	X_405118
<a href="#">Non-Commutative Geometry</a>	Periode 4+5	6.0	X_418099
<a href="#">Nonparametric Bayesian Statistics</a>	Periode 1+2	6.0	X_418124
<a href="#">Optimization of Business Processes</a>	Periode 4+5	6.0	X_400422
<a href="#">Portfolio Theory</a>	Periode 1+2	6.0	X_400535
<a href="#">Simulation Methods in Statistics</a>	Periode 1+2	6.0	X_400258
<a href="#">Statistical Data Analysis</a>	Periode 4+5	6.0	X_401029
<a href="#">Statistical Models</a>	Periode 1+2	6.0	X_400418
<a href="#">Statistics for Networks</a>	Periode 1+2	6.0	X_405110
<a href="#">Stochastic Integration</a>	Periode 4+5	8.0	X_400470
<a href="#">Stochastic Optimization</a>	Periode 1+2	6.0	X_400336
<a href="#">Stochastic Processes for Finance</a>	Periode 1+2	6.0	X_400352

## Compulsary choice 3 out of 4

Vakken:

Naam	Periode	Credits	Code
<a href="#">Dynamical Systems</a>	Periode 1+2	8.0	X_400429
<a href="#">Functional Analysis</a>	Periode 1+2	8.0	X_400328
<a href="#">Numerical Linear Algebra</a>	Periode 1+2	8.0	X_400329



<a href="#">Partial Differential Equations</a>	Periode 4+5	8.0	X_400330
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## 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.

Vakken:

Naam	Periode	Credits	Code
<a href="#">Master Project</a>	Ac. Jaar (september)	36.0	X_400355
<a href="#">Scientific Writing in English</a>	Periode 4	3.0	X_400512
<a href="#">Seminar Mathematics</a>	Periode 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.

Opleidingsdelen:

- Courses in the Joint National Programme Mastermath (30 ec compulsory)
- Suggested elective Courses (21 elective EC)
- Compulsory choice 3 out of 4
- Compulsory Courses

## Courses in the Joint National Programme Mastermath (30 ec compulsory)

Vakken:

Naam	Periode	Credits	Code
<a href="#">Abelian Varieties</a>	Periode 1+2	8.0	X_418134
<a href="#">Advanced Algebraic Geometry</a>	Periode 1+2	8.0	X_418083
<a href="#">Advanced Combinatorics</a>	Periode 1+2	8.0	X_418135
<a href="#">Advanced Linear Programming</a>	Periode 4+5	6.0	X_400326
<a href="#">Advanced Modelling in Science</a>	Periode 4+5	6.0	X_400451
<a href="#">Algebraic Geometry</a>	Periode 4+5	8.0	X_400456
<a href="#">Algebraic Number Theory</a>	Periode 1+2	8.0	X_400324
<a href="#">Algebraic Topology</a>	Periode 1+2	8.0	X_400600
<a href="#">Applied Finite Elements</a>	Periode 4+5	6.0	X_400453
<a href="#">Applied Statistics</a>	Periode 4+5	6.0	X_400452
<a href="#">Asymptotic Methods for Differential Equations</a>	Periode 4+5	8.0	X_418137
<a href="#">Asymptotic Statistics</a>	Periode 1+2	8.0	X_400323
<a href="#">Commutative Algebra</a>	Periode 4+5	8.0	X_418136
<a href="#">Computability theory</a>	Periode 1+2	8.0	X_418094
<a href="#">Continuous Optimization</a>	Periode 1+2	6.0	X_400446
<a href="#">Cryptography</a>	Periode 4+5	8.0	X_400506
<a href="#">Discrete Optimization</a>	Periode 1+2	6.0	X_400445
<a href="#">Dynamical Systems</a>	Periode 1+2	8.0	X_400429
<a href="#">Ergodic Theory</a>	Periode 1+2	8.0	X_418138
<a href="#">Fourier Analysis and Distributions</a>	Periode 1+2	8.0	X_418007
<a href="#">Functional Analysis</a>	Periode 1+2	8.0	X_400328
<a href="#">Goedel's Incompleteness Theorem</a>	Periode 4+5	8.0	X_418005
<a href="#">Heuristic Methods in Operations Research</a>	Periode 1+2	6.0	X_418006
<a href="#">Infinite dimensional systems</a>	Periode 4+5	6.0	X_418095
<a href="#">Measure Theoretical Probability</a>	Periode 1+2	8.0	X_400244
<a href="#">Numerical Linear Algebra</a>	Periode 1+2	8.0	X_400329

Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Queueing Theory	Periode 4+5	6.0	X_400397
Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Stochastic Differential Equations	Periode 4+5	6.0	X_400454
Stochastic Processes	Periode 4+5	8.0	X_400339
Symplectic Geometry	Periode 1+2	8.0	X_418036
Systems and Control	Periode 1+2	6.0	X_400332
Time series	Periode 4+5	8.0	X_400571
Topological Methods for Differential Equations	Periode 1+2	8.0	X_418140

## Suggested elective Courses (21 elective EC)

Vakken:

Naam	Periode	Credits	Code
Adaptive Finite Elements	Periode 4+5	6.0	X_418141
Applied Analysis: Financial Mathematics	Periode 1+2	6.0	X_400076
Applied Stochastic Modeling	Periode 1+2	6.0	X_400392
Coding and Cryptography	Periode 1	6.0	X_405041
Floer Theory	Periode 4+5	6.0	X_405112
Interest Rate Models	Periode 1+2	6.0	X_418091
Introduction to Contact Topology	Periode 1+2	6.0	X_405117
Levy fluctuation theory, with applications in finance and OR	Periode 1+2	6.0	X_418077
Mirror Symmetry	Periode 4+5	6.0	X_418142
Modular Forms	Periode 4+5	6.0	X_405118
Nonparametric Bayesian Statistics	Periode 1+2	6.0	X_418124
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Portfolio Theory	Periode 1+2	6.0	X_400535
Simulation Methods in Statistics	Periode 1+2	6.0	X_400258
Statistical Data Analysis	Periode 4+5	6.0	X_401029
Statistical Models	Periode 1+2	6.0	X_400418
Statistics for Networks	Periode 1+2	6.0	X_405110

<a href="#">Stochastic Integration</a>	Periode 4+5	8.0	X_400470
<a href="#">Stochastic Optimization</a>	Periode 1+2	6.0	X_400336
<a href="#">Stochastic Processes for Finance</a>	Periode 1+2	6.0	X_400352
<a href="#">Workshop Mathematical Modelling</a>	Periode 3	6.0	X_401062

## Compulsary choice 3 out of 4

Vakken:

Naam	Periode	Credits	Code
<a href="#">Algebraic Geometry</a>	Periode 4+5	8.0	X_400456
<a href="#">Algebraic Topology</a>	Periode 1+2	8.0	X_400600
<a href="#">Semisimple Lie Algebras</a>	Periode 4+5	8.0	X_418034
<a href="#">Symplectic Geometry</a>	Periode 1+2	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.

Vakken:

Naam	Periode	Credits	Code
<a href="#">Master Project</a>	Ac. Jaar (september)	36.0	X_400355
<a href="#">Scientific Writing in English</a>	Periode 4	3.0	X_400512
<a href="#">Seminar Mathematics</a>	Periode 1+2	6.0	X_405024

## Biomedical Mathematics track

Opleidingsdelen:

- [Compulsory Choice](#)
- [Compulsory Courses](#)

## Compulsory Choice

Vakken:

Naam	Periode	Credits	Code
<a href="#">Abelian Varieties</a>	Periode 1+2	8.0	X_418134
<a href="#">Adaptive Finite Elements</a>	Periode 4+5	6.0	X_418141
<a href="#">Advanced Algebraic Geometry</a>	Periode 1+2	8.0	X_418083
<a href="#">Advanced Combinatorics</a>	Periode 1+2	8.0	X_418135
<a href="#">Advanced Linear Programming</a>	Periode 4+5	6.0	X_400326
<a href="#">Advanced Modelling in Science</a>	Periode 4+5	6.0	X_400451
<a href="#">Algebraic Geometry</a>	Periode 4+5	8.0	X_400456
<a href="#">Algebraic Number Theory</a>	Periode 1+2	8.0	X_400324
<a href="#">Algebraic Topology</a>	Periode 1+2	8.0	X_400600
<a href="#">Applied Analysis: Financial Mathematics</a>	Periode 1+2	6.0	X_400076
<a href="#">Applied Finite Elements</a>	Periode 4+5	6.0	X_400453
<a href="#">Applied Statistics</a>	Periode 4+5	6.0	X_400452
<a href="#">Applied Stochastic Modeling</a>	Periode 1+2	6.0	X_400392
<a href="#">Asymptotic Methods for Differential Equations</a>	Periode 4+5	8.0	X_418137
<a href="#">Asymptotic Statistics</a>	Periode 1+2	8.0	X_400323
<a href="#">Coding and Cryptography</a>	Periode 1	6.0	X_405041
<a href="#">Commutative Algebra</a>	Periode 4+5	8.0	X_418136
<a href="#">Computability theory</a>	Periode 1+2	8.0	X_418094
<a href="#">Continuous Optimization</a>	Periode 1+2	6.0	X_400446
<a href="#">Cryptology</a>	Periode 4+5	8.0	X_400506
<a href="#">Discrete Optimization</a>	Periode 1+2	6.0	X_400445
<a href="#">Ergodic Theory</a>	Periode 1+2	8.0	X_418138
<a href="#">Floer Theory</a>	Periode 4+5	6.0	X_405112
<a href="#">Fourier Analysis and Distributions</a>	Periode 1+2	8.0	X_418007
<a href="#">Functional Analysis</a>	Periode 1+2	8.0	X_400328
<a href="#">Goedel's Incompleteness Theorem</a>	Periode 4+5	8.0	X_418005
<a href="#">Heuristic Methods in Operations Research</a>	Periode 1+2	6.0	X_418006
<a href="#">Infinite dimensional systems</a>	Periode 4+5	6.0	X_418095
<a href="#">Interest Rate Models</a>	Periode 1+2	6.0	X_418091
<a href="#">Introduction to Contact Topology</a>	Periode 1+2	6.0	X_405117
<a href="#">Levy fluctuation theory, with applications in finance and OR</a>	Periode 1+2	6.0	X_418077
<a href="#">Measure Theoretical Probability</a>	Periode 1+2	8.0	X_400244
<a href="#">Mirror Symmetry</a>	Periode 4+5	6.0	X_418142
<a href="#">Modular Forms</a>	Periode 4+5	6.0	X_405118

Nonparametric Bayesian Statistics	Periode 1+2	6.0	X_418124
Numerical Linear Algebra	Periode 1+2	8.0	X_400329
Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Portfolio Theory	Periode 1+2	6.0	X_400535
Queueing Theory	Periode 4+5	6.0	X_400397
Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Simulation Methods in Statistics	Periode 1+2	6.0	X_400258
Statistics for Networks	Periode 1+2	6.0	X_405110
Stochastic Differential Equations	Periode 4+5	6.0	X_400454
Stochastic Integration	Periode 4+5	8.0	X_400470
Stochastic Optimization	Periode 1+2	6.0	X_400336
Stochastic Processes	Periode 4+5	8.0	X_400339
Stochastic Processes for Finance	Periode 1+2	6.0	X_400352
Symplectic Geometry	Periode 1+2	8.0	X_418036
Systems and Control	Periode 1+2	6.0	X_400332
Time series	Periode 4+5	8.0	X_400571
Topological Methods for Differential Equations	Periode 1+2	8.0	X_418140

## Compulsory Courses

Vakken:

Naam	Periode	Credits	Code
Dynamical Systems	Periode 1+2	8.0	X_400429
Master Project	Ac. Jaar (september)	36.0	X_400355
Scientific Writing in English	Periode 4	3.0	X_400512
Seminar Mathematics	Periode 1+2	6.0	X_405024
Statistical Models	Periode 1+2	6.0	X_400418

## Education track

Opleidingsdelen:

- Leraar voorbereidend hoger onderwijs in Wiskunde - verplichte vakken
- Compulsory Choice
- C/E/M-variant Compulsory Course Mathematics

## Leraar voorbereidend hoger onderwijs in Wiskunde - verplichte vakken

Vakken:

Naam	Periode	Credits	Code
Algemene didactiek en Pedagogiek I	Periode 1+2, Periode 4+5	6.0	O_MLADEPI
Algemene Didactiek en Pedagogiek II	Periode 1+2, Periode 4+5	3.0	O_MLADEPII
Praktijk I	Periode 1+2+3, Periode 4+5+6	15.0	O_MLPRAKI
Praktijk II	Periode 1+2+3, Periode 4+5+6	15.0	O_MLPRAKII
Professionele ontwikkeling en onderzoek I	Periode 1+2+3, Periode 4+5+6	3.0	O_MLVPOOI
Professionele ontwikkeling en onderzoek II	Periode 1+2+3, Periode 4+5+6	6.0	O_MLVPOOII
Vakdidactiek Wiskunde I	Periode 1+2, Periode 4+5	3.0	O_MLVDWII
Vakdidactiek Wiskunde II	Periode 1+2, Periode 4+5	6.0	O_MLVDWIII
Verdieping	Periode 2+3, Periode 5+6	3.0	O_MLVERD

## Compulsory Choice

Vakken:

Naam	Periode	Credits	Code
Abelian Varieties	Periode 1+2	8.0	X_418134
Adaptive Finite Elements	Periode 4+5	6.0	X_418141
Advanced Algebraic Geometry	Periode 1+2	8.0	X_418083
Advanced Combinatorics	Periode 1+2	8.0	X_418135
Advanced Linear Programming	Periode 4+5	6.0	X_400326
Advanced Modelling in Science	Periode 4+5	6.0	X_400451
Algebraic Geometry	Periode 4+5	8.0	X_400456
Algebraic Number Theory	Periode 1+2	8.0	X_400324
Algebraic Topology	Periode 1+2	8.0	X_400600
Applied Analysis: Financial Mathematics	Periode 1+2	6.0	X_400076
Applied Finite Elements	Periode 4+5	6.0	X_400453
Applied Statistics	Periode 4+5	6.0	X_400452

Applied Stochastic Modeling	Periode 1+2	6.0	X_400392
Asymptotic Methods for Differential Equations	Periode 4+5	8.0	X_418137
Asymptotic Statistics	Periode 1+2	8.0	X_400323
Coding and Cryptography	Periode 1	6.0	X_405041
Commutative Algebra	Periode 4+5	8.0	X_418136
Computability theory	Periode 1+2	8.0	X_418094
Continuous Optimization	Periode 1+2	6.0	X_400446
Cryptology	Periode 4+5	8.0	X_400506
Discrete Optimization	Periode 1+2	6.0	X_400445
Dynamical Systems	Periode 1+2	8.0	X_400429
Ergodic Theory	Periode 1+2	8.0	X_418138
Floer Theory	Periode 4+5	6.0	X_405112
Fourier Analysis and Distributions	Periode 1+2	8.0	X_418007
Functional Analysis	Periode 1+2	8.0	X_400328
Goedel's Incompleteness Theorem	Periode 4+5	8.0	X_418005
Heuristic Methods in Operations Research	Periode 1+2	6.0	X_418006
Infinite dimensional systems	Periode 4+5	6.0	X_418095
Interest Rate Models	Periode 1+2	6.0	X_418091
Introduction to Contact Topology	Periode 1+2	6.0	X_405117
Levy fluctuation theory, with applications in finance and OR	Periode 1+2	6.0	X_418077
Measure Theoretical Probability	Periode 1+2	8.0	X_400244
Mirror Symmetry	Periode 4+5	6.0	X_418142
Modular Forms	Periode 4+5	6.0	X_405118
Nonparametric Bayesian Statistics	Periode 1+2	6.0	X_418124
Numerical Linear Algebra	Periode 1+2	8.0	X_400329
Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Portfolio Theory	Periode 1+2	6.0	X_400535
Queueing Theory	Periode 4+5	6.0	X_400397
Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Simulation Methods in Statistics	Periode 1+2	6.0	X_400258
Statistical Models	Periode 1+2	6.0	X_400418



<a href="#">Statistics for Networks</a>	Periode 1+2	6.0	X_405110
<a href="#">Stochastic Differential Equations</a>	Periode 4+5	6.0	X_400454
<a href="#">Stochastic Integration</a>	Periode 4+5	8.0	X_400470
<a href="#">Stochastic Optimization</a>	Periode 1+2	6.0	X_400336
<a href="#">Stochastic Processes</a>	Periode 4+5	8.0	X_400339
<a href="#">Stochastic Processes for Finance</a>	Periode 1+2	6.0	X_400352
<a href="#">Symplectic Geometry</a>	Periode 1+2	8.0	X_418036
<a href="#">Systems and Control</a>	Periode 1+2	6.0	X_400332
<a href="#">Time series</a>	Periode 4+5	8.0	X_400571
<a href="#">Topological Methods for Differential Equations</a>	Periode 1+2	8.0	X_418140

## C/E/M-variant Compulsory Course Mathematics

Vakken:

Naam	Periode	Credits	Code
<a href="#">Master Project (for M,C,E-variant)</a>	Ac. Jaar (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.

Opleidingsdelen:

- [Courses in the Joint National Programme Mastermath \(30 ec compulsory\)](#)
- [Suggested elective Courses \(21 elective ec\)](#)
- [Compulsory Courses](#)

## Courses in the Joint National Programme Mastermath (30 ec compulsory)

Vakken:

Naam	Periode	Credits	Code
<a href="#">Abelian Varieties</a>	Periode 1+2	8.0	X_418134
<a href="#">Advanced Algebraic Geometry</a>	Periode 1+2	8.0	X_418083
<a href="#">Advanced Combinatorics</a>	Periode 1+2	8.0	X_418135
<a href="#">Advanced Linear Programming</a>	Periode 4+5	6.0	X_400326
<a href="#">Advanced Modelling in Science</a>	Periode 4+5	6.0	X_400451
<a href="#">Algebraic Geometry</a>	Periode 4+5	8.0	X_400456
<a href="#">Algebraic Number Theory</a>	Periode 1+2	8.0	X_400324
<a href="#">Algebraic Topology</a>	Periode 1+2	8.0	X_400600
<a href="#">Applied Finite Elements</a>	Periode 4+5	6.0	X_400453
<a href="#">Applied Statistics</a>	Periode 4+5	6.0	X_400452
<a href="#">Asymptotic Methods for Differential Equations</a>	Periode 4+5	8.0	X_418137
<a href="#">Commutative Algebra</a>	Periode 4+5	8.0	X_418136
<a href="#">Computability theory</a>	Periode 1+2	8.0	X_418094
<a href="#">Continuous Optimization</a>	Periode 1+2	6.0	X_400446
<a href="#">Cryptography</a>	Periode 4+5	8.0	X_400506
<a href="#">Discrete Optimization</a>	Periode 1+2	6.0	X_400445
<a href="#">Dynamical Systems</a>	Periode 1+2	8.0	X_400429
<a href="#">Ergodic Theory</a>	Periode 1+2	8.0	X_418138
<a href="#">Fourier Analysis and Distributions</a>	Periode 1+2	8.0	X_418007
<a href="#">Functional Analysis</a>	Periode 1+2	8.0	X_400328
<a href="#">Goedel's Incompleteness Theorem</a>	Periode 4+5	8.0	X_418005

Heuristic Methods in Operations Research	Periode 1+2	6.0	X_418006
Infinite dimensional systems	Periode 4+5	6.0	X_418095
Numerical Linear Algebra	Periode 1+2	8.0	X_400329
Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Queueing Theory	Periode 4+5	6.0	X_400397
Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Stochastic Differential Equations	Periode 4+5	6.0	X_400454
Symplectic Geometry	Periode 1+2	8.0	X_418036
Systems and Control	Periode 1+2	6.0	X_400332
Time series	Periode 4+5	8.0	X_400571
Topological Methods for Differential Equations	Periode 1+2	8.0	X_418140

## Suggested elective Courses (21 elective ec)

Vakken:

Naam	Periode	Credits	Code
Adaptive Finite Elements	Periode 4+5	6.0	X_418141
Applied Analysis: Financial Mathematics	Periode 1+2	6.0	X_400076
Applied Stochastic Modeling	Periode 1+2	6.0	X_400392
Coding and Cryptography	Periode 1	6.0	X_405041
Floer Theory	Periode 4+5	6.0	X_405112
Interest Rate Models	Periode 1+2	6.0	X_418091
Introduction to Contact Topology	Periode 1+2	6.0	X_405117
Levy fluctuation theory, with applications in finance and OR	Periode 1+2	6.0	X_418077
Mirror Symmetry	Periode 4+5	6.0	X_418142
Modular Forms	Periode 4+5	6.0	X_405118
Non-Commutative Geometry	Periode 4+5	6.0	X_418099
Nonparametric Bayesian Statistics	Periode 1+2	6.0	X_418124
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Portfolio Theory	Periode 1+2	6.0	X_400535

<a href="#">Simulation Methods in Statistics</a>	Periode 1+2	6.0	X_400258
<a href="#">Statistical Models</a>	Periode 1+2	6.0	X_400418
<a href="#">Statistics for Networks</a>	Periode 1+2	6.0	X_405110
<a href="#">Stochastic Integration</a>	Periode 4+5	8.0	X_400470
<a href="#">Stochastic Optimization</a>	Periode 1+2	6.0	X_400336
<a href="#">Stochastic Processes for Finance</a>	Periode 1+2	6.0	X_400352

## Compulsory Courses

Vakken:

Naam	Periode	Credits	Code
<a href="#">Asymptotic Statistics</a>	Periode 1+2	8.0	X_400323
<a href="#">Master Project</a>	Ac. Jaar (september)	36.0	X_400355
<a href="#">Measure Theoretical Probability</a>	Periode 1+2	8.0	X_400244
<a href="#">Scientific Writing in English</a>	Periode 4	3.0	X_400512
<a href="#">Seminar Mathematics</a>	Periode 1+2	6.0	X_405024
<a href="#">Stochastic Processes</a>	Periode 4+5	8.0	X_400339

## Teachers track

Opleidingsdelen:

- [Compulsory Choice](#)
- [Compulsory Courses](#)

## Compulsory Choice

Vakken:

Naam	Periode	Credits	Code
<a href="#">Abelian Varieties</a>	Periode 1+2	8.0	X_418134
<a href="#">Adaptive Finite Elements</a>	Periode 4+5	6.0	X_418141
<a href="#">Advanced Algebraic Geometry</a>	Periode 1+2	8.0	X_418083
<a href="#">Advanced Combinatorics</a>	Periode 1+2	8.0	X_418135
<a href="#">Advanced Linear Programming</a>	Periode 4+5	6.0	X_400326
<a href="#">Advanced Modelling in Science</a>	Periode 4+5	6.0	X_400451
<a href="#">Algebraic Geometry</a>	Periode 4+5	8.0	X_400456
<a href="#">Algebraic Number Theory</a>	Periode 1+2	8.0	X_400324

Algebraic Topology	Periode 1+2	8.0	X_400600
Applied Analysis: Financial Mathematics	Periode 1+2	6.0	X_400076
Applied Finite Elements	Periode 4+5	6.0	X_400453
Applied Statistics	Periode 4+5	6.0	X_400452
Applied Stochastic Modeling	Periode 1+2	6.0	X_400392
Asymptotic Methods for Differential Equations	Periode 4+5	8.0	X_418137
Asymptotic Statistics	Periode 1+2	8.0	X_400323
Coding and Cryptography	Periode 1	6.0	X_405041
Commutative Algebra	Periode 4+5	8.0	X_418136
Computability theory	Periode 1+2	8.0	X_418094
Continuous Optimization	Periode 1+2	6.0	X_400446
Cryptology	Periode 4+5	8.0	X_400506
Discrete Optimization	Periode 1+2	6.0	X_400445
Dynamical Systems	Periode 1+2	8.0	X_400429
Ergodic Theory	Periode 1+2	8.0	X_418138
Floer Theory	Periode 4+5	6.0	X_405112
Fourier Analysis and Distributions	Periode 1+2	8.0	X_418007
Functional Analysis	Periode 1+2	8.0	X_400328
Goedel's Incompleteness Theorem	Periode 4+5	8.0	X_418005
Heuristic Methods in Operations Research	Periode 1+2	6.0	X_418006
Infinite dimensional systems	Periode 4+5	6.0	X_418095
Interest Rate Models	Periode 1+2	6.0	X_418091
Introduction to Contact Topology	Periode 1+2	6.0	X_405117
Levy fluctuation theory, with applications in finance and OR	Periode 1+2	6.0	X_418077
Measure Theoretical Probability	Periode 1+2	8.0	X_400244
Mirror Symmetry	Periode 4+5	6.0	X_418142
Modular Forms	Periode 4+5	6.0	X_405118
Nonparametric Bayesian Statistics	Periode 1+2	6.0	X_418124
Numerical Linear Algebra	Periode 1+2	8.0	X_400329
Numerical Methods for Time-dependent PDE's	Periode 4+5	8.0	X_418010
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Parallel Algorithms	Periode 1+2	8.0	X_418011
Partial Differential Equations	Periode 4+5	8.0	X_400330
Percolation	Periode 1+2	8.0	X_418139
Portfolio Theory	Periode 1+2	6.0	X_400535
Queueing Theory	Periode 4+5	6.0	X_400397

Scheduling	Periode 4+5	6.0	X_400396
Semisimple Lie Algebras	Periode 4+5	8.0	X_418034
Simulation Methods in Statistics	Periode 1+2	6.0	X_400258
Statistical Models	Periode 1+2	6.0	X_400418
Statistics for Networks	Periode 1+2	6.0	X_405110
Stochastic Differential Equations	Periode 4+5	6.0	X_400454
Stochastic Integration	Periode 4+5	8.0	X_400470
Stochastic Optimization	Periode 1+2	6.0	X_400336
Stochastic Processes	Periode 4+5	8.0	X_400339
Stochastic Processes for Finance	Periode 1+2	6.0	X_400352
Symplectic Geometry	Periode 1+2	8.0	X_418036
Systems and Control	Periode 1+2	6.0	X_400332
Time series	Periode 4+5	8.0	X_400571
Topological Methods for Differential Equations	Periode 1+2	8.0	X_418140

## Compulsory Courses

Vakken:

Naam	Periode	Credits	Code
Algemene statistiek	Periode 1+2	6.0	X_400004
Analysis 3	Periode 1+2	6.0	X_400627
Complexe Analyse	Periode 4+5	6.0	X_400386
Dynamische Systemen	Periode 1+2+3	6.0	X_400637
Master Project (for M,C,E-variant)	Ac. Jaar (september)	24.0	X_405037
Measure Theory	Periode 1+2	6.0	X_401028
Numerical Methods	Periode 4+5	6.0	X_401039
Statistical Data Analysis	Periode 4+5	6.0	X_401029

## Abelian Varieties

<b>Vakcode</b>	X_418134 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	600

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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.

## Adaptive Finite Elements

<b>Vakcode</b>	X_418141 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	500

### Overige informatie

Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via <https://www.sis.uva.nl>

## Advanced Algebraic Geometry

<b>Vakcode</b>	X_418083 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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 Combinatorics

<b>Vakcode</b>	X_418135 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	500

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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 Linear Programming

<b>Vakcode</b>	X_400326 (400326)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. L. Stougie
<b>Examinator</b>	prof. dr. L. Stougie
<b>Niveau</b>	400

### Inhoud vak

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

### Doelgroep

mMath; mBA

### Intekenprocedure

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 Science

<b>Vakcode</b>	X_400451 (400451)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Algebraic Geometry

<b>Vakcode</b>	X_400456 (400456)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

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Registration required via <http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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## Algebraic Number Theory

<b>Vakcode</b>	X_400324 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

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### Doelgroep

mMath

### Intekenprocedure

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## Algebraic Topology

<b>Vakcode</b>	X_400600 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	400

### Inhoud vak

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Registration required via <http://www.mastermath.nl>.

### Doelgroep

mMath

## Intekenprocedure

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## Algemene didactiek en Pedagogiek I

<b>Vakcode</b>	O_MLADEPI ()
<b>Periode</b>	Periode 1+2, Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Docent(en)</b>	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, dr. E. van den Berg, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. J.J.M. van Eersel, drs. K.L. Schaap, W. Maas, drs. G.D. van Hummel, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Doel vak

De student kan algemene onderwijskundige en pedagogische inzichten op het terrein van (activerende) didactiek (rol van ontwerper), communicatie in de klas (rol van uitvoerder) en gedrag- en leerproblemen (verdiepende module) vertalen naar de eigen lespraktijk.

### Inhoud vak

Deze module kent 4 onderdelen:

- de startweek (1 erts), waarin de student kennis maakt met de opleiding, met het basisinstrumentarium van een docent en de eigen startcompetenties in kaart brengt;
- colleges ten aanzien van de rol van Ontwerper en de rol van Uitvoerder;
- colleges over gedrag- en leerproblemen, waarin problematiek en aanpak van meest gangbare gedrag- en leerproblemen aan bod komen.

### Onderwijsvorm

Colleges (hoorcolleges en werkgroepen)

### Toetsvorm

- beoordeling van het portfolio
- tentamen over de colleges gedrag- en leerproblemen

### Literatuur

Een literatuurlijst wordt verstrekt aan het begin van de opleiding

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding

### Overige informatie

Voor alle onderdelen (startweek, rollen, verdiepende module) geldt een aanwezigheidsplicht

## Algemene Didactiek en Pedagogiek II

<b>Vakcode</b>	O_MLADEPII ()
<b>Periode</b>	Periode 1+2, Periode 4+5
<b>Credits</b>	3.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Docent(en)</b>	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, dr. E. van den Berg, C.L. Geraedts, drs. A. Krijgsman, dr. A.A. Kaal, dr. J.J.M. van Eersel, drs. K.L. Schaap, W. Maas, drs. G.D. van Hummel, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	500

### Doel vak

De student kan:

1. leerlingen, als individu en als lid van de groep, ondersteunen en stimuleren in hun verdere persoons- en identiteitsontwikkeling;
2. de voorbeeldfunctie ten opzichte van leerlingen vormgeven en daarop reflecteren;
3. leerlingen helpen bij de voorbereiding op hun rol in de samenleving als actief participierend burger;
4. deze en eerdere verworven competenties aantonen in een showcaseportfolio

### Inhoud vak

Deze module kent 2 onderdelen:

- colleges ten aanzien van de rol van Pedagoog;
- het werken aan de rolopdachten voor de rol van uitvoerder, ontwerper en pedagoog voor het showcaseportfolio;

### Onderwijsvorm

Colleges (hoorcolleges en werkgroepen) en zelfstudie

### Toetsvorm

- een tentamen betreffende de rol van Pedagoog
- beoordeling van het showcase portfolio, waarin de student de verworven competenties ten aanzien van alle rollen aantoont

### Literatuur

Een literatuurlijst wordt verstrekt aan het begin van de opleiding, en staat op Blackboard bij de betreffende studieonderdeel

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding

### Overige informatie

Voor de colleges geldt een aanwezigheidsplicht. Studenten die dit vooraf met de vakdidacticus/mentor overeengekomen zijn, kunnen in zelfstudie onderdelen afronden.

## Algemene statistiek

<b>Vakcode</b>	X_400004 (400004)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. F. Bijma
<b>Examinator</b>	dr. F. Bijma
<b>Docent(en)</b>	dr. F. Bijma
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege, Deeltoets extra zaalcapaciteit
<b>Niveau</b>	200

### Doel vak

Het college Algemene Statistiek is een eerste inleiding in de basisbegrippen van de mathematische statistiek. Na afloop van de cursus kan de student statistische modellen opstellen, verschillende soorten schatters bepalen, een aantal standaard toetsen opstellen en uitvoeren en betrouwbaarheidsgebieden construeren.

### Inhoud vak

In de statistiek wil men op grond van waarnemingen uitspraken doen over de kansverdeling waaruit deze waarnemingen afkomstig zijn. In het college komen achtereenvolgens aan bod: statistische modellen, verdelingsonderzoek, schatten, toetsen, en het construeren van betrouwbaarheidsgebieden. Daarbij staan begripsvorming en de presentatie van enkele veel gehanteerde methoden centraal. De stof wordt geïllustreerd aan de hand van een aantal interessante praktijkvoorbeelden. We beperken ons in dit vak hoofdzakelijk tot de zogenaamde parametrische statistiek, dat wil zeggen dat de kansverdeling op één of meer parameters na bekend is.

### Onderwijsvorm

Hoorcollege, werkcollege

### Toetsvorm

Twee schriftelijke deeltentamens

### Literatuur

Het boek "Inleiding in de Statistiek" van F. Bijma, M.A. Jonker, A.W. van der Vaart, Epsilon Uitgaven, 2013

### Aanbevolen voorkennis

Studenten dienen de kennis van calculus en kansrekening paraat te hebben.

### Doelgroep

2BA, 2WN, 2W, 2Ect

## Analysis 3

<b>Vakcode</b>	X_400627 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. D.R.A.W. Notbohm
<b>Examinator</b>	dr. D.R.A.W. Notbohm
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

### Doel vak

Verwerven van verdere kennis en vaardigheden op het gebied van de analyse.

### Inhoud vak

Metrische ruimten, integraaltheorie voor functies van meer variabelen, differentiaalvormen, stelling van Stokes

### Onderwijsvorm

Hoor- en werkcolleges, huiswerk

### Toetsvorm

2 deeltentamens, huiswerk

### Literatuur

C. H. Edwards, Advanced Calculus of Several Variables (Dover Books on Mathematics)

F. H. Croom, Principles of Topology,

### Aanbevolen voorkennis

Wiskundige Analyse 1 en Analyse op  $\mathbb{R}^n$

### Doelgroep

2W, 2WN

### Intekenprocedure

via blackboard

## Applied Analysis: Financial Mathematics

<b>Vakcode</b>	X_400076 (400076)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. A.C.M. Ran
<b>Examinator</b>	prof. dr. A.C.M. Ran
<b>Docent(en)</b>	prof. dr. A.C.M. Ran

<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

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

### Inhoud vak

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.

### Onderwijsvorm

Lectures, exercises, discussion of exercises.

### Toetsvorm

Homework exercises and oral examination

### Literatuur

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.

### Aanbevolen voorkennis

Calculus and Linear Algebra

### Doelgroep

3W, mMath, mBA, 3Ect

## Applied Finite Elements

<b>Vakcode</b>	X_400453 (400453)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

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Registration required via <http://www.mastermath.nl>

## Doelgroep

mMath

## Intekenprocedure

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## Overige informatie

Locatie: Universiteit Utrecht en Universiteit Twente.

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

## Applied Statistics

<b>Vakcode</b>	X_400452 (400452)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

## Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

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## Doelgroep

mMath

## Intekenprocedure

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## Applied Stochastic Modeling

<b>Vakcode</b>	X_400392 (400392)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. R. Bekker
<b>Examinator</b>	dr. R. Bekker
<b>Docent(en)</b>	dr. R. Bekker



<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	400

### Doel vak

To learn the most often used stochastic models and how they are applied in practice.

### Inhoud vak

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. We end with an overview of mathematical modeling, including aspects such as the economic context, the choice of solution method, decision support systems, etc.

### Onderwijsvorm

Hoor- en werkcollege.

### Toetsvorm

Written examination.

### Literatuur

Lecture notes.

### Doelgroep

mBA, mMath

## Asymptotic Methods for Differential Equations

<b>Vakcode</b>	X_418137 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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## Asymptotic Statistics

<b>Vakcode</b>	X_400323 (400323)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	500

### Inhoud vak

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### Doelgroep

mMath

### Intekenprocedure

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## Coding and Cryptography

<b>Vakcode</b>	X_405041 (405041)
<b>Periode</b>	Periode 1
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.M.H. de Jeu
<b>Examinator</b>	prof. dr. R.M.H. de Jeu
<b>Docent(en)</b>	prof. dr. R.M.H. de Jeu
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Doel vak

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

### Inhoud vak

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).

### Onderwijsvorm

Lectures and exercise classes

### Toetsvorm

Written exam and homework

### Literatuur

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).

### Aanbevolen voorkennis

Some knowledge on linear algebra, on the integers modulo  $n$ , and on polynomials.

### Doelgroep

mAI, mCS, mMath, mPDCS

## Commutative Algebra

<b>Vakcode</b>	X_418136 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.M.H. de Jeu
<b>Examinator</b>	prof. dr. R.M.H. de Jeu
<b>Niveau</b>	400

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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## Complexe Analyse

<b>Vakcode</b>	X_400386 (400386)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.C.A.M. van der Vorst
<b>Examinator</b>	prof. dr. R.C.A.M. van der Vorst
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege

<b>Niveau</b>	300
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### Doel vak

De cursus beoogt enerzijds een inleiding te geven in de theoretische grondslagen van de complexe analyse en anderzijds vaardigheid te verschaffen in het oplossen van vraagstukken zoals het berekenen van integralen en het sommeren van reeksen. De eerste helft van de cursus wordt gegeven voor wiskunde en natuurkunde studenten. De tweede helft is theoretischer van aard.

### Inhoud vak

Tijdens het college worden de volgende onderwerpen behandeld:

- elementaire eigenschappen van analytische functies
- conforme afbeeldingen en harmonische functies
- complexe integratie en de stelling en integraalformule van Cauchy
- formulering en bewijzen met windingsgetallen
- singulariteiten, Laurent-ontwikkeling, residuenstelling
- meerwaardige functies
- toepassingen op gewone integralen

### Onderwijsvorm

College en werkcollege.

### Toetsvorm

Schriftelijk, met deeltentamens aan het einde van perioden 4 en 5.

### Literatuur

Complex Variables and Applications (8th edition) van James Ward Brown en Ruel V. Churchill, uitgever: Mc Graw Hill, ISBN 007-126328-4.

### Doelgroep

2W, 2WN

## Computability theory

<b>Vakcode</b>	X_418094 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

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>

### Doelgroep

mMath

### Intekenprocedure

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

## Continuous Optimization

<b>Vakcode</b>	X_400446 (400446)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath;mBA

### Intekenprocedure

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.

## Cryptology

<b>Vakcode</b>	X_400506 (400506)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doelgroep

mMath

### Intekenprocedure

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.

### Overige informatie

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>

## Discrete Optimization

<b>Vakcode</b>	X_400445 (400445)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Dynamical Systems

<b>Vakcode</b>	X_400429 (400429)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. B.W. Rink
<b>Examinator</b>	dr. B.W. Rink
<b>Docent(en)</b>	dr. B.W. Rink
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

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.

### **Inhoud vak**

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  $(x,y) \mapsto (2x+y, x) \pmod{1}$  on the torus  $\mathbb{R}^2/\mathbb{Z}^2$  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.

### **Onderwijsvorm**

Lectures (2x45 minutes) and exercise session (45 minutes) weekly.

### **Toetsvorm**

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.

## Literatuur

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

## Vereiste voorkennis

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

## Aanbevolen voorkennis

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.

## Doelgroep

mMath

## Intekenprocedure

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.

## Overige informatie

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>.

## Dynamische Systemen

<b>Vakcode</b>	X_400637 ()
<b>Periode</b>	Periode 1+2+3
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. B.W. Rink
<b>Examinator</b>	dr. B.W. Rink
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

## Doel vak

Het leren van de theorie en praktijk van niet-lineaire gewone differentiaalvergelijkingen.

## Inhoud vak

Dit college is gewijd aan de theorie van niet-lineaire gewone differentiaalvergelijkingen. Aan de orde komen existentie en uniciteit



van oplossingen, methoden voor het expliciet berekenen van oplossingen, de grafische methode voor eendimensionale vergelijkingen, bifurcaties, lineaire differentiaalvergelijkingen in twee dimensies, fasevlak analyse, limietcycli, storingstheorie, symmetrie en mechanische systemen. Aan de hand van concrete voorbeelden wordt geïllustreerd hoe men dergelijke problemen aanpakt.

### Onderwijsvorm

De cursus bestaat uit een hoorcollege en een werkcollege per week.

### Toetsvorm

Inleveropgaven en deeltentamens. De eerste inleveropgave telt voor 10% mee in het eindcijfer, het eerste deeltentamen voor 30%, de tweede inleveropgave voor 10% en het tweede deeltentamen voor 50%. Tevens dient de student bij 75% van alle colleges en werkcolleges aanwezig te zijn geweest.

### Literatuur

Steven Strogatz, "Nonlinear dynamics and chaos: with applications to physics, biology, chemistry and engineering", paperback edition, Westview Press, 1st ed, 2001

### Aanbevolen voorkennis

Eerstejaars cursussen Calculus en Analyse

### Doelgroep

2W, 2W-B, 2-WN, 3BA, mBA, CHW-doorstroom

### Overige informatie

Actuele informatie over dit vak zal worden aangeboden op Blackboard.

## Ergodic Theory

<b>Vakcode</b>	X_418138 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	500

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

You have to register your participation in each Mastermath course via <http://www.mastermath.nl/registration/>

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## Floer Theory

<b>Vakcode</b>	X_405112 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. O. Fabert
<b>Examinator</b>	dr. O. Fabert
<b>Docent(en)</b>	dr. O. Fabert
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	600

### Doel vak

The goal of this course is to give an introduction to the construction of Floer homology.

### Inhoud vak

In order to prove the Arnold conjecture about the number of fixed points of Hamiltonian systems on closed symplectic manifolds, A. Floer developed a novel infinite-dimensional version of Morse theory. Floer theory nowadays plays an important role in various areas of modern mathematics, ranging from mathematical physics (mirror symmetry of string theory) to topology (three manifolds and knots). After discussing the basic notions from symplectic geometry needed to formulate the conjecture, we give a complete exposition of Floer's original proof for so-called monotone symplectic manifolds and discuss further applications and generalizations.

### Onderwijsvorm

lectures

### Toetsvorm

to be determined

### Literatuur

to be determined

### Aanbevolen voorkennis

dynamical systems, differential geometry, partial differential equations, homology

### Doelgroep

mMath

## Fourier Analysis and Distributions

<b>Vakcode</b>	X_418007 (418007)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen

<b>Coördinator</b>	prof. dr. J.J.O.O. Wiegerinck
<b>Examinator</b>	prof. dr. J.J.O.O. Wiegerinck
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doelgroep

mMath

### Intekenprocedure

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.

### Overige informatie

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>

## Functional Analysis

<b>Vakcode</b>	X_400328 (400328)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. J.J.O.O. Wiegerinck
<b>Examinator</b>	prof. dr. J.J.O.O. Wiegerinck
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

This course is part of the joint national master programme in mathematics.

For schedules, course locations and course descriptions see

<http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Goedel's Incompleteness Theorem

<b>Vakcode</b>	X_418005 (418005)
<b>Periode</b>	Periode 4+5

<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Doelgroep

mMath

### Intekenprocedure

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.

### Overige informatie

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>

## Heuristic Methods in Operations Research

<b>Vakcode</b>	X_418006 (418006)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see

<http://www.mastermath.nl>.

### Doelgroep

mMath, mBA

### Intekenprocedure

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

<b>Vakcode</b>	X_418095 ()
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<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. A.C.M. Ran
<b>Examinator</b>	prof. dr. A.C.M. Ran
<b>Niveau</b>	500

### Doel vak

Introduction to the theory of infinite dimensional systems.

### Inhoud vak

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> .

### Onderwijsvorm

Lectures

### Toetsvorm

Homework only

### Literatuur

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

### Aanbevolen voorkennis

Analysis, differential equations, preferably also a first course in mathematical systems theory.

### Doelgroep

Master students in mathematics, physics, engineering.

### Intekenprocedure

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.

## Interest Rate Models

<b>Vakcode</b>	X_418091 ()
<b>Periode</b>	Periode 1+2

<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Docent(en)</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

The course description is available on:

<http://studiegids.uva.nl/web/uva/sgs/nl/c/14265.html>

### Doelgroep

mSFM, mMath

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Introduction to Contact Topology

<b>Vakcode</b>	X_405117 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. F. Pasquotto
<b>Examinator</b>	dr. F. Pasquotto
<b>Docent(en)</b>	dr. F. Pasquotto
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	600

### Doel vak

A contact structure is a geometric structure on a smooth manifold, defined by a one-form

which satisfies a condition called "maximal non-integrability". Examples of manifolds

admitting a contact structure are: odd-dimensional Euclidean spaces, spheres, and tori.

The main aim of this course is to introduce the student to the basic notions of contact

topology. In the second part of the course we hope to discuss some of the more recent

developments of this field and some of its deep connections (with, for instance,

low-dimensional topology, symplectic topology, and Hamiltonian dynamics).

### Inhoud vak

Contact structures, characteristic foliations, families of contact structures and Moser's method,

the tight-overtwisted dichotomy, special knots in contact manifolds, convex surfaces and open book decompositions.

### Onderwijsvorm

Lectures and tutorials

### Toetsvorm

Hand-in problems (40%) and a final take-home exam (60%)

### Literatuur

The main references for this course will be:

H. Geiges, Introduction to Contact Topology, Cambridge University Press

J. Etnyre, Introductory Lectures on Contact Geometry

Additional reading might be suggested during the course.

### Aanbevolen voorkennis

Some basic knowledge of topology and the standard basic notions that are taught in the first course on Differential Geometry, such as: manifolds, smooth maps, tangent vectors, differential forms, Lie derivatives along vector fields, the flow of a tangent vector, tangent and cotangent bundle.

### Doelgroep

Master students of Mathematics

## Levy fluctuation theory, with applications in finance and OR

<b>Vakcode</b>	X_418077 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	500

### Inhoud vak

The course description is available on:

<http://studiegids.uva.nl/web/uva/sgs/en/c/12428.html>

### Doelgroep

mSFM, mMath

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Master Project

<b>Vakcode</b>	X_400355 (400355)
<b>Periode</b>	Ac. Jaar (september)
<b>Credits</b>	36.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. C.M. Quant
<b>Examinator</b>	dr. C.M. Quant
<b>Niveau</b>	600

## Doel vak

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.

## Inhoud vak

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).

## Onderwijsvorm

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

## Toetsvorm

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

## Literatuur

Assigned individually

## Vereiste voorkennis

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

## Doelgroep

mMath

## Overige informatie

If you are planning to start your external project within four months, please make an appointment with Annemieke van Goor ([vangoor@few.vu.nl](mailto: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 (for M,C,E-variant)

<b>Vakcode</b>	X_405037 (405037)
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<b>Periode</b>	Ac. Jaar (september)
<b>Credits</b>	24.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. C.M. Quant
<b>Examinator</b>	dr. C.M. Quant
<b>Niveau</b>	600

### Doel vak

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.

### Inhoud vak

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.

### Onderwijsvorm

Either the student performs individual research or the student is an intern at a host organization.

### Toetsvorm

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/>

### Literatuur

assigned individually

### Vereiste voorkennis

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

### Doelgroep

mSFM, mMath

### Overige informatie

If you are planning to start your external project within four months, please make an appointment with Annemieke van Goor ([vangoor@few.vu.nl](mailto: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>

## Measure Theoretical Probability

<b>Vakcode</b>	X_400244 (400244)
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<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

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>.

### Doelgroep

mMath, mSFM

### Intekenprocedure

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 Theory

<b>Vakcode</b>	X_401028 (401028)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.W.J. Meester
<b>Examinator</b>	prof. dr. R.W.J. Meester
<b>Docent(en)</b>	prof. dr. R.W.J. Meester
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege, Deeltoets extra zaalcapaciteit
<b>Niveau</b>	300

### Doel vak

Basics of measure theory and the Lebesgue integral

### Inhoud vak

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 measure, 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.

### Onderwijsvorm

Classical classes with exercise classes.

### Toetsvorm

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.

### Literatuur

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

### Vereiste voorkennis

Basics of calculus.

### Doelgroep

3W, 3Ect, 3WN

## Mirror Symmetry

<b>Vakcode</b>	X_418142 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	600

### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2014-2015/zoek-vak/vak/742960>

### Doelgroep

mMath

### Overige informatie

Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via <https://www.sis.uva.nl>

## Modular Forms

<b>Vakcode</b>	X_405118 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. S.R. Dahmen
<b>Examinator</b>	dr. S.R. Dahmen

<b>Docent(en)</b>	dr. S.R. Dahmen
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	600

### Doel vak

The aim of this course is to familiarize students with basic concepts, techniques, and applications of modular form theory as well as with some modern (deep) results about modular forms and their applications. The students will also learn how to perform explicit calculations with modular forms using the (free open-source) mathematics software system Sage.

### Inhoud vak

This is an introductory course into the subject of modular forms and their applications. A modular form is a complex analytic function defined on the complex upper half plane which has a certain symmetry with respect to the action of  $SL(2, \mathbb{Z})$  (or some subgroup) on the upper half plane and which satisfies some growth condition. Near the turn of the 19th to 20th century it became clear that the coefficients of the series expansions are often integers with an important number theoretical interest. This insight has only grown in the 20th century and nowadays modular forms are an indispensable tool in modern number theory (but also play an important role in other subjects, e.g. physics). One of the great successes was their use in the proof of Fermat's Last Theorem by Andrew Wiles around 1994.

Topics include: the modular group and congruence subgroups, definition of modular forms and first properties, Eisenstein series, theta series, dimension of modular form spaces, Hecke operators, Petersson inner product. In the final part of the course we will give a global outlook on the use of modular forms and their associated Galois representations in the solution of Diophantine equations, in particular Fermat's Last Theorem.

### Onderwijsvorm

Two hours of lecturing (with breaks), followed by a one-hour exercise session.

### Toetsvorm

Homework exercises and a final exam (either oral or written, depending on the number of participants).

### Literatuur

We will cover parts of the book "A first course in modular forms" by Fred Diamond and Jerry Shurman, Springer Graduate Texts in Mathematics Volume 228.

Some additional handouts will be provided later in the course.

### Vereiste voorkennis

Basics of linear algebra, group theory, and complex analysis.

### Aanbevolen voorkennis

Some familiarity with Galois theory would be helpful (but not strictly necessary) for the last few lectures.

### Doelgroep

## Non-Commutative Geometry

<b>Vakcode</b>	X_418099 ()
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	400

### Inhoud vak

Information course via

<http://studiegids.uva.nl/web/uva/sgs/nl/c/14275.html>

### Doelgroep

mMath

### Overige informatie

Course registration at the UVA is compulsory at least 4 weeks before the start of the semester via <https://www.sis.uva.nl>

## Nonparametric Bayesian Statistics

<b>Vakcode</b>	X_418124 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	500

### Inhoud vak

The course description is available on:

<http://studiegids.uva.nl/web/uva/sgs/nl/c/7984.html>

### Doelgroep

mMath, mSFM

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Numerical Linear Algebra

<b>Vakcode</b>	X_400329 (400329)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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.

## Numerical Methods

<b>Vakcode</b>	X_401039 (401039)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. R. Castelli
<b>Examinator</b>	dr. R. Castelli
<b>Docent(en)</b>	dr. R. Castelli
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

### Doel vak

- 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.

### Inhoud vak

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.

### Onderwijsvorm

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

### Toetsvorm

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

### Literatuur

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

### Vereiste voorkennis

A basic course in linear algebra (e.g. X\_400041 or X\_400042)

### Aanbevolen voorkennis

A basic course in linear algebra.

### Doelgroep

2W, 2W-B, 2-WN, mBA, mBA-D

## Numerical Methods for Time-dependent PDE's

<b>Vakcode</b>	X_418010 (418010)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

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> .

### Doelgroep

mMath

### Intekenprocedure

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.

## Optimization of Business Processes

<b>Vakcode</b>	X_400422 (400422)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.M. Koole

<b>Examinator</b>	prof. dr. G.M. Koole
<b>Docent(en)</b>	prof. dr. G.M. Koole
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

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

### Inhoud vak

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.

### Onderwijsvorm

Lectures and practical work.

### Toetsvorm

Written examination, individual assignments, and a book presentation.

### Literatuur

Lecture notes.

### Aanbevolen voorkennis

Applied Stochastic Modeling or equivalent knowledge

### Doelgroep

mBA, mBA-D, mMath

### Overige informatie

Attendance mandatory.

## Parallel Algorithms

<b>Vakcode</b>	X_418011 (418011)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see

<http://www.mastermath.nl>.

### Doelgroep

mMath



### Intekenprocedure

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.

## Partial Differential Equations

<b>Vakcode</b>	X_400330 (400330)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. J. Hulshof
<b>Examinator</b>	prof. dr. J. Hulshof
<b>Docent(en)</b>	prof. dr. J. Hulshof
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

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>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Percolation

<b>Vakcode</b>	X_418139 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. J. van den Berg
<b>Examinator</b>	prof. dr. J. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Doel vak

The aim is to introduce classical results (computation of certain critical values) as well as more recent developments (e.g. conformal

invariance; see course description below) in percolation theory. At the end of the course the student is expected to understand these results and to be familiar with the machinery developed in the course.

### **Inhoud vak**

Percolation deals with the connectivity properties of large (in many cases infinite) networks, for instance a 'honeycomb' lattice, from which a certain fraction  $q$  of the nodes or bonds is randomly removed (coloured red) and the remaining part is coloured green. It is inspired by phenomena in physics and life sciences, but has become a mathematical topic of independent interest. It is one of the nicest examples of a system with critical behaviour: There is a critical value of the parameter  $q$  at which the global properties change drastically.

After a general introduction, the first part of the course treats several classical results, including Kesten's famous proof that the critical probability for bond percolation on the square lattice is  $1/2$ . Then we turn to new exciting developments which started around 2000 with work by Oded Schramm, Wendelin Werner (Fields medal 2006), Stanislav Smirnov (Fields medal 2010) and others. A key result is that at the critical value the interface between green and red regions, seen at large scale, can be described mathematically in a very nice and explicit way. Key words here are conformal invariance and Schramm-Loewner evolutions. These notions will be explained and studied during the course, and some explicit computations will be made using this machinery.

### **Onderwijsvorm**

There will be a weekly 3-hour lecture. (Sometimes the third hour will be used for making or discussing homework exercises).

### **Toetsvorm**

Homework assignments and oral exam

### **Literatuur**

I will present some chapters from the book "Probability on graphs" by Geoffrey Grimmett (Cambridge University Press, 2010). Further I will use (and provide) lecture notes by myself, and some material which is freely available from the internet.

### **Vereiste voorkennis**

Basic probability and analysis

### **Aanbevolen voorkennis**

Some knowledge of Brownian motion and stochastic calculus, and of conformal maps, is useful in the second half of the course, but not necessary (the ingredients we use will be introduced and explained during the course).

### **Doelgroep**

Master students Mathematics, master students Stochastics and Financial Mathematics. Also interesting for master students Theoretical Physics.

### **Intekenprocedure**

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.

## Portfolio Theory

<b>Vakcode</b>	X_400535 (400535)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	500

### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2014-2015/zoek-vak/vak/8856>

### Doelgroep

mSFM, mMath

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Praktijk I

<b>Vakcode</b>	O_MLPRAKI ()
<b>Periode</b>	Periode 1+2+3, Periode 4+5+6
<b>Credits</b>	15.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Coördinator</b>	ir. E.J.F. Scheringa
<b>Examinator</b>	ir. E.J.F. Scheringa
<b>Niveau</b>	500

### Doel vak

De student maakt kennis met het onderwijs in de praktijk, verzorgt lessen en is betrokken bij andere leerlinggerichte activiteiten. Hij kan binnen de context van de school theoretische inzichten praktisch vormgeven en weet de praktijkomgeving te benutten om aan eigen ontwikkelpunten te werken.

De student werkt samen met anderen binnen en buiten de school en kan zijn functioneren als teamlid beschrijven en toelichten.

### Inhoud vak

Het totale aantal klassencontacturen dat een student moet maken tijdens Praktijk 1 en 2, bedraagt tenminste 250. Tijdens deze uren observeert of verzorgt de student lessen en neemt deel aan andere leerlinggerichte activiteiten. Hij/zij geeft tenminste 120 lessen, waarvan minimaal 40 lesuren in de bovenbouw havo/vwo.

De verdeling en fasering van dit aantal uren over Praktijk 1 en 2 wordt in overleg met de begeleider op school bepaald. In Praktijk 1 ligt de nadruk op het observeren en het onder begeleiding voorbereiden, uitvoeren en evalueren van lessen.

Dit opleidingsonderdeel loopt parallel aan vakdidactiek 1 en algemene didactiek en pedagogiek 1, waardoor een goede wisselwerking mogelijk is tussen theorie en praktijk.

### Toetsvorm

Praktijk 1 wordt door de schoolbegeleider beoordeeld aan de hand van een checklist. De schoolbegeleider doet daarbij een voorstel dat door de instituutsbegeleider moet worden onderschreven.

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding

## Praktijk II

<b>Vakcode</b>	O_MLPRAKII ()
<b>Periode</b>	Periode 1+2+3, Periode 4+5+6
<b>Credits</b>	15.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Coördinator</b>	ir. E.J.F. Scheringa
<b>Examinator</b>	ir. E.J.F. Scheringa
<b>Niveau</b>	500

### Doel vak

De student kan, als docent-in-opleiding, verantwoordelijkheid dragen voor het zelfstandig voorbereiden, uitvoeren en evalueren van lessen in de onder- en bovenbouw van het Havo/VWO. Hij kan tevens een bijdrage leveren aan schoolbrede activiteiten. Hij kan binnen de context van de school theoretische inzichten praktisch vormgeven en weet de praktijkomgeving te benutten om aan eigen ontwikkelpunten te werken. Hij kan reflecteren op opgedane ervaringen en verworven inzichten en deze op dusdanige manier beschrijven dat zij inzichtelijk worden voor anderen. De student toont zich professioneel in de samenwerking met anderen binnen en buiten de school en kan zijn functioneren als teamlid beschrijven en toelichten.

### Inhoud vak

Het totale aantal klassencontacturen dat een student moet maken tijdens Praktijk 1 en 2, bedraagt tenminste 250. Tijdens deze uren observeert of verzorgt de student lessen en neemt deel aan andere leerlinggerichte activiteiten. Hij/zij geeft tenminste 120 lessen, waarvan minimaal 40 lessen in de bovenbouw havo/vwo.

De verdeling en fasering van dit aantal uren over Praktijk 1 en 2 wordt in overleg met de begeleider op school bepaald. Tijdens Praktijk 2 draagt de student verantwoordelijkheid voor een of meer klassen. Hij bereidt het onderwijs voor, voert het uit en evalueert het. Hij werkt hierbij nadrukkelijk samen met sectiegenoten en andere collega's binnen de school en is zich bewust van de context waarin zijn lessen plaatsvinden. In het portfolio doet hij verslag van zijn functioneren als teamlid en collega in de school.

Dit opleidingsonderdeel loopt parallel aan vakdidactiek 2 en algemene didactiek en pedagogiek 2, waardoor een goede wisselwerking mogelijk is tussen theorie en praktijk.

### Toetsvorm

Praktijk 2 wordt door de schoolbegeleider beoordeeld aan de hand van een checklist waarop het eindcijfer voor de praktijk wordt gebaseerd. De schoolbegeleider doet daarbij een voorstel dat door de instituutsbegeleider moet worden onderschreven.

Tevens beoordeelt schoolbegeleider het functioneren van de student als teamlid en collega op basis van de door de student uitgevoerde portfolio-opdrachten.

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding.

## Professionele ontwikkeling en onderzoek I

<b>Vakcode</b>	O_MLVPOOI ()
<b>Periode</b>	Periode 1+2+3, Periode 4+5+6
<b>Credits</b>	3.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Docent(en)</b>	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. S. Attema-Noordewier, drs. W. Jongejan, dr. H.B. Westbroek, dr. E. van den Berg, C.L. Geraedts, drs. A. Krijgsman, prof. dr. J.J. Beishuizen, dr. A.A. Kaal, dr. J.J.M. van Eersel, drs. K.L. Schaap, W. Maas, drs. G.D. van Hummel, F.L. de Vries MSc, drs. H. Stouthart
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	500

### Doel vak

De student kan systematische reflecteren op het eigen handelen in de onderwijspraktijk en daardoor richting geven aan de eigen professionele ontwikkeling.

De student kan een onderzoeksvraag formuleren voor een onderzoek aan zijn/haar eigen onderwijspraktijk, deze vraag inbedden in een theoretisch kader en een opzet maken voor de uitvoering van het onderzoek.

### Inhoud vak

Dit vak bestaat uit twee delen: een reflectiedeel en een onderzoeksdeel. Het reflectiedeel krijgt vorm en inhoud in zogenaamde peergroepbijeenkomsten. Hierin reflecteert de studenten samen met anderen op zijn/haar handelen in de praktijk en leert daaruit ontwikkelpunten af te leiden, acties te formuleren en deze te evalueren. Verschillende instrumenten en methodes worden gebruikt (logboek,

reflectiecirkel, intervisie,...) om de student in staat te stellen de complexiteit van de onderwijspraktijk te doorgronden en hiervan te leren. Daarnaast wordt een start gemaakt met het formuleren van de eigen visie op onderwijs en leren.

In het onderzoeksdeel wordt een opzet gemaakt van een praktijkonderzoek. In dit onderzoek diept de student één of meer vraagstukken uit de (eigen) onderwijspraktijk uit, waarbij een onderzoeksvraag ingebed wordt in een theoretisch kader en op één of enkele scholen empirisch materiaal wordt verzameld. In plenaire bijeenkomsten komen onderwerpen aan de orde als het formuleren van de probleemstelling en de onderzoeksvraag, het verkennen van de literatuur en het verzamelen van de data. Daarnaast kan de student beroep doen op individuele begeleiding rondom zijn/haar onderzoek. Dit alles mondt uit in een eerste onderzoeksformat voor het praktijkonderzoek dat vervolgens in het vak Professionele Ontwikkeling en Onderzoek 2 uitgevoerd, gepresenteerd en geëvalueerd wordt.

### Onderwijsvorm

colleges, werkgroepbijeenkomsten en individuele begeleiding van het onderzoek door instituutsbegeleiders.

### Toetsvorm

Uitvoeren van opdrachten.

### Literatuur

Een literatuurlijst wordt verstrekt aan het begin van de opleiding.

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding.

### Overige informatie

Voor alle onderdelen geldt een aanwezigheidsplicht.

## Professionele ontwikkeling en onderzoek II

<b>Vakcode</b>	O_MLVPOOII ()
<b>Periode</b>	Periode 1+2+3, Periode 4+5+6
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Coördinator</b>	dr. H.B. Westbroek
<b>Examinator</b>	dr. H.B. Westbroek
<b>Docent(en)</b>	dr. C.P. van Velzen, drs. W. Jongejan, dr. T. Bosma, dr. H.B. Westbroek, dr. E. van den Berg, dr. A.A. Kaal, dr. J.J.M. van Eersel, dr. A. Handelzalts, W. Maas
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	500

### Doel vak

De student kan een praktijkonderzoek opzetten, uitvoeren en hierover rapporteren.

### Inhoud vak

Dit vak bestaat uit twee delen: een reflectiedeel en een onderzoeksdeel. Het reflectiedeel krijgt vorm en inhoud in begeleide en zelfstandige intervisiegroepen waarin studenten reflecteren op hun praktijk aan de hand van cases en eigen videobeelden. Daarnaast formuleren de studenten in dit deel hun visie op onderwijs en leren.

In het praktijkonderzoeksdeel diept de student in samenwerking met een medestudent één of meer vraagstukken uit de (eigen) onderwijspraktijk uit. Hij of zij doet dat door het samen opzetten, uitvoeren en evalueren van een op de eigen onderwijspraktijk gericht onderzoek waarbij op één of enkele scholen empirisch materiaal wordt verzameld. Aan de hand van de opzet die deels gemaakt is tijdens de module Professionele Ontwikkeling en Onderzoek 1 en deels in POO 2 ontwerpen studenten onderzoeksinstrumenten om empirisch gegevens te verzamelen voor het beantwoorden van de onderzoeksvraag en voeren zij het onderzoek uit.

Voordat het onderzoeksplan mag worden uitgevoerd, moet het worden goedgekeurd door de eerste en tweede beoordelaar.

In een artikel voor collega docenten rapporteren studenten over het onderzoek waarin aan de orde komen vraagstelling, relevantie, verankering in bestaande theorie, gebruikte instrumenten, data, conclusie en discussie. De studenten presenteren ook hun onderzoek tijdens de Onderwijsresearchdag.

### **Onderwijsvorm**

Onderzoek, verplichte deelname aan hoorcolleges praktijkonderzoek en werkcollege, intervisiebijeenkomsten, individuele begeleiding door instituutsbegeleiders.

### **Toetsvorm**

De rapportage van het praktijkonderzoek vindt plaats in de vorm van een posterpresentatie en een artikel voor een vaktijdschrift voor leraren.

Het artikel wordt gezamenlijk beoordeeld door de eerste begeleider en tweede lezer, die wordt aangezocht door de eerste begeleider. De presentatie van het onderzoek op de Onderwijsresearchdag wordt meegenomen in de eindbeoordeling. Ook de mate van zelfstandigheid in het opzetten, uitvoeren en rapporteren van het onderzoek wordt beoordeeld

### **Literatuur**

Een literatuurlijst wordt verstrekt aan het begin van de opleiding.

### **Vereiste voorkennis**

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding.

Om dit vak te volgen moet het vak Professionele Ontwikkeling en Onderzoek 1 met goed gevolg zijn afgelegd.

### **Overige informatie**

Voordat het onderzoeksplan mag worden uitgevoerd, moet het worden goedgekeurd door de eerste en tweede beoordelaar.

Voor alle onderdelen geldt een aanwezigheidsplicht.

## Queueing Theory

<b>Vakcode</b>	X_400397 (400397)
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<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the joint national master programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>

### Doelgroep

mMath

### Intekenprocedure

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.

## Scheduling

<b>Vakcode</b>	X_400396 (400396)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the joint national master programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath, mBA

### Intekenprocedure

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

<b>Vakcode</b>	X_400512 ()
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<b>Periode</b>	Periode 4
<b>Credits</b>	3.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	M. van den Hoorn
<b>Examinator</b>	M. van den Hoorn
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

The aim of this course is to provide the writing student with the essential linguistic means for producing English academic texts which are effective, idiomatically and stylistically appropriate and grammatically correct.

### Inhoud vak

The initial focus in the course lies on the form of scientific texts in the Exact Sciences:

- Abstract (or summary)
- Introduction
- Methods
- Results
- Discussion

#### General course outline

##### Introducing the topics

- Academic and technical writing in English
- The characteristics of different kinds of scientific texts
- How scientific writing is judged and assessed
- Where do you find your information and how do you present it?
- How to avoid committing plagiarism

##### Who am I writing for? What do I want to say?

- Your readership
- Key parts of an academic article: title, abstract, introduction, methods, results and discussion

##### Writing the actual article

- Paragraph and sentence construction: how do I link paragraphs together?
- Writing simple and complex sentences. Active and passive sentences.
- Argumentation : how do I put an argument? How do I frame my own opinion?

##### Should I use "I" or "we"?

##### Writing correct English

- Use of apostrophes and colons
- Word order, verb tenses, time and tense
- Avoiding mistakes typically made by Dutch writers
- Common spelling mistakes

You will be making considerable use of peer assessment: examining fellow students' written work and giving them feedback. This method provides useful insights into how a text might be improved. The process of providing someone else with feedback on their text is something that you will find very instructive.

### Onderwijsvorm

The course is focused on self-tuition. The plenary sessions concentrate on the process of writing and the product of writing. Homework is part of the course. With each topic, participants work through a phased series of exercises that usually conclude with the requirement to write a short piece of text. The instructor will append extensive written remarks to this text.

### Toetsvorm

There will be no examination. However, students will receive their credits only when they have participated in all classes (presence is obligatory) and also when they have handed in the assignments satisfactorily. Students will receive a 'pass' when they have finished the course.

### Literatuur

For this course you need the book *Effective Scientific Writing: an advanced learner's guide to better English* (A. Bolt & W. Bruins, ISBN 978 90 8659 6171). This book can be obtained at the VU bookstore, which is located in the VU main building. The costs are € 27,95 per book. For questions contact the Taalcentrum-VU at 020 - 598 9804.

### Vereiste voorkennis

Bachelor Exact Sciences

### Doelgroep

3BA, mBA, mMath, mSFM

## Seminar Mathematics

<b>Vakcode</b>	X_405024 (405024)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. B.T. Knapik
<b>Examinator</b>	dr. B.T. Knapik
<b>Docent(en)</b>	dr. B.T. Knapik
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

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.

### Inhoud vak

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

**Onderwijsvorm**

Seminar talks by students, individual coaching, group discussion, self study.

**Toetsvorm**

Seminar talk

**Literatuur**

Various; will be announced in the seminar

**Doelgroep**

mMath, mSFM

**Overige informatie**

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

<b>Vakcode</b>	X_418034 (418034)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	400

**Inhoud vak**

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> .

**Doelgroep**

mMath

**Intekenprocedure**

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

<b>Vakcode</b>	X_400258 (400258)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	400

### Inhoud vak

The course description is available on:

<http://studiegids.uva.nl/web/uva/sgs/en/c/170.html>

### Doelgroep

mMath, mSFM

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Statistical Data Analysis

<b>Vakcode</b>	X_401029 (401029)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. F. Bijma
<b>Examinator</b>	dr. F. Bijma
<b>Docent(en)</b>	dr. F. Bijma
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

### Doel vak

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.

### Inhoud vak

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.

**Onderwijsvorm**

Lectures, computer classes.

**Toetsvorm**

Weekly homework assignments and written exam.

**Literatuur**

Lecture notes.

**Aanbevolen voorkennis**

Students should have basic knowledge on statistics, e.g. Algemene Statistiek (X\_400004).

**Doelgroep**

2BA, 2W, 2W-B, 2-WN, 3W, 3Ect.

**Overige informatie**

Language of tuition: English

## Statistical Models

<b>Vakcode</b>	X_400418 (400418)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. E.N. Belitser
<b>Examinator</b>	dr. E.N. Belitser
<b>Docent(en)</b>	prof. dr. M.C.M. de Gunst, dr. E.N. Belitser
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

**Doel vak**

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.

**Inhoud vak**

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

**Onderwijsvorm**

Course of lectures, exercises and tutorial

**Toetsvorm**

Assignments and examination.

**Literatuur**

Lecture notes "Statistical Models" by M.C.M. de Gunst.

**Vereiste voorkennis**

Basic statistics course

**Aanbevolen voorkennis**

Algemene Statistiek (X\_400004) and Statistische Data Analysis (X\_401029). A sufficient mark for the exercises is required for entry to the written examination.

**Doelgroep**

mBA, mBA-D, mMath

**Overige informatie**

Students will use statistical package R ([www.r-project.org/](http://www.r-project.org/)) for data analysis.

**Statistics for Networks**

<b>Vakcode</b>	X_405110 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. M.C.M. de Gunst
<b>Examinator</b>	prof. dr. M.C.M. de Gunst
<b>Docent(en)</b>	prof. dr. M.C.M. de Gunst
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	600

**Doel vak**

After this course students are acquainted with the main statistical methods and models for network analysis.

**Inhoud vak**

Researchers from diverse disciplines as biology, physics, sociology, economics, computer science and mathematics, are more and more involved with the collection, modeling and analysis of network data. The relational nature of network data means that statistical analysis of such data is generally more involved than the 'standard' statistical analysis, that different mathematical models and different statistical methods are needed, and that different problems need to be faced. The aim of this course is to get students acquainted with the main methods and models for network analysis. The course focuses on the mathematical aspects of statistical modeling and statistical analysis of networks; computational aspects of network analysis will not be covered. Topics that will be discussed are: descriptive statistics for networks, network sampling, network modeling, inference for networks, and modeling and prediction for processes on network graphs.

**Onderwijsvorm**

Lectures

**Toetsvorm**

Written exam and possibly presentations.

**Literatuur**

- Statistical Analysis of Network Data by E.D. Kolaczyk, Springer, 2010.
- Additional material will be provided during the course.

**Vereiste voorkennis**

An introductory probability course, like Kansrekening 1 (X\_400189) plus Kansrekening 2 (X\_400190), and an introductory statistics course, like Algemene Statistiek (X\_400004).

**Aanbevolen voorkennis**

Statistical Data Analysis (X\_401029)

**Doelgroep**

mMath, mSFM

## Stochastic Differential Equations

<b>Vakcode</b>	X_400454 (400454)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	500

**Inhoud vak**

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see

<http://www.mastermath.nl>.

**Doelgroep**

mMath

**Intekenprocedure**

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.

## Stochastic Integration

<b>Vakcode</b>	X_400470 (400470)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	400

**Inhoud vak**

The course description is available on:

<http://studiegids.uva.nl/web/uva/sgs/en/c/173.html>

**Doelgroep**

### Overige informatie

Course registration is compulsory via <https://www.sis.uva.nl>

## Stochastic Optimization

<b>Vakcode</b>	X_400336 (400336)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. S. Bhulai
<b>Examinator</b>	dr. S. Bhulai
<b>Docent(en)</b>	dr. S. Bhulai
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

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

### Inhoud vak

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.

### Onderwijsvorm

Lectures.

### Toetsvorm

Programming and written exercises, final exam.

### Literatuur

Lecture notes will be posted on BlackBoard

### Vereiste voorkennis

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

### Aanbevolen voorkennis

Stochastische Processen (X\_401026) and Wachtrijmodellen (X\_401061) or equivalent courses on Stochastic Processes and Queueing Theory and a programming language.

### Doelgroep

mBA, mBa-D, mMath, mSFM

## Stochastic Processes



<b>Vakcode</b>	X_400339 (400339)
<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

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>

### Doelgroep

mMath

### Intekenprocedure

You have to register your participation in each Mastermath course via <http://www.mastermath.nl/registration/>

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## Stochastic Processes for Finance

<b>Vakcode</b>	X_400352 (400352)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. E.N. Belitser
<b>Examinator</b>	dr. E.N. Belitser
<b>Docent(en)</b>	dr. E.N. Belitser
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	400

### Doel vak

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.

### Inhoud vak

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.

### Onderwijsvorm

Lectures and exercises.

### Toetsvorm

Assignments and written examination.

### Literatuur

Lecture notes.

Shreve, S.E., Stochastic Calculus for Finance I: The Binomial Asset Pricing Model. Springer.

Shreve, S.E., Stochastic Calculus for Finance II: Continuous-time models. Springer.

In addition, it is useful to have the following book: Bjork, T., Arbitrage Theory in Continuous Time, third edition. Oxford University Press.

### Vereiste voorkennis

Introductory probability theory and statistics, calculus.

### Aanbevolen voorkennis

Introductory probability theory and statistics, calculus.

### Doelgroep

mBA, mBA-D, mMath, mSFM, master Econometrics, Quantitative Finance

### Overige informatie

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

<b>Vakcode</b>	X_418036 (418036)
<b>Periode</b>	Periode 1+2

<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

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> .

### Doelgroep

mMath

### Intekenprocedure

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.

## Systems and Control

<b>Vakcode</b>	X_400332 (400332)
<b>Periode</b>	Periode 1+2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Niveau</b>	400

### Inhoud vak

This course is part of the joint national master programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Time series

<b>Vakcode</b>	X_400571 (400571)
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<b>Periode</b>	Periode 4+5
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. G.J.B. van den Berg
<b>Examinator</b>	prof. dr. G.J.B. van den Berg
<b>Docent(en)</b>	prof. dr. A.W. van der Vaart
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Inhoud vak

This course is part of the Joint National Master Programme in Mathematics.

For schedules, course locations and course descriptions see <http://www.mastermath.nl>.

### Doelgroep

mMath

### Intekenprocedure

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.

## Topological Methods for Differential Equations

<b>Vakcode</b>	X_418140 ()
<b>Periode</b>	Periode 1+2
<b>Credits</b>	8.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.C.A.M. van der Vorst
<b>Examinator</b>	prof. dr. R.C.A.M. van der Vorst
<b>Docent(en)</b>	prof. dr. R.C.A.M. van der Vorst
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	600

### Inhoud vak

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

### Doelgroep

mMath

### Intekenprocedure

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.

## Vakdidactiek Wiskunde I

<b>Vakcode</b>	O_MLVDWII ()
<b>Periode</b>	Periode 1+2, Periode 4+5
<b>Credits</b>	3.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Coördinator</b>	drs. W.S. Hoekstra
<b>Examinator</b>	drs. W.S. Hoekstra
<b>Docent(en)</b>	drs. W.S. Hoekstra
<b>Lesmethode(n)</b>	Werkcollege
<b>Niveau</b>	500

### Doel vak

De student kan vakinhoudelijke en vakdidactische kennis, vaardigheden en inzichten vertalen naar de eigen vaklessen.

### Inhoud vak

Tijdens de vakdidactiekcolleges maakt de student kennis met de inhoud en didactiek van het schoolvak en leert deze inzichten in de praktijk vorm te geven. Er is aandacht voor vakspecifieke kennis en vaardigheden en de voor het schoolvak relevante ICT-toepassingen. In het vakdidactiekprogramma vindt eveneens een vertaling plaats van algemeen didactische thema's naar het vak. De leservaringen op school spelen hierbij een belangrijke rol.

### Onderwijsvorm

Werkcolleges

### Toetsvorm

Beoordeling van het portfolio

### Literatuur

Drijvers, P., Van Streun, A., & Zwaneveld, B. (Red.)(2012). Handboek Wiskundedidactiek . Utrecht: Epsilon.

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding

### Overige informatie

Er geldt een aanwezigheidsplicht

## Vakdidactiek Wiskunde II

<b>Vakcode</b>	O_MLVDWIII ()
<b>Periode</b>	Periode 1+2, Periode 4+5
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Coördinator</b>	drs. W.S. Hoekstra

<b>Examinator</b>	drs. W.S. Hoekstra
<b>Docent(en)</b>	drs. W.S. Hoekstra
<b>Lesmethode(n)</b>	Werkcollege
<b>Niveau</b>	500

### Doel vak

De student kan vakinhoudelijke en vakdidactische kennis, vaardigheden en inzichten vertalen naar de eigen vaklessen en zijn aanpak verantwoorden.

### Inhoud vak

De tijdens Vakdidactiek 1 opgedane kennis en vaardigheden worden in Vakdidactiek 2 verder uitgebreid en verdiept. In dit semester ligt het accent op het zelfstandig vormgeven van een samenhangende lessenserie gericht op de bovenbouw van het Voortgezet Onderwijs, die inhoudelijk en vakdidactisch verantwoord moet worden.

### Onderwijsvorm

Werkcolleges

### Toetsvorm

Beoordeling van het portfolio

### Literatuur

Een literatuurlijst wordt verstrekt aan het begin van de opleiding

### Vereiste voorkennis

Dit vak is alleen te volgen als onderdeel van de universitaire lerarenopleiding

Reguliere studenten dienen eerst Vakdidactiek 1 afgerond te hebben alvorens aan Vakdidactiek 2 kan worden deelgenomen. Voor instromers (studenten met een tweedegraads bevoegdheid en een master in het Schoolvak) geldt deze verplichting niet.

### Overige informatie

Er geldt een aanwezigheidsplicht

## Verdieping

<b>Vakcode</b>	O_MLVERD ()
<b>Periode</b>	Periode 2+3, Periode 5+6
<b>Credits</b>	3.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Psychologie en Pedagogiek
<b>Docent(en)</b>	drs. J.K.W. Riksen, drs. H.R. Goudsmit, drs. Y.G. Meindersma, drs. W.S. Hoekstra, drs. S. Donszelmann, dr. H.B. Westbroek, dr. E. van den Berg, C.L. Geraedts, drs. A. Krijgsman, dr. J.J.M. van Eersel, drs. K.L. Schaap, W. Maas, drs. G.D. van Hummel, F.L. de Vries MSc, drs. H. Stouthart, drs. I. Pauw, drs. C.D.P. van Oeveren
<b>Lesmethode(n)</b>	Werkcollege,
<b>Niveau</b>	500

### Doel vak

1. De student verdiept zich in een onderdeel binnen zijn of haar schoolvak of cluster.
2. De student is zich bewust van zijn of haar rol als docent in een pluriforme samenleving.
3. De student kan verschillende aspecten van diversiteit in het onderwijs benoemen en aangeven in hoeverre deze aspecten in zijn of haar eigen schoolvak een rol spelen.

### Inhoud vak

Binnen de clusters en vakken worden (verplichte) verdiepingsmodulen aangeboden. Daarnaast volgt elke student het onderdeel diversiteit, waarin een aantal aspecten van onderwijs in een pluriforme samenleving aan bod komen:

1. Wat betekent identiteitsontwikkeling in een door diversiteit gekenmerkte samenleving?
2. Wat is de zin en onzin van diversiteitsgevoelig onderwijs?
3. Wat zijn de verschillende thematieken van diversiteit in de klas?
4. Wat is er bekend uit onderzoek over diversiteit in de onderwijspraktijk?

### Onderwijsvorm

Hoorcollege, werkcollege.

### Toetsvorm

Analyse van een casus.

### Literatuur

Syllabus met artikelen wordt verstrekt.

## Workshop Mathematical Modelling

<b>Vakcode</b>	X_401062 (401062)
<b>Periode</b>	Periode 3
<b>Credits</b>	6.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. J. Hulshof
<b>Examinator</b>	prof. dr. J. Hulshof
<b>Docent(en)</b>	prof. dr. R.W.J. Meester, prof. dr. J. Hulshof
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Inhoud vak

Dit vak is een intensieve workshop van vier weken, waarbij de studenten in groepen van 5 à 6 zelf een probleem uit een ander wetenschapsgebied of uit de industrie verkennen, wiskundig modelleren en analyseren. De probleemstellingen zijn open geformuleerd er is geen a priori sturing richting bepaalde deelgebieden van de wiskunde. In de vierde week wordt het werk afgerond met een presentatie en een verslag.

### Onderwijsvorm

Project

**Toetsvorm**

Beoordeling van werkwijze, presentatie en verslag.

**Doelgroep**

3W, 3-WN, mMath, mPhys