Business Analytics MSc

VU University Amsterdam - Faculteit der Exacte Wetenschappen - M Business Analytics - 2015-2016

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 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 18 EC. Moreover, it is possible to do the Research Paper BA (6 EC) 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. This makes the total of work related credit points 60 EC, being the equivalent of one year of study. 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. Typically, a student participating in the dual master's program should expect to obtain the Master's diploma after two and a half years.

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 84 EC (including a Master Project of 36 EC)
- compulsory selection 18 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.

Programme components:

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

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

There is a compulsory selection of at least three courses (18 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.

Courses:

Name	Period	Credits	Code
Advanced Linear Programming	Period 4+5	6.0	X_400326
Advanced Selforganisation	Period 2	6.0	X_400434
Business Intelligence	Period 1	6.0	E_BK3_BI
Business Process Analytics	Period 4	6.0	X_400650
Continuous Optimization	Period 1+2	6.0	X_400446
Corporate Financial Management	Period 4	6.0	E_BK3_CFM
Entrepreneurship in Data Science and Analytics	Period 4+5	6.0	X_405122
Evolutionary Computing	Period 1	6.0	X_400111
Heuristic Methods in Operations Research	Period 1+2	6.0	X_418006
Mathematical Systems and Control Theory	Period 1+2	6.0	X_400180
Neural Networks	Period 1	6.0	X_400132
Numerical Methods	Period 4+5	6.0	X_401039
Optimization of Business Processes	Period 4+5	6.0	X_400422
Performance of Networked Systems	Period 4	6.0	X_405105
Project Optimization of Business Processes	Period 3	6.0	X_400213
Scheduling	Period 4+5	6.0	X_400396
Stochastic Optimization	Period 1+2	6.0	X_400336
Stochastic Processes for Finance	Period 1+2	6.0	X_400352

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.

Courses:

Name	Period	Credits	Code
Applied Analysis: Financial Mathematics	Period 1+2	6.0	X_400076
Applied Stochastic Modeling	Period 1+2	6.0	X_400392
Data Mining Techniques	Period 5	6.0	X_400108

Master Project Business Analytics	Ac. Year (September)	36.0	X_400459
Research Paper Business Analytics	Ac. Year (September)	6.0	X_400206
Statistical Models	Period 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 progam consists of 120 European creditpoints (EC)
- compulsory courses 72 EC (including a Master Project of 36 EC)
- compulsory choice 24 EC
- optional courses 24 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.

Programme components:

- Compulsory Selection
- Compulsory Courses

Compulsory Selection

There is a compulsory selection of at least four courses (24 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.

Courses:

Name	Period	Credits	Code
Advanced Linear Programming	Period 4+5	6.0	X_400326

Advanced Selforganisation	Period 2	6.0	X_400434
Business Intelligence	Period 1	6.0	E_BK3_BI
Business Process Analytics	Period 4	6.0	X_400650
Continuous Optimization	Period 1+2	6.0	X_400446
Corporate Financial Management	Period 4	6.0	E_BK3_CFM
Entrepreneurship in Data Science and Analytics	Period 4+5	6.0	X_405122
Evolutionary Computing	Period 1	6.0	X_400111
Heuristic Methods in Operations Research	Period 1+2	6.0	X_418006
Investments	Period 4	6.0	E_EBE3_INV
Mathematical Systems and Control Theory	Period 1+2	6.0	X_400180
Neural Networks	Period 1	6.0	X_400132
Numerical Methods	Period 4+5	6.0	X_401039
Optimization of Business Processes	Period 4+5	6.0	X_400422
Performance of Networked Systems	Period 4	6.0	X_405105
Scheduling	Period 4+5	6.0	X_400396
Stochastic Optimization	Period 1+2	6.0	X_400336
Stochastic Processes for Finance	Period 1+2	6.0	X_400352

Compulsory Courses

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

Courses:

Name	**Period**	**Credits**	**Code**
Applied Analysis: Financial Mathematics	Period 1+2	6.0	X_400076
Applied Stochastic Modeling	Period 1+2	6.0	X_400392
Data Mining Techniques	Period 5	6.0	X_400108
Master Project Business Analytics	Ac. Year (September)	36.0	X_400459
Project Optimization of Business Processes	Period 3	6.0	X_400213
Research Paper Business Analytics	Ac. Year (September)	6.0	X_400206
Scientific Writing in English	Period 4	3.0	X_400512
Statistical Models	Period 1+2	6.0	X_400418

Advanced Linear Programming

Course code	X_400326 (400326)

Period	Period 4+5
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. L. Stougie
Examinator	prof. dr. L. Stougie
Level	400

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

Target group
mMath

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

Advanced Selforganisation

Course code	X_400434 (400434)
Period	Period 2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Teaching method(s)	Lecture
Level	400

Course objective
To understand, simulate and analyse the behaviour and self-organization of complex systems. The student is able to explain, implement and recognize basic principles and properties of such systems.

Course content
This course is about the understanding of the behavior and self-organization of complex systems: systems in which the interaction of the components is not simply reducible to the properties of the components. The general question the we address is: how should systems of very many independent computational (e.g. robotic or software) agents cooperate in order to process information and achieve their goals, in a way that is efficient, self- optimizing, adaptive, and robust in the face of damage or attack? We will look at natural systems that solve some of the same problems that we want to solve, e.g. adaptive path minimization by ants, wasp and termite nest building, army ant raiding, fish schooling and bird flocking, coordinated cooperation in slime molds, synchronized firefly flashing, evolution by natural selection, game theory and the evolution of cooperation. The course includes a practical part in which students implement a simulation of a self-organizing complex system and conduct structured experimental analysis with this simulation.

Form of tuition
Theory in lectures and practice in labs.

Type of assessment
Report including description of simulation and experimental analysis.

Course reading
Schut M.C., Scientific Handbook for Simulation of Collective Intelligence, 2007. Will be distributed in class.

Target group
mAI, mBA, mCS, mPDCS

Remarks
More information available on BlackBoard. This is a project- oriented course and therefore students will be expected to have basic programming skills.

Applied Analysis: Financial Mathematics

Course code	X_400076 (400076)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. A.C.M. Ran
Examinator	prof. dr. A.C.M. Ran
Teaching staff	prof. dr. A.C.M. Ran
Teaching method(s)	Lecture
Level	400

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

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

Form of tuition
Lectures, exercises, discussion of exercises.

Type of assessment
Homework exercises and oral examination

Course reading

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

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

Recommended background knowledge
Calculus and Linear Algebra

Target group
3W, mMath, mBA, 3Ect

Applied Stochastic Modeling

Course code	X_400392 (400392)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. R. Bekker
Examinator	dr. R. Bekker
Teaching staff	dr. R. Bekker
Teaching method(s)	Lecture, Seminar
Level	400

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

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

Form of tuition
Hoor- en werkcollege.

Type of assessment
Written examination.

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

Target group
mBA, mMath

Business Intelligence

Course code	E_BK3_BI (61312020)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. J.F.M. Feldberg
Examinator	prof. dr. J.F.M. Feldberg
Teaching staff	prof. dr. J.F.M. Feldberg
Teaching method(s)	Lecture, Practical, Computer lab
Level	300

Course objective
Students that successfully finished this course must be able:
• To define, describe and recall the basic concepts, principles and theories underlying business intelligence solutions (decision support systems).
• To classify and compare business intelligence solutions as well as the constituent components of business intelligence solutions.
• To apply business intelligence concepts, principles and theories to business problems.
• To analyse a business intelligence case, and propose business intelligence solutions.
• To evaluate and discuss the organizational and social implications of business intelligence solutions.
• To design a schema representing managerial information needs (‘star schema’).
• To analyse data and decide which data to use given a problem to be solved.
• To create insights using an established business intelligence tool (Cognos Powerplay)

Course content
Modern organizations, in particular the management of these organizations, tend to suffer more from an overload of data than from a lack of data. To a great extent this overload is caused by the overwhelming growth of information systems in organizations. Enterprise Systems (ERP), Customer Relationship Systems (CRM) as well as the growing number of Internet- based applications (e. g. e- commerce) are all important sources for the explosion of financial, production, marketing and other business data. The challenge for most organizations is to develop and build systems that support the transformation of the collected data into knowledge. To be successful in this transformation processes organizations have to develop the capability to aggregate, analyze and use data to make informed decisions. This course deals with the theory concerning business intelligence as well as with the application of business intelligence solutions. To be able to successfully implement business intelligence solutions, one has to have knowledge about their functioning and proficiency in using them, as well as knowledge about their field of application, e. g., how to select, transform, integrate, condense, store and analyze relevant data. This course uses the term 'business intelligence & analytics' in a broad sense. A narrow interpretation would only deal with software

solutions ('data warehousing' and 'online analytical processing'). The broad interpretation - to be used in this course - also includes: theories concerning decision making, related decision support systems and their application for management, i. e., data warehousing, online analytical processing, big data and data mining.

Form of tuition
lecture
tutorial

Type of assessment
written interim examination
(weekly) Business intelligence tutorial tests.
All tests and exams will be administered through a digital test system.

Course reading
- To be announced.
- Various papers.

Recommended background knowledge
- Basic course in Information Systems, f. e. on the level of Laudon & Laudon, Management Information Systems,
- O'Brien, James A., Introduction to Information Systems.

Remarks
Language: "Dutch & English"

Business Process Analytics

Course code	X_400650 ()
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. H. Leopold MSc
Examinator	dr. H. Leopold MSc
Teaching staff	dr. H. Leopold MSc
Teaching method(s)	Lecture, Practical
Level	400

Continuous Optimization

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

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

Target group
mMath

Registration procedure
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Corporate Financial Management

Course code	E_BK3_CFM (61342390)
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	prof. dr. A.B. Dorsman
Examinator	prof. dr. A.B. Dorsman
Teaching staff	prof. dr. A.B. Dorsman
Teaching method(s)	Lecture, Study Group
Level	300

Course objective
This course expands on financial topics covered in the first and second year. The emphasis in this course is on the Optimal Capital Structure of a corporation. The aim is to prepare students for a (possible) career as (assistant) Financial Manager in Industry or in the FBI sector: Finance, Banking (commercial and investment) and Insurance, incl. pension funds, investments funds, stock markets, Euronext, DNB, ECB, AFM, Ministry of Finance etc.

Course content
The following topics, issues and concepts will be dealt with:
- Capital structure in perfect Markets
- Leverage and Debt
- Optimal Capital Structure with Taxes and Financial Distress
- Payout Policy, Dividends and Share Repurchases
- Capital budgeting and Valuation
- Financial Modeling
- Corporate Governance

Form of tuition
Lecture. Students have to complete before each lecture quizzes (tests) on MyFinancLab.

Type of assessment

written interim examination (80% 5, 0 min.) cases / tutorials (20% of final grade based on average of scores of tests and quizzes on MyFinanceLab.

Course reading
J. Berk en P. DeMarzo, Corporate Finance, Pearson, 3de Global Edition, 2013, ISBN 9781783990320

Entry requirements
This course is for Business Administration students and/or Pre- Master BK students specializing in Financial Management. Students must be familiar with Corporate Finance / Financial Management as covered in the 1st and 2nd year.

Remarks
ONLY FOR PREMASTER STUDENTS:
For this course you do not need to subscribe. You will be subscribed by the department.

Data Mining Techniques

Course code	X_400108 (400108)
Period	Period 5
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. M. Hoogendoorn
Examinator	dr. M. Hoogendoorn
Teaching staff	dr. M. Hoogendoorn
Teaching method(s)	Lecture
Level	500

Course objective
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.

Course content
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).

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

Type of assessment
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.

Course reading
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

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

Target group
mBA, mCS, mAI, mBio

Entrepreneurship in Data Science and Analytics

Course code	X_405122 ()
Period	Period 4+5
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. G.M. Koole
Examinator	prof. dr. G.M. Koole
Teaching staff	prof. dr. G.M. Koole
Teaching method(s)	Lecture, Seminar
Level	400

Course objective
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.

Course content
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.

Form of tuition
weekly lectures

Type of assessment
The assessment consists of:
- a written exam
- the writing of a business plan

Course reading
handouts to be distributed during the course

Target group
mBA, mMath, mCS, mAI, mIS, mPDCS

Remarks
Register as usual and via Blackboard

Evolutionary Computing

Course code	X_400111 (400111)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. A.E. Eiben
Examinator	prof. dr. A.E. Eiben
Teaching staff	prof. dr. A.E. Eiben, J.V. Heinerman MSc
Teaching method(s)	Lecture
Level	400

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

Course content
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.

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

Type of assessment
Written exam and pogramming assignment (weighted average).

Course reading
Eiben, A.E., Smith, J.E., Introduction to Evolutionary Computing.
Springer, 2003 ISBN 3-540-40184-9.
Slides available from http://www.cs.vu.nl/~gusz/ecbook/ecbook.html .

Target group
mBA, mAI, mCS, mPDCS

Heuristic Methods in Operations Research

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

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

Target group
mMath, mBA

Registration procedure
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Investments

Course code	E_EBE3_INV (60332090)
Period	Period 4
Credits	6.0
Language of tuition	English

Faculty	Fac. der Economische Wet. en Bedrijfsk.
Coordinator	dr. T.C. Dyakov
Examinator	dr. T.C. Dyakov
Teaching staff	dr. T.C. Dyakov
Teaching method(s)	Lecture, Study Group
Level	300

Course objective
This course aims to make students familiar with the insights from investments and portfolio management theory. Students also have to be able to apply these insights in practical situations involving portfolio decisions and investment management for both individuals and institutions.
The course is divided in four parts – portfolio theory and asset pricing, security analysis and portfolio management, fixed income securities, and derivatives.

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

Part 1. Portfolio theory and asset pricing (Lecture 1-4)
- calculate statistical measures of risk and return, such as expected returns and standard deviations, ex post and ex-ante, perform a time series analysis of historical rates of return, understand stylized facts about asset returns in terms of their distributional characteristics;
- calculate and understand the implications of risk measures (Value-at-Risk and Conditional tail expectation) based on different distributional assumptions;
- understand and apply the concept of risk aversion in the utility function of an investor and its effect on asset allocation;
- compute and explain the concept of expected utility;
- optimally allocate a portfolio between risk-free and risky assets based on mean-variance preferences and understand the effect of leverage;
- obtain a mean-variance frontier from a universe of assets;
- define systematic and firm-specific risk and evaluate the effect of portfolio diversification on the firm-specific risk in a portfolio;
- interpret and estimate index models, explain the decomposition of risk that they imply and obtain optimal portfolios based on them;
- have a thorough understanding of the Capital Asset Pricing Model (CAPM), its assumptions and resulting equilibrium conditions; test empirically the validity of the CAPM implications and be able to review extensions of the CAPM that rely on relaxing one or more of its assumptions;
- have a thorough understanding of factor models and the Arbitrage Pricing Theory (APT) and its equilibrium implications;
- identify and discuss the forms or market efficiency and related empirical tests of the efficient market hypothesis;
- understand the premises of behavioral finance;
- master the methodology behind testing empirically the validity of the CAPM and the multifactor APT model;

Part 2. Security analysis and portfolio management (Lecture 5-6):
- have a thorough understanding of the business cycle and the macroeconomic factors that affect security prices;
- understand industry analysis and the sensitivity of different industries to the business cycle;

- value a firm using the appropriate dividend discount model and the price/earnings ratio derived from it; understand the limitations of each of these models;
- be able to analyze a firm using basic financial statements; analyze problems by using the ROE decomposition;
- carry out portfolio performance evaluation by calculating various risk-adjusted return measures;
- understand market timing and be able to test the market timing ability of a portfolio manager;
- decompose excess portfolio returns into components that can be attributed to different asset allocation choices;
- apply active portfolio management models;
- analyze hedge fund characteristics and strategies and be able to set up a statistical arbitrage strategy.

Part 3. Fixed-income securities (Lecture 7-9):
- have a thorough understanding of the characteristics and risk determinants of bonds;
- calculate yields and prices of different types of bonds;
- understand the key ratios used by rating agencies to determine bond ratings;
- understand the role of protective covenants against default risk;
- understand the principle of securitization for reallocation of credit risk;
- understand the concept of the yield curve and be able to describe the major term structure theories;
- calculate forward rates from the spot yield curve;
- construct the yield curve from observed coupon bond prices;
- fit the yield curve using the Nelson & Siegel model;
- have a thorough understanding of the concept of duration and be able to calculate it for individual bonds and for bond portfolios;
- calculate price approximations using duration and convexity
- construct immunized bond portfolios and understand the limits to conventional immunization;
- understand active bond portfolio management.

Part 4. Options, futures and other derivatives (Lecture 10-12):
- calculate pay-offs of derivative contracts and trading strategies based on them;
- build option-based portfolio strategies that achieve a certain risk-return profile;
- identify the embedded options via the pay-off structure of different assets and identify the ways in which the option-like characteristics impact the prices of these assets;
- understand the put-call parity relationship
- identify the determinants of option prices;
- apply a binomial option pricing model via a replicating portfolio or using risk-neutral valuation;
- compute the Black-Scholes value of an option;
- compute hedge ratios and construct portfolio insurance strategies using option hedge ratios;
- understand the trading mechanisms involving futures contracts, incl. margin trading arrangements, the trading strategies based on them and the risks involved.

Course content
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 financial

decisions taken by individual households (additional pension savings, saving for ones children's education (and how), buying a house, etc.) Investment theory is also strongly linked with 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, the debate about the (in)solidity of pensions, etc. The Investments course aims to provide an overview of 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. The course is divided in four parts – portfolio theory and asset pricing, security analysis and portfolio management, fixed income securities, and derivatives.

Form of tuition
Lectures and tutorial sessions.

Type of assessment
Written exam and Case work. Exam questions are meant to test the candidate's theoretical insight as well as analytical and computational skills. Case work is used to test students implementation skills in Excel of the material treated in the course. Correctly completing a minimum of case work is compulsory for obtaining a pass for this course. Guidelines are communicated via Blackboard at the start of the course.

Course reading
The course literature consists of detailed lecture slides to be found under Course documents on Blackboard. These will be posted weekly before each set of lectures. In addition to them, the textbook below is a compulsory reading material:
- Zvi Bodie, Alex Kane and Alan J. Marcus: Investments, McGraw Hill (10th
edition)
As optional supporting material for the applied Excel work, I suggest the following books:
- Adair, Excel Applications for Investments (introductory book to Excel and its applications for investment problems).
- Mary Jackson and Mike Staunton, Advanced Modeling in Finance using Excel and VBA, Wiley Finance (advanced VBA applications and programming).

Entry requirements
The course builds upon prior knowledge in the 1st and 2nd year Finance courses (Finance 1.4, 2.2 and 2.4 for Economics students and Finance and Financial modeling 1.5 and Financial Management 2.4 for Financial Management students). For students coming from different programs or having a different background, this should correspond to mastering the concepts in the book of Braeley and Myers, Principles of corporate finance, chapters 1-15, 20-23, 27-30.

Remarks
The course is taught in English.

ONLY FOR PREMASTER STUDENTS:
For this course you do not need to subscribe. You will be subscribed by the department.

Master Project Business Analytics

Course code	X_400459 (400459)
Period	Ac. Year (September)
Credits	36.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	drs. H.J.M. van Goor-Balk
Examinator	drs. H.J.M. van Goor-Balk
Teaching method(s)	Lecture
Level	600

Course objective
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.

Course content
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.

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

Type of assessment
A written report and a verbal presentation.

Course reading
assigned individually

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

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

Target group
mBA, mBA-D

Remarks
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)

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

Mathematical Systems and Control Theory

Course code	X_400180 (400180)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. A.C.M. Ran
Examinator	prof. dr. A.C.M. Ran
Teaching staff	prof. dr. A.C.M. Ran
Teaching method(s)	Lecture, Seminar
Level	400

Course objective
The course aims to introduce the student to the mathematical theory of control systems.

Course content
Many phenomena are characterized by dynamic behaviour where we are interested in a certain input/output behaviour. Examples are to be found in the exact and natural sciences (mechanics, biology, ecology), in engineering (air- and spacecraft design, mechanical engineering) as well as in economics and econometrics (macro- economical models, trend and seasonal influences in demand and supply, production systems). Systems theory is concerned with modeling, estimation and control of dynamical phenomena. During the course the following subjects will be treated: models and representations (linear systems, input-output, state space, transfer function, stochastic systems, spectrum), control (stabilisation, feedback, pole placement, dynamic programming, the LQ problem), and identification and prediction (parameter estimation, spectral analysis, Kalman- filter, model reduction). Applications are in the area of optimal control and prediction.

Form of tuition
There is a lecture of two hours each week. In addition, there is another session which will be half lecture and half practicum, in which there is the possibility to ask questions about the compulsary computerpracticum. The practicum makes use of the Matlab package.

Type of assessment
The computerpracticum counts for 70%, the oral examination concerns the theory and counts for 30%.

Course reading
Chr. Heij, A.C.M. Ran and F. van Schagen, Introduction to Mathematical Systems Theory, Birkhauser Verlag.

Recommended background knowledge
Analysis, probability theory, statistics.
Complex analysis and Fourier theory would be useful, but are not absolutely necessary.

Target group
3W, mBA, mMath

Neural Networks

Course code	X_400132 (400132)
Period	Period 1
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. M. Hoogendoorn
Examinator	dr. M. Hoogendoorn
Teaching staff	dr. M. Hoogendoorn
Teaching method(s)	Lecture, Practical
Level	500

Course objective
The course provides an introduction to key concepts and algorithms for pattern recognition and neural networks. It strives towards providing insight both from a theoretical perspective as well as more practical settings. In the end, the student should be able to confidently apply the aforementioned techniques in real-life settings and understand their theoretical basis.

Course content
The course provides an introduction to key concepts and algorithms for pattern recognition and neural networks. It covers the following topics:

- classification, regression, and clustering problems,
- elements of statistical pattern recognition,
- methods for estimation of probability distributions,
- linear classifiers, including Support Vector Machines,
- single-layer and multi-layer networks,
- RBF-networks and kernel methods
- methods for dimensionality reduction
- methods for feature extraction and selection

Moreover, several real-life applications of pattern recognition, including recognition of speech, handwritten characters, images, etc., will be discussed in depth.

Form of tuition
Lectures (h) and practical (pra).

Type of assessment

Practical assignments and written examination. Both count for 50% of the final grade and both grades should be sufficient in order to pass the course.

Course reading
Simon Haykin, Neural Networks and Learning Machines, Pearson Education, 3rd international edition, 2008

Target group
mAI mBio, mBA, mCS

Remarks
More information will be available via Blackboard.

Numerical Methods

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

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

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

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

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

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

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

Recommended background knowledge
A basic course in linear algebra.

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

Registration procedure
Enroll on blackboard

Optimization of Business Processes

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

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

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

Form of tuition
Lectures and practical work.

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

Course reading
Lecture notes.

Recommended background knowledge
Applied Stochastic Modeling or equivalent knowledge

Target group
mBA, mBA-D, mMath

Remarks
Attendance mandatory.

Performance of Networked Systems

Course code	X_405105 ()
Period	Period 4
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	prof. dr. R.D. van der Mei
Examinator	prof. dr. R.D. van der Mei
Teaching staff	dr. ing. T. Kielmann, prof. dr. R.D. van der Mei
Teaching method(s)	Lecture
Level	400

Course objective
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.

Course content
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?

Form of tuition

Classroom lectures and practical homework assignments.

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

Course reading
Textbook, supplemented with a reader on Stochastic Performance Modelling.

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

Entry requirements
The students should have basic knowledge of computer networks.

Target group
mBA, mCS, mPDCS, mEct

Project Optimization of Business Processes

Course code	X_400213 (400213)
Period	Period 3
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. R. Bekker
Examinator	dr. R. Bekker
Teaching staff	dr. R. Bekker
Teaching method(s)	Lecture, Practical
Level	500

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

Course content
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.

Form of tuition
Project

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

Course reading
None.

Recommended background knowledge
Applied Stochastic Modeling (X_400392).

Target group
mBA, mBA-D

Remarks
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

Course code	X_400206 (400206)
Period	Ac. Year (September)
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	drs. H.J.M. van Goor-Balk
Examinator	drs. H.J.M. van Goor-Balk
Teaching method(s)	Lecture
Level	500

Course objective
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.

Course content
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.

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

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

Target group
mBA, mBA-D

Remarks
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).

More information:
- http://tinyurl.com/research-paper-nl (NL)
- http://tinyurl.com/ba-paper-en (EN)

Scheduling

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

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

Target group
mMath, mBA

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

Scientific Writing in English

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

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

At the end of the course students
- know how to structure a scientific article;
- know what the information elements are in parts of their scientific article;

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

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

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

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

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

Type of assessment
Students will receive the three course credits when they meet the following requirements:
- Students hand in three writing assignments (Introduction, Methods, Discussion)
- Students get a pass mark for all writing assignments;
- Students provide elaborate peer feedback (Introduction, Methods,

Discussion, Abstract);
- Students attend at least 7 out of 8 sessions;
- Students are well prepared for each session (i.e. do all homework assignments);
- Students participate actively in class;
- Students do not plagiarise or self-plagiarise.

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

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

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

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

Remarks
- To do well, students are expected to attend all lessons. Group schedules are to be found at VUnet and on Blackboard.
- A VUnet registration for this course automatically gives access to the corresponding Blackboard site. Group registration only takes place via Blackboard (general groups: registration by students following FEW programmes offering this course; groups assigned to specific studies: registration through programme and course coordinator).
- Make sure Scientific Writing in English does not overlap with another course.
- If you have registered for a group in Blackboard, you are expected to

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

Statistical Models

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

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

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

Form of tuition
Course of lectures, exercises and tutorial
.

Type of assessment
Assignments and examination.

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

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

Target group
mBA, mBA-D, mMath

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

Stochastic Optimization

Course code	X_400336 (400336)
Period	Period 1+2

Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. S. Bhulai
Examinator	dr. S. Bhulai
Teaching staff	dr. S. Bhulai
Teaching method(s)	Lecture
Level	400

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

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

Form of tuition
Lectures.

Type of assessment
Programming and written exercises, final exam.

Course reading
Lecture notes will be posted on BlackBoard

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

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

Target group
mBA, mBa-D, mMath, mSFM

Stochastic Processes for Finance

Course code	X_400352 (400352)
Period	Period 1+2
Credits	6.0
Language of tuition	English
Faculty	Faculteit der Exacte Wetenschappen
Coordinator	dr. E.N. Belitser
Examinator	dr. E.N. Belitser

Teaching staff	dr. E.N. Belitser
Teaching method(s)	Lecture
Level	400

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

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

Form of tuition
Lectures and exercises.

Type of assessment
Assignments and written examination.

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

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

Recommended background knowledge
Measure Theory.

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

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