



## Business Analytics MSc

Vrije Universiteit Amsterdam - Faculteit der Exacte Wetenschappen - M Business Analytics - 2016-2017

The Master's program in Business Analytics is a multidisciplinary program aimed at improving business performance by applying a combination of methods that draw from mathematics, computer science and business management. Based on a good understanding of the field and making excessive use of data, you will learn to statistically analyze these data, develop and analyze predictive models, and optimize business processes. The emphasis is on the complete trajectory of decision making in practice; together with the combination of the three different fields of expertise, this makes the Business Analytics program unique.

The goal of the master program Business Analytics is to prepare students for a career in business, industry, or within governmental or research facilities, with (possibly only initially) a major quantitative aspect.

There are two variants of the program: The Professional Track and the Dual Master's Program.

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## BA Dual Variant

The dual Master's program combines work and study. During the first 16 months of this program the student is employed part time, and studies part time. The work has to be relevant for the study and the dual work period is granted with 12 EC. Moreover, it is possible to do the Research Paper BA on a case-study that is work related, provided the case-study is combined with a sound theoretical basis. Often, the external master project is carried out at the same organization as the dual work period. The students can only start their internship or Master Project after having finished the compulsory Research Paper BA (6 EC) and having completed all but possibly one program components.

Admission to the dual Master's program is granted to those who have a Business Analytics Bachelor's degree. For those with another university Bachelor's degree, such as Mathematics, Econometrics, Computer Science, or a Bachelor's degree from an institute of higher education, admission may be granted on an individual basis. Those seeking admission to the dual Master's program should realize that admission also depends on obtaining suitable employment. The VU has contacts with a number of companies that are interested in participating in this program.

For more information concerning the dual master's program, contact the coordinator for the external master's project or the master coordinator.

The program consists of 120 European credit points (EC)

- compulsory courses 78 EC (including a Master Project of 36 EC)
- constrained selection 24 EC
- optional courses 18 EC

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

Opleidingsdelen:

- [Master BA The Dual Master's Programme - Compulsory selection Mathematics and BA](#)
- [Suggested elective courses](#)
- [Compulsory Courses](#)

## Master BA The Dual Master's Programme - Compulsory selection Mathematics and BA

There is a constrained selection of at least four courses (24 EC) from this list below.

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

Vakken:

Naam	Periode	Credits	Code
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Advanced Linear Programming	Periode 4+5	6.0	X_400326
Business Intelligence and Analytics	Periode 4	6.0	E_IBK3_BIA
Business Process Analytics	Periode 4	6.0	X_400650
Computational Intelligence	Periode 2	6.0	XMU_417015
Continuous Optimization	Periode 1+2	6.0	X_400446
Entrepreneurship in Data Science and Analytics	Periode 4+5	6.0	X_405122
Evolutionary Computing	Periode 1	6.0	X_400111
Financial Markets and Institutions	Periode 4	6.0	E_EBE3_FMI
Heuristic Methods in Operations Research	Periode 1+2	6.0	X_418006
Investments	Periode 5	6.0	E_EBE3_INVES
Machine Learning 1	Periode 1	6.0	XMU_418144
Numerical Methods	Periode 4+5	6.0	X_401039
Optimization of Business Processes	Periode 4+5	6.0	X_400422
Performance of Networked Systems	Periode 4	6.0	X_405105
Project Optimization of Business Processes	Periode 3	6.0	X_400213
Scheduling	Periode 4+5	6.0	X_400396
Stochastic Optimization	Periode 1+2	6.0	X_400336
Stochastic Processes for Finance	Periode 1+2	6.0	X_400352

## Suggested elective courses

Vakken:

Naam	Periode	Credits	Code
Computational Finance	Periode 4+5	6.0	XMU_418045
Distributed Systems	Periode 2	6.0	X_400130
International Financial Management	Periode 5	6.0	E_IBK3_IFM
Programming Large-scale Parallel Systems	Periode 1	6.0	XM_40017
Statistics for Networks	Periode 1+2	6.0	X_405110
Stochastic Simulation	Periode 2	6.0	XMU_428577
Text Mining	Periode 4	6.0	L_PABAALG002

## Compulsory Courses

Both the Research Paper BA (6 EC) and the Master Project (36 EC) may be work-related. The work period consists of 18 EC. The total work related

credit points has therefore a maximum of 60 EC.

Compulsory alongside the mentioned courses, are a compulsory choice (18 EC) and optional courses (15 EC) to complete 120 EC.

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

Vakken:

Naam	Periode	Credits	Code
<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="#">Data Mining Techniques</a>	Periode 5	6.0	X_400108
<a href="#">Dual Workperiod</a>	Ac. Jaar (september)	12.0	XM_41010
<a href="#">Master Project Business Analytics</a>	Ac. Jaar (september)	36.0	X_400459
<a href="#">Research Paper Business Analytics</a>	Ac. Jaar (september)	6.0	X_400206
<a href="#">Statistical Models</a>	Periode 1+2	6.0	X_400418

## Professional track

The emphasis will be on a broad and multidisciplinary education, preparing the student for a role as an academically trained quantitative professional in a multidisciplinary organization. Even so, the possibility to continue after the Master in a PhD program exists also for these variants.

Business Analytics is a two-year program. The first six months are devoted to compulsory courses. Over the next twelve months, you will deepen your knowledge in the three fields of expertise after which you will have the opportunity to specialize in business process optimization, computational intelligence and financial risk management. Combining the knowledge you acquire and applying it to practical situations plays an essential role in the program. As such, the Master's degree is concluded with a six-month individual internship at a company (the Master's project). The students can only start their internship or Master Project after having finished the compulsory Research Paper BA (6 EC) and having completed all but possibly one program components.

The program consists of 120 European creditpoints (EC)  
- compulsory courses 72 EC (including a Master Project of 36 EC)  
- compulsory choice 30 EC  
- optional courses 18 EC

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

Opleidingsdelen:

- Compulsory Selection
- Compulsory Courses
- Suggested elective courses

## Compulsory Selection

There is a constrained selection of at least five courses (30 EC) from this list below.

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

Vakken:

Naam	Periode	Credits	Code
<a href="#">Advanced Linear Programming</a>	Periode 4+5	6.0	X_400326
<a href="#">Business Intelligence and Analytics</a>	Periode 4	6.0	E_IBK3_BIA
<a href="#">Business Process Analytics</a>	Periode 4	6.0	X_400650
<a href="#">Computational Intelligence</a>	Periode 2	6.0	XMU_417015
<a href="#">Continuous Optimization</a>	Periode 1+2	6.0	X_400446
<a href="#">Entrepreneurship in Data Science and Analytics</a>	Periode 4+5	6.0	X_405122
<a href="#">Evolutionary Computing</a>	Periode 1	6.0	X_400111
<a href="#">Financial Markets and Institutions</a>	Periode 4	6.0	E_EBE3_FMI
<a href="#">Heuristic Methods in Operations Research</a>	Periode 1+2	6.0	X_418006
<a href="#">Investments</a>	Periode 5	6.0	E_EBE3_INVES
<a href="#">Machine Learning 1</a>	Periode 1	6.0	XMU_418144
<a href="#">Numerical Methods</a>	Periode 4+5	6.0	X_401039
<a href="#">Optimization of Business Processes</a>	Periode 4+5	6.0	X_400422
<a href="#">Performance of Networked Systems</a>	Periode 4	6.0	X_405105
<a href="#">Scheduling</a>	Periode 4+5	6.0	X_400396
<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

The following list contains the compulsory courses (72 EC).

Vakken:

Naam	Periode	Credits	Code
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<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="#">Data Mining Techniques</a>	Periode 5	6.0	X_400108
<a href="#">Master Project Business Analytics</a>	Ac. Jaar (september)	36.0	X_400459
<a href="#">Project Optimization of Business Processes</a>	Periode 3	6.0	X_400213
<a href="#">Research Paper Business Analytics</a>	Ac. Jaar (september)	6.0	X_400206
<a href="#">Statistical Models</a>	Periode 1+2	6.0	X_400418

## Suggested elective courses

Vakken:

Naam	Periode	Credits	Code
<a href="#">Computational Finance</a>	Periode 4+5	6.0	XMU_418045
<a href="#">Distributed Systems</a>	Periode 2	6.0	X_400130
<a href="#">International Financial Management</a>	Periode 5	6.0	E_IBK3_IFM
<a href="#">Programming Large-scale Parallel Systems</a>	Periode 1	6.0	XM_40017
<a href="#">Statistics for Networks</a>	Periode 1+2	6.0	X_405110
<a href="#">Stochastic Simulation</a>	Periode 2	6.0	XMU_428577
<a href="#">Text Mining</a>	Periode 4	6.0	L_PABAALG002

## 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>Docent(en)</b>	prof. dr. L. Stougie
<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

**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.

**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 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. During the course you learn to handle such practically motivated problems as an independent researcher. This means that you:

- learn to determine the appropriate model
- are able to formulate the problem mathematically correct
- are able to solve the stochastic model
- know how to interpret the outcome.

## 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.

## Onderwijsvorm

Lecture and instruction.

## Toetsvorm

Written examination and an hand-in assignment.

## Literatuur

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

## Doelgroep

mBA, mMath

# Business Intelligence and Analytics

<b>Vakcode</b>	E_IBK3_BIA ()
<b>Periode</b>	Periode 4
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Fac. der Economische Wet. en Bedrijfsk.
<b>Coördinator</b>	dr. M.G.A. Plomp

<b>Examinator</b>	dr. M.G.A. Plomp
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege, Instructiecollege, Responsiecollege
<b>Niveau</b>	300

### Doel vak

#### Academic skills:

In this course we teach you to analyze and apply the basic concepts, principles and theories that are needed to address the business intelligence & analytics (BI&A) challenges organizations face. Furthermore, you will learn how to apply knowledge learned from scientific publications on practical BI&A related problems as well as why business intelligence & analytics are considered digital innovations.

#### Quantitative skills:

You will learn to select and analyse data to solve business cases and as such create business insights.

#### Knowledge:

You will obtain fundamental knowledge on concepts and theories related to BI&A that are important for organizations. You will learn to describe and define the core BI&A concepts, principles and theories that are important for organizations in general, and as drivers for innovation more specifically.

#### Bridging theory and practice:

You will learn to apply theoretical knowledge in specific practice situations. You will also learn to translate business strategies into information requirements for decision support systems and to work with business intelligence tools (solve business cases and create business insights) that are well established in businesses. Business consultants are actively involved in this course and will share their experience through case presentations and discussions in the tutorial sessions. Furthermore, this course will offer insight into the professional possibilities in the field of BI&A.

#### Social skills:

In the 'in company' masterclasses you will work in a team and present BI&A pitches to a business audience.

### LEARNING OUTCOMES

After successfully finishing this course you must be able:

- To define, describe and recall the basic concepts, principles and theories underlying business intelligence & analytics solutions (decision support systems).
- To evaluate and discuss the organizational and social implications of business intelligence & analytics solutions
- To classify and compare business intelligence & analytics solutions as well as the constituent components of business intelligence & analytics solutions
- To apply business intelligence & analytics concepts, principles and theories to business problems
- To explore data-driven business models
- To explore, analyze and determine how big data can drive business model innovation
- To analyze business cases, and propose business intelligence & analytics solutions and decide which data to use given a business problem to be solved.
- To create insights using established business intelligence & analytics tools.

### **Inhoud vak**

Data is hot! How organizations deal with the overabundance of data and the ability to transform data into insights have become critical success factors for every organization. Key words in this context are 'big data', 'data science', and 'data –driven decision making and innovation'. This course offers the handles that are needed to fully deploy the potential of data, and business intelligence & analytics solutions in order to create competitive advantage. The course primarily has a managerial focus, technology will be used primarily to create hands on experience with relevant BI&A technologies and as such enhance insights in their features and characteristics. There is a lot of business involvement in this course: experts from industry and BI&A consultants will share their insights and experience in the weekly workshops.

### **Onderwijsvorm**

Lectures  
Tutorials

### **Toetsvorm**

Written exam – Individual assessment  
Interim Assignment(s) / Tests

### **Literatuur**

This course is article based.  
Readings will be announced in the course manual.

### **Aanbevolen voorkennis**

BK:  
2.1 Business Information Technology

IBA:  
2.1 Business Information Systems

## **Business Process Analytics**

<b>Vakcode</b>	X_400650 ()
<b>Periode</b>	Periode 4
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. H. Leopold MSc
<b>Examinator</b>	dr. H. Leopold MSc
<b>Docent(en)</b>	dr. H. Leopold MSc
<b>Lesmethode(n)</b>	Hoorcollege, Practicum
<b>Niveau</b>	400

### **Doel vak**

After taking this course, the student will:

- be aware of the current possibilities to support BPM with information technology.
- understand and be able to employ process mining techniques for the purpose of process discovery, compliance checking, and improvement.

- know key technologies for analyzing large process model repositories.
- know and be able to employ basic as well as advanced NLP techniques for the purpose of process analysis.
- know and be able to use process model simulation for testing and improving process design.

### **Inhoud vak**

There is a steadily increasing interest of organizations to use Business Process Management (BPM) for documenting and improving their operations. However, the associated manual effort for thoroughly eliciting, documenting, and updating process knowledge in the form of process models is often considerable.

Within this course, we put an emphasis on the technological and analytical perspective and discuss how they can support organizations in effectively and efficiently implementing BPM. In fact, techniques from the fields of information retrieval, data mining as well as simulation provide valuable foundations to reduce to the manual effort in the context of BPM. Hence, we introduce and discuss four different technological angles and demonstrate how each of these angles can strengthen the different phases of the BPM life cycle. In particular, we address the following technological areas:

1. **Process Mining:** The technology of process mining builds on the analysis of event logs that were generated by information or workflow systems. We discuss how process mining techniques can be used for process discovery, compliance checking, and improvement and elaborate on basic as well as advanced process mining algorithms. In addition, we introduce current process mining tools for the application of process mining in practice.
2. **Process Model Collections:** Many large organizations maintain process model repositories with several hundred process models. Hence, manual analysis efforts are time-consuming and cumbersome. Recognizing this, we introduce key concepts to automatically analyze process model collections. Among others, we discuss techniques for process model comparison, process model search, and behavioral analysis of process models.
3. **Natural Language Analysis:** The automated analysis of natural language, which is referred to as Natural Language Processing (NLP), has been applied in many contexts. As an example, consider Apple's Siri or Google's S Voice, which are capable of interpreting human speech. In fact, also organizations and their business processes may considerably benefit from natural language processing techniques. Hence, we introduce the key NLP techniques that are relevant in the context of BPM. Among others, we discuss techniques for process model content analysis, process model quality insurance, and identification of improvement potential in process models.
4. **Simulation:** The simulation of business processes is a tool that is used to predict performance and to understand the impact of change. It, for instance, allows organizations to test processes before they are actually technically implemented in a system. Due to its usefulness for organizations, we introduce the technological foundations for process simulation and give an overview of process simulation tools.

The various lectures and instructions will be devoted to these technological areas.

## Onderwijsvorm

There will be lectures as well as work instructions.

## Toetsvorm

The grading for students who follow this course in the scheduled period will be based on two grades:

1. The first grade is based on a number of home assignments. The goal of the assignments is to evaluate whether the students can successfully apply the content from the lecture. Among others, the students will be asked to mine a business process model from a given event log and to automatically infer relevant information using natural language processing tools from a given text.
2. The second grade is gained by participating in the regular exam during the exam week. The exam is a closed book exam, which consists of theoretical questions and small assignments. Selected chapters from the books "Fundamentals of Business Process Management", "Process Mining", and "Speech and Language Processing" will be the basis for this exam.

The overall result for this exam is the rounded, weighted average of the first grade (50%) and the second grade (50%) provided that both grades (unrounded) at least amount to a 5.00. If either of the grades is lower than a 5.00, the overall grade for this course is determined by the rounded, lowest grade of the two.

For all students who fail the course in the scheduled period or decide to follow the course outside this period, the course is graded solely by the grade for the re-exam. This is a full exam similar to the original exam and the assignments. The re-exam is a closed book exam, too.

## Literatuur

1. Fundamentals of Business Process Management. Dumas, M., La Rosa, M., Mendling, J., Reijers, H.A. Springer, 2013. ISBN: 978-3-642-33142-8 (Print) 978-3-642-33143-5 (Online).
2. Process Mining. Discovery, Conformance and Enhancement of Business Processes. van der Aalst, Wil. Springer, 2011. ISBN: 978-3642193446.
3. Speech and Language Processing, Jurafsky, Dan, Martin, James H. Pearson International Edition, 2008. ISBN: 978-0135041963.

## Aanbevolen voorkennis

Students will, among others, benefit from the knowledge they acquired in the courses Information Management and Business Process Management. Motivated students, however, will be able to master the course without prior knowledge from these courses.

## Doelgroep

This is an interdisciplinary course. Any student who is interested in learning how technology can be used to improve business processes in practice is invited to join this course.

## Computational Finance

<b>Vakcode</b>	XMU_418045 ()
<b>Periode</b>	Periode 4+5

<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

#### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2016-2017/zoek-vak/vak/24987>

#### Doelgroep

mSFM

#### Overige informatie

This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, [servicedesk-esc-science@uva.nl](mailto:servicedesk-esc-science@uva.nl), +31 (0)20 525 7100.

Enrolment via <https://m.sis.uva.nl/vakaanmelden> is required.

## Computational Intelligence

<b>Vakcode</b>	XMU_417015 ()
<b>Periode</b>	Periode 2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. A.E. Eiben
<b>Examinator</b>	prof. dr. A.E. Eiben
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

#### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2016-2017/zoek-vak/vak/22870>

#### Overige informatie

This course is offered at the UvA. For more information contact: FNWI Education Service Centre, Science Park 904, [servicedesk-esc-science@uva.nl](mailto:servicedesk-esc-science@uva.nl), +31 (0)20 525 7100.

Enrolment via <https://m.sis.uva.nl/vakaanmelden> is required.

## 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>	dr. R. Bekker
<b>Examinator</b>	dr. R. Bekker
<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.

## Data Mining Techniques

<b>Vakcode</b>	X_400108 (400108)
<b>Periode</b>	Periode 5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. M. Hoogendoorn
<b>Examinator</b>	dr. M. Hoogendoorn
<b>Docent(en)</b>	dr. M. Hoogendoorn
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Doel vak

The aim of the course is that students acquire data mining knowledge and skills that they can apply in a business environment. How the aims are to be achieved: Students will acquire knowledge and skills mainly through the following: an overview of the most common data mining algorithms and techniques (in lectures), a survey of typical and interesting data mining applications, and practical assignments to gain "hands on" experience. The application of skills in a business environment will be simulated through various assignments of the course.

### Inhoud vak

The course will provide a survey of basic data mining techniques and their applications for solving real life problems. After a general introduction to Data Mining we will discuss some "classical" algorithms like Naive Bayes, Decision Trees, Association Rules, etc., and some recently discovered methods such as boosting, Support Vector Machines, and co-learning. A number of successful applications of data mining will also be discussed: marketing, fraud detection, text and Web mining, possibly bioinformatics. In addition to lectures, there will be an extensive practical part, where students will experiment with various data mining algorithms and data sets. The grade for the course will be based on these practical assignments (i.e., there will be no final examination).

### Onderwijsvorm

Lectures (h) and compulsory practical work (pra). Lectures are planned to be interactive: there will be small questions, one-minute discussions, etc.

### Toetsvorm

Practical assignments (i.e. there is no exam). There will be two assignments done in groups of three. There is a possibility to get a grade without doing these assignments: to do a real research project instead (which will most likely to involve more work, but it can also be more rewarding). For the regular assignments the first assignment counts for 40% and the second for 60%. The grade of both assignments needs to be sufficient to pass the course.

### Literatuur

Ian H. Witten, Eibe Frank, Mark A. Hall, Data Mining: Practical Machine Learning Tools and Techniques (Third Edition). Morgan Kaufmann, January 2011  
ISBN 978-0-12-374856-0

### Aanbevolen voorkennis

Kansrekening and Statistiek or Algemene Statistiek (knowledge of statistics and probabilities) or equivalent. Recommended: Machine Learning.

### Doelgroep

mBA, mCS, mAI, mBio

## Distributed Systems

<b>Vakcode</b>	X_400130 (400130)
<b>Periode</b>	Periode 2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. ing. T. Kielmann
<b>Examinator</b>	dr. ing. T. Kielmann
<b>Docent(en)</b>	dr. ing. T. Kielmann
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	400

### Doel vak

After taking this course, students will be able to:

- understand the intricacies related to designing and developing a distributed computer system.
- understand the tradeoffs between centralized, distributed, and fully decentralized solutions.
- understand the impact of scalability on performance and fault-tolerance of a distributed system.
- understand the impact of performance and fault tolerance on data consistency.

- understand the peculiarities of process coordination on large scale.

### **Inhoud vak**

It is difficult to imagine a standalone modern computer system: every such system is one way or the other connected through a communication network with other computer systems. A collection of networked computer systems is generally referred to as a distributed (computer) system. As with any computer system, we expect a distributed system to simply work, and often even behave as if it were a single computer system. In other words, we would generally like to see all the issues related to the fact that data, processes, and control are actually distributed across a network hidden behind well-defined and properly implemented interfaces. Unfortunately, life is not that easy.

As it turns out, distributed systems time and again exhibit emergent behavior that is difficult to understand by simply looking at individual components. In fact, many aspects of a distributed system cannot even be confined to a few components, as is easily seen by just considering security.

In this course, we pay attention to the principles from which modern distributed systems are built. Unfortunately, these principles cannot be viewed independently from each other: each one is equally important for understanding why a distributed system behaves the way it does. We will consider the following principles:

- architectures
- processes
- communication
- naming
- coordination
- consistency and replication
- fault tolerance

These principles will be discussed in the context of a few simplifying concepts that have been used to master the complexity of developing distributed systems: objects, files, documents, and events.

### **Onderwijsvorm**

The course is taught as a series of lectures, in combination with exercise classes.

### **Toetsvorm**

Written exam.

### **Literatuur**

This year, we will use a reader. Details about its distribution will be announced via blackboard in due time.

### **Aanbevolen voorkennis**

Students should have taken a standard course on computer networks. Experience with (distributed) programming will be helpful.

### **Doelgroep**

mCS, mPDCS, mSNE (UvA)

## **Dual Workperiod**

<b>Vakcode</b>	XM_41010 ()
<b>Periode</b>	Ac. Jaar (september)
<b>Credits</b>	12.0
<b>Voertaal</b>	Nederlands
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	drs. H.J.M. van Goor-Balk
<b>Niveau</b>	500

### Doel vak

During the dual work period the student gains experience and skills. The dual period allows the student to bring the learning into practice. So the student can apply his theoretical knowledge into practice. The student also brings practical work experience back to the university. In addition, the student will receive relevant work experience while studying. As a result the student is easier to deploy in the labor market after graduation.

### Inhoud vak

During sixteen months, students are required to divide their time equally between work and study. So study and work are fully integrated. The student is an employee and a student at the same time. The student is on the payroll of the host organization for 20-24 hours a week during 16 months. The student will conduct work which is of direct relevance to the BA master study programme.

### Onderwijsvorm

The student is an employee of the host organization.

### Toetsvorm

The formal approval of the BA Internship Committee is required before the student can actually take up employment.

### Overige informatie

For more information on the dual program:

- <http://tinyurl.com/duaal-ba-studeren> (NL)
- <http://tinyurl.com/dual-programme> (EN)

Met ingang van het komende studiejaar (1-9-2016) zullen nieuwe duale masterstudenten de 12 EC variant volgen (16 maanden duale werkperiode bij een bedrijf). Studenten van de lichte(n) daarvoor die hun duale werkperiode afronden in 2016-17 zullen nog 18 EC krijgen (vakcode X\_400460).

## Entrepreneurship in Data Science and Analytics

<b>Vakcode</b>	X_405122 ()
<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. J.F.M. Feldberg, prof. dr. E. Masurel, prof. dr. G.M. Koole
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	400

### Doel vak

The objective of this course is to learn about entrepreneurship, with a focus on IT, and especially business ideas that involve Data Science and/or Analytics.

### Inhoud vak

This course consists of several elements:

- lectures about different aspects of entrepreneurship;
- guest lectures by for example successful entrepreneurs and investors in starting companies;
- writing a business plan for a real or imaginary company.

For students who have the intention to start their own company we will make it possible to pitch their ideas for venture capitalists (like a Dragons's Den).

Presence during the lectures is compulsory.

The course will be given by Enno Masurel (specialized in Entrepreneurship, FEWEB), Frans Feldberg (Business Intelligence, FEWEB) and Ger Koole (Analytics, FEW), assuring that all aspects of entrepreneurship will be covered.

### Onderwijsvorm

weekly lectures

### Toetsvorm

The assessment consists of:

- a written exam
- the writing of a business plan

### Literatuur

handouts to be distributed during the course

### Doelgroep

mBA, mMath, mCS, mAI, mIS, mPDCS

### Overige informatie

Register as usual and via Blackboard

## Evolutionary Computing

<b>Vakcode</b>	X_400111 (400111)
<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. A.E. Eiben
<b>Examinator</b>	prof. dr. A.E. Eiben
<b>Docent(en)</b>	prof. dr. A.E. Eiben, J.V. Heinerman MSc
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

To learn about computational methods based on Darwinian principles of evolution. To illustrate the usage of such methods as problem solvers and as simulation tools. To gain hands-on experience in performing experiments.

### Inhoud vak

The course is treating various algorithms based on the Darwinian evolution theory. Driven by natural selection (survival of the fittest), an evolution process is being emulated and solutions for a given problem are being "bred". During this course all "dialects" within evolutionary computing are treated (genetic algorithms, evolutiestrategieën, evolutionary programming, genetic programming, and classifier systems). Applications in optimisation, constraint handling, machine learning, and robotics are discussed. Specific subjects handled include:

various genetic structures (representations), selection techniques, sexual and asexual variation operators, (self-)adaptivity. Special attention is paid to methodological aspects, such as algorithm design and tuning. If time permits, subjects in Artificial Life will be handled. Hands-on-experience is gained by a compulsory programming assignment.

### Onderwijsvorm

Oral lectures and compulsory programming assignment (in teams of 3). Highly motivated students can replace the programming assignment by a special research track under the personal supervision of the lecturer (s).

### Toetsvorm

Written exam and programming assignment (weighted average).

### Literatuur

Eiben, A.E., Smith, J.E., Introduction to Evolutionary Computing. Springer, 2015, 2nd edition, ISBN 978-3-662-44873-1.

### Vereiste voorkennis

Programming skills are necessary to do the practical assignment.

### Doelgroep

mBA, mAI, mCS, mPDCS

## Financial Markets and Institutions

<b>Vakcode</b>	E_EBE3_FMI ()
<b>Periode</b>	Periode 4
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Fac. der Economische Wet. en Bedrijfsk.
<b>Coördinator</b>	dr. J. Wrampelmeyer
<b>Examinator</b>	dr. J. Wrampelmeyer
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege, Instructiecollege
<b>Niveau</b>	300

### Doel vak

In the course, you develop a deep understanding of financial markets, bank supervision and central banking (Academic skills, Knowledge). You learn to analyze central bank policies and bank supervision using the concepts from the literature (Bridging theory and practice).

After the course, you can:

- state stylized facts of the term structure of interest rates;
- describe the structure of the banking sector and banking supervision;
- define the principles of monetary policy;
- classify policies of the major central banks;
- describe approaches to managing systemic risk;
- explain the bank supervision framework;
- interpret central bank policies in terms of objectives.

### Inhoud vak

Financial market are playing an important role in a modern economy. This course promises to give students the latest and greatest in how the financial system operates and where its weaknesses lie. It is an important building block for understanding our economy and students can connect micro and macro theories to the concepts developed in this course. The course also provides the necessary background for a future career in a policy environment or financial institution.

### Onderwijsvorm

Lectures.

Tutorials.

### Toetsvorm

Written exam – Individual assessment.

Interim Assignments – Group assessment.

### Literatuur

- Mishkin, Matthews and Guiliodori (2013) Economics of Money, Banking and Financial Markets: European edition, 1st European edition, Pearson.

ISBN 978-0273731801

- Additional readings will be announced on Blackboard.

### Vereiste voorkennis

Finance I or equivalent.

### Aanbevolen voorkennis

Finance I, Finance II and Corporate Finance.

### Overige informatie

It is not allowed to follow this course if you already earned credits (ECs) for the course Finance, Banking & Insurance from the old curriculum or International Financial Management from the new curriculum.

## 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.

## International Financial Management

<b>Vakcode</b>	E_IBK3_IFM ()
<b>Periode</b>	Periode 5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Fac. der Economische Wet. en Bedrijfsk.
<b>Coördinator</b>	dr. K.L. Wolk
<b>Examinator</b>	dr. K.L. Wolk
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege, Instructiecollege
<b>Niveau</b>	300

### Doel vak

The objective of the course is to acquaint students with the developments in international financial markets from a perspective of managerial decision making. The course is designed to provide future's financial managers with an understanding of the fundamental concepts and the tools necessary to be effective global managers. The aim is to provide students with an understanding of these concepts and techniques used in risk management. (Knowledge, Quantitative Skills) The students will develop skills in reading and understanding academic papers as well as critical thinking on economic events with a focus on the financial aspects of managerial decisions. (Research Skills, Bridging Theory and Practice) They are encouraged to improve analytical thinking abilities, to think beyond the boundaries of economics and finance theories. (Academic Skills, Broadening your Horizon)

### Inhoud vak

During the course, we will mainly discuss the structure of financial markets (foreign exchange, fixed income and equity markets) and explore the issues that are encountered by multinational enterprises, with an emphasis on risk management. When having completed this course, students

will have a clear understanding how financial markets and institutions work and how the multinational firm interacts with the other market participants. In particular, students will:

- understand the development of the international monetary system and other financial institutions,
- be acquainted with the specifics of various financial markets (money, bond, equity)
- learn how to manage foreign exchange risk and interest risk in a multinational firm.

#### Onderwijsvorm

- Lectures
- Tutorials

#### Toetsvorm

Written exam – Individual assessment  
(Interim) Assignment(s) – Group assessment

#### Literatuur

1. Eun & Resnick: International Finance, Global Edition (ISBN: 9780077161613)
2. Additional articles and/or cases (announced at the start of the course)

#### Aanbevolen voorkennis

BK:  
2.2 Finance; 3.4 Financial Modelling and Derivatives; 2.5 Finance II

IBA:  
2.2 Finance; 2.5 Corporate Finance in Emerging Economies; 3.4 Financial Modelling and Derivatives

## Investments

<b>Vakcode</b>	E_EBE3_INVES ()
<b>Periode</b>	Periode 5
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Fac. der Economische Wet. en Bedrijfsk.
<b>Coördinator</b>	dr. T.C. Dyakov
<b>Examinator</b>	dr. T.C. Dyakov
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

#### Doel vak

This course offers a comprehensive introduction to the world of investments. The course is structured in four broad parts, covering fundamental areas of investments: Portfolio theory and asset pricing; Empirical evidence on security returns and portfolio management; Fixed-income securities and; Options, futures and other derivatives. All four parts of the course are closely knitted to the learning goals of Quantitative skills, Academic skills, and Bridging theory and practice.

By the end of the course students should be able to:

- compute fundamental risk-management techniques: Value-at-Risk and Expected Shortfall;
- apply the Markowitz portfolio selection model and construct an efficient frontier of risky assets;
- compare the Capital Asset Pricing Model (CAPM) against the Arbitrage Pricing Theory. Test the predictions of the CAPM;
- price fixed income securities and construct the Term Structure of Interest Rate;
- solve portfolio immunization problems by matching the duration of assets and liabilities;
- build a binomial tree and apply the Black-Scholes formula.

### **Inhoud vak**

Investment decisions take a prominent role in everyday life. We can think of investment decisions taken by institutional investors (banks, insurance companies, pension funds, mutual funds), but also of financial decisions taken by individual households (additional pension savings, savings for children education, buying a house, etc.). Investment theory is also strongly linked to risk management. The importance of sound decision making in this field has been underlined by recent experiences on financial markets, law suits involving complex financial products for retail clients, etc. The key objective of this course is to provide understanding of the pricing of different asset classes and insights into the principles of investment analysis. A framework is developed that allows one to address a variety of (at first sight) completely different investment problems in a unified way.

### **Onderwijsvorm**

Lectures.  
Tutorials.

### **Toetsvorm**

Written exam – individual assessment.  
(Interim) Assignment(s) – group assessment.

### **Literatuur**

Zvi Bodie, Alex Kane and Alan J. Marcus: Investments and Portfolio Management, McGraw Hill (latest international edition).  
Additional readings might be announced on Blackboard.

### **Vereiste voorkennis**

Finance I or equivalent.

### **Aanbevolen voorkennis**

Finance II or equivalent.

The course relies on prior knowledge on linear algebra and statistics (Quantitative Research Methods I and II). Even though it offers a very brief introduction to the concepts and tools in this area that we will primarily use, students are strongly advised to review this material from relevant courses in the first two years of studies.

### **Overige informatie**

This course provides the knowledge basis for students aiming at an MSc in Finance and a career in the financial sector.

## **Machine Learning 1**

<b>Vakcode</b>	XMU_418144 ()
<b>Periode</b>	Periode 1
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Lesmethode(n)</b>	Hoorcollege

#### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2016-2017/zoek-vak/vak/23348>

#### 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>

## Master Project Business Analytics

<b>Vakcode</b>	X_400459 (400459)
<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>	drs. H.J.M. van Goor-Balk
<b>Examinator</b>	drs. H.J.M. van Goor-Balk
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	600

#### Doel vak

The objectives of the internship are:

- To research and analyse a specific issue or problem affecting the host organization, and to suggest (potential) solutions.
- To gain an understanding of the way in which the organization functions. The student will gain a general impression how the organization as a whole works, including its primary business processes and its support processes. The internship should be positioned within these processes.
- To practise and develop social and communication skills. The student is introduced to the standards and values in place within the host organization. He will develop communication skills through personal interaction with the staff of the organization, and through the written and verbal reports.
- To explore potential career options.

#### Inhoud vak

Each Master's programme is concluded by an external master project. This is in principle a project to be carried out within a business, industry or research facility other than the departments of Mathematics and Computer Science.

#### Onderwijsvorm

The student is an intern of the host organization. The student will be supervised by a staff member of the Faculty of Science.

### Toetsvorm

A written report and a verbal presentation.

### Literatuur

assigned individually

### Vereiste voorkennis

At least 78 credits, and the Research Paper Business Analytics.

### Doelgroep

mBA, mBA-D

### Overige informatie

If you are planning to start your Master Project within four months, please make an appointment with Annemieke van Goor

([H.J.M.van.Goor-Balk@vu.nl](mailto:H.J.M.van.Goor-Balk@vu.nl))

More information (NL):

- <http://tinyurl.com/masterproject>

- <http://tinyurl.com/bedrijfscontacten>

handleiding:

- <http://tinyurl.com/plmq8nd>

More information (EN):

- <http://tinyurl.com/phvzzbz>

- <http://tinyurl.com/guide-internship>

- <http://tinyurl.com/internship-vacancies>

## 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>	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. G.J.B. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege, Werkcollege
<b>Niveau</b>	300

### Doel vak

- Students are familiar with the main algorithms of numerical analysis and know how to implement these efficient in Matlab.
- Students can apply methods from numerical analysis to solve a variety of problems (both in applications and in mathematical analysis).
- Students can evaluate the reliability of numerical methods.

### 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 in the lectures 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, X\_400042, X\_400638 or X\_400639)

### Doelgroep

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

### Intekenprocedure

Enroll on blackboard

## 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.

## Performance of Networked Systems

<b>Vakcode</b>	X_405105 ()
<b>Periode</b>	Periode 4
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	prof. dr. R.D. van der Mei
<b>Examinator</b>	prof. dr. R.D. van der Mei
<b>Docent(en)</b>	dr. ing. T. Kielmann, prof. dr. R.D. van der Mei
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

**Doel vak**

Students will acquire basic knowledge of:

- performance aspects of networked systems, consisting of servers, services, and clients
- performance engineering principles and methods,
- quantitative models for predicting and optimizing the performance of networked systems,
- quantitative models for planning capacity of networked systems.

Students will gain experience in engineering and planning performance of networked systems, and will learn how to tackle practical performance problems arising in the ICT industry.

**Inhoud vak**

Over the past few decades, information and communication technology (ICT) has become ubiquitous and globally interconnected. As a consequence, our information and communication systems are expected to process huge amounts of (digital) information, which puts a tremendous burden on our ICT infrastructure. At the same time, our modern society has become largely dependent on the well-functioning of our ICT systems; large-scale system failures and perceivable Quality of Service (QoS) degradation may completely disrupt our daily lives and have huge impact on our economy.

Motivated by this, the course will focus on performance-related issues

of networked systems. In the first part, we study capacity planning and modeling for server systems and networks. In the second part, we study the client side of performance while focusing on web applications for both desktop and mobile devices. We address questions like:

- How can we design and engineer networked systems for performance?
- How can we plan server capacity in networked systems?
- How can web applications improve performance across wired and wireless networks?

### Onderwijsvorm

Classroom lectures and practical homework assignments.

### Toetsvorm

The assessment will be based on both homework assignments and a written exam.

### Literatuur

Textbook, supplemented with a reader on Stochastic Performance Modelling.

High Performance Browser Networking, Ilya Grigorik, O'Reilly, 2013.

### Vereiste voorkennis

The students should have basic knowledge of computer networks.

### Doelgroep

mBA, mCS, mPDCS, mEct

## Programming Large-scale Parallel Systems

<b>Vakcode</b>	XM_40017 ()
<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. ir. H.E. Bal
<b>Examinator</b>	prof. dr. ir. H.E. Bal
<b>Docent(en)</b>	prof. dr. ir. H.E. Bal
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	400

### Doel vak

You will

- be introduced to the domain of High Performance Computing (HPC)
- learn about design methods for parallel algorithms
- compare different parallel computer architectures
- analyze performance of network topologies
- develop basic familiarity with a range of parallel programming constructs, environments and languages
- gain insight into some selected parallel applications

### Inhoud vak

This lecture discusses how programs can be written that run in parallel on a large number of processors, with the main goal of reducing execution time. The class has a brief introduction into parallel computing systems (architectures). The focus of the class, however, is on programming methods, languages, and applications. Both traditional techniques (like MPI message passing) and more advanced techniques like parallel object-oriented approaches from the Java ecosystem or dedicated HPC programming languages (like Cray's high productivity language Chapel) will be discussed. Several parallel applications are discussed, including nearest-neighbor stencil computations, N-body simulations and search algorithms.

**Onderwijsvorm**

Lectures (4 hours per week), given by prof.dr.ir. Henri Bal (VU) and Dr Clemens Grelck (UvA). There is a separate Parallel Programming Practical (6 ECTS) in P2 and P3 whose aim is to complement the contents of this course with practical skills and experience. That course makes heavy use of our state-of-the-art DAS research cluster.

**Toetsvorm**

Written exam

**Literatuur**

Papers will be made available on Blackboard

**Doelgroep**

mAI, mBIO, mCS, mPDCS, m Computational Science

**Overige informatie**

Lecturers:

prof.dr.ir. Henri Bal (VU)

Dr. Clemens Grelck (UvA)

**Project Optimization of Business Processes**

<b>Vakcode</b>	X_400213 (400213)
<b>Periode</b>	Periode 3
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	dr. mr. B.L. Gorissen
<b>Examinator</b>	dr. mr. B.L. Gorissen
<b>Docent(en)</b>	dr. mr. B.L. Gorissen
<b>Lesmethode(n)</b>	Hoorcollege, Practicum
<b>Niveau</b>	500

**Doel vak**

Acquiring skills and experience necessary for building decision support systems, and learning to apply relevant scientific knowledge.

**Inhoud vak**

Project optimization of business processes concerns the construction and/or design of (part of) a decision support system (DSS) that:  
 - is designed and built in a scientifically sound way;

- can be used in practice (the DSS is built in VBA).  
The DSS is built in groups of students.

### Onderwijsvorm

Project

### Toetsvorm

Individual test for VBA, individual grade for participation in group project based on observed participation and a short oral exam.

### Literatuur

None.

### Aanbevolen voorkennis

Applied Stochastic Modeling (X\_400392).

### Doelgroep

mBA, mBA-D

### Overige informatie

Important note: you are expected to attend the kick-off meeting. If (due to circumstances) you are not able to attend this meeting, you should notify the lecturer in advance. Failing to do so may exclude you from this course.

## Research Paper Business Analytics

<b>Vakcode</b>	X_400206 (400206)
<b>Periode</b>	Ac. Jaar (september)
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Coördinator</b>	drs. H.J.M. van Goor-Balk
<b>Examinator</b>	drs. H.J.M. van Goor-Balk
<b>Lesmethode(n)</b>	Hoorcollege
<b>Niveau</b>	500

### Doel vak

The objective of the report is to demonstrate the student's ability to describe a problem in a clear manner (the report should therefore be concise and 'to the point') for the benefit of an expert manager.

### Inhoud vak

As part of the BA programme, students are required to produce a 'thesis'. This is an account of a research project undertaken by the student further to a specific problem statement. The input for this research may involve the use of computer-generated data, although it can also be drawn from the existing literature.

The student records his or her findings in a written report - the research paper - and also gives a verbal presentation, both in English. The paper should emphasize the business-related aspects of the programme as well as the more fundamental aspects of mathematics and/or computer science.

### Onderwijsvorm

Supervision by a staff member of preferably the Faculty of Science.

### Toetsvorm

A written report and a verbal presentation (both in English).

### Doelgroep

mBA

### Overige informatie

Students should consult the coordinator to find a topic and a supervisor. If you are planning to write your paper within two months, please make an appointment with Annemieke van Goor ([H.J.M.van.Goor-Balk@vu.nl](mailto:H.J.M.van.Goor-Balk@vu.nl)).

More information:

- <http://tinyurl.com/research-paper-nl> (NL)

- <http://tinyurl.com/ba-paper-en> (EN)

## 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>	dr. R. Bekker
<b>Examinator</b>	dr. R. Bekker
<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.

## 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>	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

Lectures and tutorials.

### Toetsvorm

Assignments and examination.

### Literatuur

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

### Vereiste voorkennis

Statistics course.

### Aanbevolen voorkennis

Linear Algebra, Probability Theory and Statistics. Statistical Data Analysis (X\_401029)

### 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, dr. E.N. Belitser
<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, presentations, homework assignments.

### **Toetsvorm**

Assignments, 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**

XM\_MAT\_S 1, XM\_MAT\_AG 1, XM\_SFM

## **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>	prof. dr. S. Bhulai
<b>Examinator</b>	prof. dr. S. Bhulai
<b>Docent(en)</b>	prof. 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**

A programming language.

**Aanbevolen voorkennis**

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

**Doelgroep**

mBA, mBa-D, mMath, mSFM.

## 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>	prof. dr. J. van den Berg
<b>Docent(en)</b>	prof. dr. J. van den Berg
<b>Lesmethode(n)</b>	Hoorcollege
<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 discussion of exercises

### **Toetsvorm**

Assignments and written examination.

### **Literatuur**

The following books will be used:

Shreve, "Stochastic Calculus for Finance I: The Binomial Asset Pricing Model", Springer;

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

### **Vereiste voorkennis**

Probability (X\_400622) and Analysis 1 (X\_400005), or their equivalents.

### **Aanbevolen voorkennis**

Measure Theory.

### **Doelgroep**

mBA, mBA-D, mMath, mSFM, master Econometrics.

### **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" or "Stochastic differential equations". On the other hand, after completing this course, students may be motivated to follow other courses (like the two mentioned above) where stochastic calculus is treated in a deeper and more rigorous way.

## **Stochastic Simulation**

<b>Vakcode</b>	XMU_428577 ()
<b>Periode</b>	Periode 2
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Exacte Wetenschappen
<b>Niveau</b>	400

#### Inhoud vak

<http://studiegids.uva.nl/xmlpages/page/2015-2016/zoek-vak/vak/15356>

#### Intekenprocedure

Registration is required via <https://www.sis.uva.nl> before the start of the semester. Please visit the website of your programme through <http://student.uva.nl> and check the A-Z list 'Course and Exam Registration' for more information.

## Text Mining

<b>Vakcode</b>	L_PABAALG002 ()
<b>Periode</b>	Periode 4
<b>Credits</b>	6.0
<b>Voertaal</b>	Engels
<b>Faculteit</b>	Faculteit der Geesteswetenschappen
<b>Coördinator</b>	dr. M.G.J. van Erp
<b>Examinator</b>	dr. M.G.J. van Erp
<b>Docent(en)</b>	drs. E. Maks, dr. H.D. van der Vliet, prof. dr. P.T.J.M. Vossen, dr. M.G.J. van Erp
<b>Lesmethode(n)</b>	Werkcollege, Hoorcollege
<b>Niveau</b>	300

#### Doel vak

Je maakt kennis met de mogelijkheden en problemen van het automatisch analyseren van natuurlijk taal door computers. De studenten krijgen praktische opdrachten waarbij ze met bestaande technologie leren werken en de problemen en mogelijkheden van het vakgebied zelf ervaren. Studenten kiezen zelf een eindproject waarbij ze de geleerde taaltechnologie toepassen, evalueren en de resultaten communiceren via een rapport.

#### Overige informatie

Deze module is een verplicht vak in het derde jaar Lifestyle Informatics en Informatie, Multimedia en Management. Voor de laatste praktische sessie van het vak geldt een aanwezigheidsplicht omdat daar ook de eindwerkstukken gepresenteerd worden. Ook voor studenten van de Faculteit der Geesteswetenschappen is dit een interessant vak, specifieke voorkennis is niet vereist, affiniteit met computers is handig omdat de practica en opdrachten enig programmeerwerk vereisen.