

Faculty of Science

Prospectus 2010 - 2011

Mathematics

Master

Radboud University Nijmegen

Preface

This booklet is the prospectus for the Master program of Mathematics at the Radboud University Nijmegen. It contains information about the objectives, the goals and the contents of the program. Furthermore a lot of practical information is given.

P.S. This prospectus has been made with great care. However the authors are not responsible for inaccuracies. If you have comments or proposals for improvements don't hesitate to contact them.

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1 Introduction

The Radboud University Nijmegen offers a Master of Science program in Mathematics. The English taught MSc program takes two years and provides students with a thorough knowledge of the relevant mathematics. The first year consists of core courses and electives in mathematics. The second year is largely devoted to the final thesis work, which involves participating in one of the department's advanced research projects or a traineeship or an internship within a company. If you pass the MSc exam you are awarded 'Master of Science'.

The Radboud University Nijmegen is a general university, offering almost all possible academic Programs, ranging from Arts and Law, to Medicine and Science. This Master program allows a substantial choice of topics from all these areas, thereby offering the possibility to combine Mathematics with other studies.

1.1 Admittance

Entering the Mathematics Master requires a bachelor degree in Mathematics from any Dutch university. With an equivalent degree one can also be admitted, but approval of the Exam Committee Mathematics will be required. In this case, the Exam Committee can demand that one adds specific courses to the master program, depending on the Master specialization. For example, with a bachelor degree in Physics with a minor in Mathematics, one will be admitted to the Mathematics Master with the specialization Physics.

1.2 Aims of the Master's programme

The aims of the Master's (or doctoraal) programme Mathematics have been laid down as follows in the Education and Examination Regulations (Art. 1.4).

The aims of the study programme are:

1. *To provide students with the knowledge, skills and insights pertaining to the fields of physics and astronomy that will enable them to practise their future professions independently, and to become eligible for the advanced programmes for scientific researchers or designers (O-variant), communication experts (C-variant), teachers (E-variant) or research managers in business organizations (MT-variant).*
2. *Academic education.*

Naturally, this description refers to professions for which a scientific education in mathematics is either required or useful. This general aim is concretized in a number of detailed objectives.

Basically, prospective students are expected to possess all the knowledge, skills and insights mentioned in the attainment targets of the Bachelor's programme. Consequently, additional requirements may be set with regard to previous education, in individual cases, with regard to entrants from other institutions. Furthermore, the Master's programme pursues the following specific additional aims:

- Students acquire more specialized knowledge and insights pertaining to one or more sub-areas of mathematics
- Students become acquainted with one or more disciplines outside the fields of mathematics or with one or more sub-areas in mathematics, other than the sub-area of specialization mentioned above
- Students learn how to analyse complex problems independently and how to formulate standard and innovative solutions
- Students learn how to test theories using concrete questions which they will have developed themselves
- Students who wish to obtain the Master's title in the Communication or Education variant will further deepen their knowledge of and insight into teaching and communication theories respectively, and will be able to apply this knowledge and these insights during practical training in the fields of communication or education
- Students in the Master's phase of the Management variant will further deepen their knowledge of and insight into management and organizational aspects, and will subsequently apply this knowledge and these insights during practical training in a business environment

1.3 Credit point system

The Radboud University uses the European Credit Transfer System (ec) employed by all universities in the European Union. One year consists of 60 ec credits, the total Master program consists of 120 ec. One ec stands for 28 study hours.

1.4 Dutch Master Program in Mathematics

The Departments of Mathematics of the Dutch universities have coordinated their efforts to enhance their Master Programs in Mathematics. Part of the cooperation is aimed at organizing joint courses in mathematics. The joint courses offer the students the highest quality of instruction and open opportunities for interaction with students of other institutes of mathematics. For students who intend to pursue a PhD program after completion of their Master Program the joint program may widen the range options for continuing their studies. For more information concerning the Dutch Master Program in Mathematics see the web site www.mastermath.nl.

Each master student in mathematics is obliged to attend courses from the Dutch Master Program in Mathematics with a total weight of 30 ec or more.

1.5 Mathematics Clusters

Mathematics clusters form a new part of the Dutch mathematical landscape. A cluster is a collaboration between a number of Dutch universities, which is organized around a specific research area. Nijmegen takes part in three of the four clusters that are currently active:

- **DIAMANT** (Discrete, Interactive & Algorithmic Mathematics, Algebra & Number Theory) involving: CWI (Center for Mathematics and Computer Science, Amsterdam),

RU (Nijmegen), TU/e (Eindhoven), UL (Leiden).

- **GQT** (Geometry and Quantum Theory, consisting of: RU (Nijmegen), UvA (Amsterdam), UU (Utrecht).
- The RU does not take part in the third cluster **NDNS** (Nonlinear Dynamics of Natural Systems), involving: CWI, RUG (Groningen), UL, UU, VU (Amsterdam),
- The mathematics cluster **STAR** ('Stochastics - Theoretical and Applied Research'), that was founded on May 15, 2009 is the fourth member of the group of mathematics clusters, where the RU takes part in.

While primarily founded in order to boost mathematical research in the Netherlands, the clusters are of great importance to master's students. This is firstly because they organize the bulk of the courses within the Dutch Master Program in Mathematics, and secondly because in writing your master's theses you will probably be attracted by some of the research themes offered by one of the clusters that Nijmegen takes part in.

The relevant websites are:

DIAMANT: <http://www.win.tue.nl/diamant/>

GQT: <http://www.gqt.nl>

STAR: <http://www.eurandom.tue.nl/STAR/index.htm>

1.6 Mathematical Research Institute

The Mathematical Research Institute, MRI (website: <http://web.science.uu.nl/mri>) is one of the research schools in The Netherlands. It is the combined research school for the mathematics departments of the universities of Groningen, Nijmegen, Twente and Utrecht. The MRI is one of three national research schools in mathematics in the Netherlands. The others are EIDMA and Stieltjes . The MRI participates in the European research institute EURANDOM .

The research programme of the Mathematical Research Institute focuses on the fundamental aspects of mathematics, as well as on interactions with its applications.

Each year the MRI organizes one or two Master Classes. The Master Classes offer a one-year programme centered around a theme that is close to one of the research areas supported by the MRI. The Master Class can form a significant contribution to a PhD programme or can form a preparatory year for a PhD. The programme runs from September through June and includes two full days of lectures and seminars per week and individual work on a test problem.

(See also: <http://web.science.uu.nl/mri/masterclass.php> .)

The 2010-2011 topics of the MRI Master Classes are:

- Moduli Spaces.

More information on the specific course in this masterclass can be found on:
http://web.science.uu.nl/mri/documents/brochure2010_11.pdf .

1.7

2 Program

2.1 Structure of the master programme

The Master program at the Faculty of Science is offered in four tracks: a Research track (R), a Communication track (C), an Education track (E), and a Management & Technology track (MT). At this moment, only the Research track has a complete program in the English language. The other tracks are primarily aimed at the Dutch market and the Dutch educational system, and are therefore taught in Dutch.

- The **R-track** leads students to a high level of knowledge in mathematics. It consists of advanced courses and a final research project including a Master thesis and an oral presentation of it. Students with this MSc in Mathematics are admissible to a PhD program. The program is suited as preparation for an academic career, in particular via a subsequent PhD study, but also for a career as mathematical researcher outside the universities.
- The **C-track** is intended for a job in science communication in a broad sense. The program prepares students for a career in popularisation of science.
- The **E-track** is intended as a preparation for a job in teaching mathematics and mathematics curriculum development.
- The **MT-track** is intended as a preparation for jobs in the field of management. It prepares students for a career in science-related business and administration and for innovation and enterprise from a mathematical perspective.

Every master student chooses both a track and a specialization within mathematics. The specializations within mathematics are:

- Algebra & Logic
- Mathematical Physics
- Applied Stochastics

These specializations are discussed in Chapter 3. The specialization consists of a certain amount (depending on the track one chooses) of advanced courses to be selected in correspondence with the research topic.

2.2 Master thesis

At the start of the Master program, the student is expected to contact one or more prospective Master thesis supervisors to discuss a program. Normally the student will contact a thesis supervisor in the first semester of the Master program. The courses that are needed to prepare for the Master thesis work are determined by the Master thesis supervisor and the student together. It is therefore advisable to contact the prospective Master thesis supervisor to discuss the content of these courses. The individual program needs approval by the examination committee. To select a prospective Master thesis supervisor, please look at the descriptions of the different specialisations within the department of mathematics. The

contact persons of the departments can be approached at any stage for information or to set up a program in the electives section.

If you do not know yet who your thesis supervisor will be at the beginning of your Master program please contact the coordinator of the specialisation you are most interested in and together make a plan for the first year of your Master.

2.3 Regulations Graduation project

The Graduation project is the completion to the Master Program. The central part consists of either a thesis or an apprenticeship. In both cases there is a staff member to supervise. In this paragraph one can find a more elaborate description of the Graduation Project.

Graduation Project including master thesis

The project consists of:

1. Acquiring knowledge about a specific subject by way of literature study, consultation and/or participating in a seminar.
2. Conducting scientific research.
3. Writing a thesis.
4. Presenting the master thesis and defending it in front of an audience of experts.

Graduation Project including an apprenticeship.

The project consists of:

1. Acquiring knowledge about a specific subject by way of literature study, consultation and/or participating in a seminar
2. Doing work experience during an apprenticeship.
3. Writing an apprenticeship report.
4. Presenting the apprenticeship report and defending it in front of an audience of experts.

Assessment

The procedure for graduation project assessment consists of the following steps:

1. The supervisor approves of the thesis and /or the apprenticeship report, and notifies the program coordinator.
2. The program coordinator appoints a second rater, the supervisor organizes the presentation of the master thesis or the apprenticeship report in consultation with the student and the second rater.
3. After the presentation the supervisor determines the grade for the graduation project in consultation with the second rater.

2.4 The Research Track (R-track)

The research track prepares the student for an academic career that includes a clear research component either in academia or in business, e.g. as a researcher in commercial laboratory, (academic) hospital, etc. In particular, students who aspire to continue in a PhD-programme need to take the research track.

The research track ends with a graduation project which usually consists of a master's thesis including some mathematical research. In particular, the research track can bring the student to some of the forefronts of research.

The research track is closely related to the specialisations Mathematical Physics, Algebra and Logic and Applied Stochastics.

We advise the student to contact as soon as possible a supervisor, so that a suitable programme can be put together at the beginning of the master.

With this tailor made programme the student is well prepared for the master mathematics.

The programme should comply with the regulations as in the table below.

Research Track

Major specialisation	30 ec
Minor specialisation	24 ec
Mathematical Electives	17 ec
Master Thesis Project	40 ec
Philosophy	3 ec
Free Electives	6 ec

The major specialisation should be a coherent package of courses of 30 ec of a certain area of mathematics. The minor or second specialization should also be a coherent package and can be either chosen in or outside mathematics. **In addition to the requirements in the table below, 30 ec have to be chosen from the national Dutch Master Program in Mathematics.** A maximum of 18 ec can be chosen from the third year Bachelor courses in Mathematics.

2.5 The Communication track (C-track)

The communication track (C-track) educates people for the areas of scientific communication (research, applications, media). The student who graduates in Communication is more than a science student, and has acquired complementary theoretical insights and communicative skills that broaden his own field of expertise (beta-gamma-integration). He has an insight in communication about innovation processes and processes of change, as well as an insight in the use of (mass) media and popularization.

If you are interested in the interaction between science and the society, science communication might be an interesting way to go. Science communication is one of the

graduation variants on the beta-faculty in Nijmegen. Among other things, it deals with perceptions, participation processes, knowledge production, interdisciplinarity and risks and uncertainties in science. Moreover, much attention is paid to writing skills (essay, columns), presentation skills and research methods. During your graduation project (30 ECTS), you link up theory from the courses with your beta background.

The job profile entails three fields: intermediary organisations between science and society (advisory bodies, interest groups and gouvernements), science communication research and science journalism. The Science Communication graduation variant is not only a very interesting new field of study for which there is a need on the labour market, it provides you with knowledge that may come in handy in every speciality!

More information can be obtained at <http://www.betacom.science.ru.nl/> from: Prof. dr H. Zwart, Room: HG 02.808, Tel. 3652038, E-mail: h.zwart@science.ru.nl

In this main subject in the Masterfase 63 ec are contributed to the beta education, and 57 ec to the modules and apprenticeship of the C-variant.

Communication track

Mathematical Specialisation	30 ec
Mathematical Electives	24 ec
C-package	27 ec
Apprenticeship & Master Thesis	30 ec
Philosophy	3 ec
Free Electives	6 ec

In addition to the requirements in the table below, 30 ec have to be chosen from the national Dutch Master Program in Mathematics. A maximum of 18 ec can be chosen from the third year Bachelor courses in Mathematics.

The C-package includes: Framing Knowledge (3), Knowledge Society (3), Science, Media and Strategy (3), Introduction Science Communication (3), Science & Societal interaction (3), Risk Communication (3) and Boundary Work (3).

Free Electives

The free elective space can be filled with courses lectured by the Communication faculty. The approval for other free electives (for instance from Communication sciences, Psychology, Sociology, Biomedical Sciences, or other universities) will be given in consultancy with the student.

Apprenticeship & Master thesis. (24 ec + 6 ec)

The apprenticeship (24 ec) is communication research regarding the interface between Science and Society. Topics can be for instance: the role of scientists (experts) in conflicts between interest groups, conceptualization of social and scientific topics in the mass media (internet, film, tv. etc.), risk communication concerning disasters, the making of a Strategic Communication plan, the effectiveness of newsletters and websites, and political and social opinion forming.

The topic and methodology are always determined in consultation with the student, depending on his wishes and foreknowledge. The apprenticeship can be placed external (within a nonprofit organization, ministry, or commercial organization), or accommodated on the faculty. The master thesis (6 ec) considers the results from the communication research in context with relevant literature, and makes recommendations for further research.

The quality and intensity of the supervision regarding the student will be guaranteed through apprenticeship agreements made with the internal and external supervisors.

2.6 The Education track (E-track)

The Education track (E-track) prepares students for a career in High School education. It consists of a major course of 30 ec, in which preferably subjects are integrated that make it possible to view school mathematics from a higher point of view, for instance because of the historical importance of the development of Mathematics. Furthermore 14 ec free electives math, obligatory 3 ec Philosophy and 6 ec free electives. For the master Thesis Project of 10 ec the student can choose between a mathematical specialisation thesis and a didactic thesis. For information about the didactic thesis, please contact the study advisor (see appendix A of the Bachelor Wiskunde prospectus).

Education Track

Mathematical specialisation	30 ec
Mathematical Electives	14 ec
E-traineeships	57 ec
Master Thesis Project	10 ec
Philosophy	3 ec
Free Electives	6 ec

In addition to the requirements in the table below, 30 ec have to be chosen from the

national Dutch Master Program in Mathematics. A maximum of 18 ec can be chosen from the third year Bachelor courses in Mathematics.

2.7 The Management and Technology track (MT-track)

Goal

The set-up and filling-in of the management and applications variant strives to integration of beta and gamma aspects. In the MT variant the appliance of beta knowledge is the central aspect. Students are required to be capable of doing beta research in an applied setting; that also includes the handling of the company and managements difficulties, which cohere with those appliances.

For the filling-in of the MT variant thoughts go out to a mutual consensus about the contents of scientific professional education (in particular research apprenticeships) in the fourth year and the external apprenticeship location (organization that applies such beta know-how) in the fifth year.

Master education

In the main part of the Master 63 ec are contributed to the beta education, and 57 ec to the modules and apprenticeship of the MT-variant.

Management and Applications Track

Mathematical Specialisation	30 ec
Mathematical Electives	24 ec
MT-package	30 ec
Master Thesis Project	27 ec
Philosophy	3 ec
Free Electives	6 ec

In addition to the requirements in the table below, 30 ec have to be chosen from the national Dutch Master Program in Mathematics. A maximum of 18 ec can be chosen from the third year Bachelor courses in Mathematics.

Courses

This year the following courses are being offered:

- *MT- courses:* Business & Society (5 ec), Organization Theory (5 ec).
- *MT-integration courses:* Innovation Management (5ec), Strategy & Marketing (5 ec),

Finance & Accounting (5ec).

- *MT-free electives (5ec, choices of)*: Research Strategy & Management (3ec), Project Management (3 ec) and courses given in the C-track (Communication).

See also:

<http://www.studiegids.science.ru.nl/2010/science/prospectus/afstudeervarianten/contents/info/22826/>

Master project.

The master project consists of conducting research in the cutting edge of science, technology, society and organization, mostly within a profit- or non-profit organization or the government.

Together with the student projects and research questions will be actively looked for, in which not only company or management knowledge is required, but also a science/ physics background is an advantage. Also it is desirable that a connection can be made between the fourth' year beta research and the master project MA. We emphasize the expression master project and not apprenticeship, because the student isn't supposed to just work at a company or institution, but, based on a completed phrasing of a question, handles a problem that is relevant to the organization.

Possible research areas for master projects are:

- Developing and/or evaluating of instruments for innovation-, science-, and environment policy.
- Researching the bottlenecks in the implementation of a technological innovation in an organization.
- Researching the consequences of actions of (for instance) environmentalists on company policy.
- Developing and/or evaluating instruments for personnel policy of a R&D department.
- Evaluation of the decision process of research projects in a R&D department.
- Developing instruments for improving the collaboration between universities and businesses.
- Developing instruments for supporting produce development.

3 Specialisations

3.1 Introduction

Mathematical research in the Radboud University Nijmegen is focussed on the following themes:

- Algebra and Logic
- Mathematical Physics
- Applied Stochastics

In any track (R, C, E, MT) it is important to find a specialisation for graduation and, accordingly, a matching program of courses. When you start your master you have to find a supervisor for your thesis and you put together a program with advice from your supervisor. Electives can be chosen freely, but the total package has to be approved by the examination board. If you do who the supervisor of your thesis will be at the beginning of your master contact the coördinator of the specialisation to put together a program for the first year.

3.2 Algebra and Logic

Coördinator: Prof. dr. Mai Gehrke.

Algebra, originally the study of arithmetic and the solution of equations, transformed over the latter part of the 19th century and the first part of the 20th into the study of abstract algebraic structures and their relationships. This transformation sprang from work on various types of algebraic systems including systems of linear equations, permutation groups, and propositional logics. This 'modern algebra' has had a profound impact on many domains of mathematics including functional analysis, geometry, topology, and logic. As a consequence algebra has also been deeply influenced by various other fields. Applications in mathematical physics focus on operator algebra, algebraic geometry, and symmetry groups among other. Another source of applications and inspiration for algebra is logic. The algebraic nature of logic may be seen as having been explored already by Leibniz but was firmly identified by Boole in his analysis of 'the laws of thought' in the 1850s. These insights were properly turned into modern algebra by Tarski and Lindenbaum's construction of the free algebra describing a logic. The connection between algebra and logic has also influenced algebra focusing on lattice-ordered algebras, categorical structures, categories as generalised algebras, algorithmic and constructivist issues, and topological duality theory as central subjects. This part of algebra has grown and expanded over the last half century, driven by the advent of computers and computer and information sciences. As the methods and issues of these new disciplines deepen and get more sophisticated, the synergistic impact on algebra is getting ever more important.

The Algebra and Logic group has a seminar:

<http://www.math.ru.nl/~mgehrke/Algebra&Logic/Algebra&Logic.htm>

The seminar provides an opportunity for students to get acquainted with the work of the group and provides a setting for informal talks by visitors to the group.

Research in Nijmegen

The research of the group covers a broad cross-section of the classical modern algebra topics including polynomial rings, groups, fields and lattice-ordered algebras. An identifying common thread is the focus on the interplay of computational, logical, and geometric ideas and methods. Gehrke's work focuses on topological methods in algebra both as they pertain to applications in geometry and physics and in logic and foundations of computer science. Van den Essen's research is in Affine Algebraic Geometry, a recently named subbranch of Algebraic Geometry which focusses on the a study of affine varieties. Bosma's work is in computer algebra. His research is focussed on number theoretic algorithms and has applications in cryptography. He has also been involved in the development of the computer algebra programme, Magma. Souvignier's research area is group theory with special emphasis on algorithmic methods in computational representation theory and crystallographic groups. The leading question of Veldman's research has been to take Brouwer's proposals for a reform of mathematics seriously and to develop mathematics according to intuitionistic principles. For more and current information on the research of the group, consult the page <http://www.ru.nl/science/ca/> and the individual links from there.

Master programme

The master programme is tailor made for each student taking the research track in Algebra and Logic. We advise the to contact as soon as possible a supervisor in order to compose a programme for the research master Algebra and Logic. In case you don't know who should act as your supervisor, please contact prof.dr. Mai Gehrke as soon as possible.

In 2010-2011 the following courses are given in Nijmegen that fit well into the research master Algebra and Logic:

First Semester

Automatic Sequences

6 ec

Commutative Algebra

8 ec

Model Theory

8 ec

Furthermore in the Dutch National Master's Program the following courses are offered that fit well into the specialisation Algebra and Logic:

First Semester

Algebraic Number Theory

8 ec

VU

Representation Theory

8 ec

VU

Number Theory and Cryptography

6ec

UU

Second Semester

Universal Algebra

6 ec

Intuitionistic Mathematics

6 ec

Second Semester

Algebraic Geometry

8 ec

UvA

Diophantine Equations

8 ec

UvA

Complexity Theory

8 ec

UU

Set Theory
8 ec
UU
Proof Theory
8 ec
UU

(MM: MasterMath; these courses are part of the national Dutch Master program in Mathematics)

This programme connects well with the Bachelor minor in informatics, and electives within the Master in theoretical computer science are recommended. For more information please follow the educational programme link from the webpage of the group or talk to one of the members of the group.

3.3 Mathematical Physics

Coördinator: Prof. dr. Erik Koelink

From the time of Newton (1642-1727) until about 1930, mathematics and theoretical physics were inseparable. Breakthroughs typically took place simultaneously in both areas, and progress at both fronts often even resulted from the work of a single scientist, such as Newton himself, Huygens, Euler, Lagrange, Laplace, Fourier, Gauss, Poisson, Cauchy, Jacobi, Hamilton, Riemann, and Poincaré. Their work provided the foundations of 'classical' mathematical physics (as well as of large areas of mathematics), which culminates in the field of partial differential equations (the Maxwell equations are a case in point). A second stage in the development of mathematical physics is connected with some of the greatest names in 20th century science, like Einstein, Born, Dirac and Wigner on the physics side, and Hilbert, Weyl, von Neumann and Kolmogorov on the maths side. The cross-fertilization of mathematics and physics led by these people was instrumental in establishing key areas of modern physics like general relativity and quantum mechanics as well as parts of mathematics like differential geometry, Lie groups and functional analysis.

This typical cross-fertilization subsided between about 1930-1975, when research at the frontiers of physics felt no need for advanced or new mathematics (whose relevance to physics was even openly derided by Feynman), whilst simultaneously mathematics began to be developed according to its own internal criteria established by Hilbert and others (notably the French Bourbaki group). (In addition, after 1945 some of the greatest mathematicians like Grothendieck refused to make use of insights from modern physics because of its connection to nuclear weapons.) This has led, for example, to the creation of modern algebraic geometry and algebraic number theory by Weil, Grothendieck, Serre, Deligne, and others. This development may be said to have culminated in the extremely deep and abstract proof of Fermat's Last Theorem by Wiles in the mid-1990s. From about 1975, however, mathematical

physics has began to regain the élan it used to have.

First, mathematicians like Atiyah, Singer and Penrose, and physicists like 't Hooft and Witten recognized the connection between differential geometry and gauge theories. This connection goes via the notion of index theory (originating in analysis) and is crucial, for example, in the technical implementation of Sacharov's scenario for baryogenesis mentioned earlier. This recognition has led to very important progress in both physics (magnetic monopoles, instantons, anomalies, and other topological phenomena in classical and quantum field theory) and mathematics (e.g. Donaldson theory and Floer homology). In its immediate wake, deep relationships between algebraic geometry and quantum field theory and string theory were discovered and developed by Witten, Kontsevich and others. The work of Dijkgraaf, Verlinde and Verlinde also played an important role here.

Second, Connes began to develop an entire new domain of mathematics called noncommutative geometry on the basis of ideas from quantum physics (e.g. the Dirac equation), operator algebras (an area of mathematics created by von Neumann in the 1930's) and index theory (the field launched by Atiyah and Singer just mentioned). This body of work has led to breakthroughs in a number of areas in pure mathematics (like index theory and foliation theory). Furthermore, as might have been expected, the subject was successfully applied to physics within a decade after its inception, for example to the quantum Hall effect, the theory of quasicrystals, and the Standard Model of elementary particle physics. More recently, noncommutative geometry has also been related to renormalization theory in perturbative quantum field theory, and to string theory.

Third, the classical area of integrable systems (going back to Lagrange, Jacobi and others, with important later contributions by Lax) underwent a complete rejuvenation in that it got related to the Langlands program (originally an area of pure mathematics in which number theory and representation theory interacted). Also, the notion of a Frobenius manifolds emerged from the work of Witten, Manin, Dijkgraaf and others as a new setting for integrable systems. These three areas together have culminated in an independent field of research called the geometric Langlands program.

The above developments have been widely recognized by the mathematical community. Atiyah has been awarded both of the two most prestigious prizes in mathematics, viz. the Abel prize (with Singer) and the Fields Medal. Connes and Kontsevich won the Fields Medal as well, as did Witten (although he is a physicist). Lax and Serre were awarded the Abel Prize. Penrose has won the Wolf Prize and numerous other awards, as did 't Hooft, who won the Nobel prize. And so on and so forth.

Research in Nijmegen

Each of the three current research directions in mathematical physics just mentioned is well represented at Nijmegen, and there are other themes as well, so students interested in research in mathematical physics are offered a rich choice. Clauwens' research is in algebraic topology. Heckman's research lies in the interaction between Lie theory, integrable systems, and geometry, and is closely related to the third topic above. It is currently centered around the link between the geometric Langlands program and Hitchin's integrable system. Koelink's research is on the interplay of representation theory of Lie and quantum groups and

special functions as well as the interaction of quantum groups and operator algebras and non-commutative geometry.

Landsman's research combines noncommutative geometry with quantization theory (i.e. the theory that tries to establish the precise mathematical relationship between classical and quantum physics). One goal is the quantization of singular spaces, in the hope of eventually developing a quantum theory of the Big Bang (a purely classical notion which according to Stephen Hawking and others is probably smoothened out in quantum theory). Maassen works in quantum probability, including the application of stochastic calculus to the interaction of molecules with light, and the functional analysis of quantum noise. In addition he works in the modern theory of quantum information and quantum computing.

Van Suijlekom's main interest is in the mathematical structure of quantum gauge theories: the building blocks of the Standard Model of elementary particle physics. Again, noncommutative geometry provides an ideal mathematical setup for studying these theories. Mürger specializes in category theory, operator algebras and their applications to quantum field theory. He is also interested in constructive quantum field theory. Steenbrink's work is mainly in algebraic geometry. Over the last few years it has focused on two streams: the study of discriminant complements and moduli spaces, and the study of threefolds which are double covers of projective space (double solids).

Preparation

When coming from the BSc Program in mathematics, the student is recommended to prepare for the MSc Program by filling in the free space in the BSc Program with (a selection of) the following courses:

1st semester:

Mechanics 1B (3 ec)

Mechanics 2B (3 ec),

2nd semester:

Mechanical waves(3 ec),

Introduction to quantum mechanics (3 ec)

3d semester:

Analytical mechanics (3 ec),

Special relativity (3 ec)

Vibrations and waves (3 ec)

4th semester:

Quantum mechanics 1a & 1b (6 ec),

Electricity and magnetism 1 & 2 (6 ec),

Introduction Fourier theory (3 ec),

Curves and surfaces (3 ec)

5th semester:

Introduction to Functional Analysis (6 ec)

Quantum mechanics 2 (6 ec)

6th semester:

Introduction to partial differential equations (6 ec)

Quantum mechanics 3 (6 ec)

Up to 18 ec of courses from the 5th and 6th semester may be taken in the master programme.

Master programme

The master programme is tailor made for each student taking the research variant in Mathematical Physics. We advise the to contact as soon as possible a supervisor in order to compose a programme for the research master Mathematical Physics. In case you don't know who should act as your supervisor, please contact prof.dr. E. Koelink as soon as possible.

In 2010-2011 the following courses fit well into the research master Mathematical Physics:

First Semester

Lie Algebras

9 ec

Structure of SpaceTime

6 ec

Introduction to Differential Geometry

6 ec

Furthermore the following courses are offered in the National Master Program or by the MRI that fit well with the research master Mathematical Physics:

Second Semester

Abstract Harmonic Analysis

6 ec

Advanced Differential Geometry

6 ec

Spin Geometry

6 ec

First Semester

Symplectic Geometry

8 ec

UU

Algebraic Topology

8 ec

UU

Functional Analysis

8 ec

UU

Second Semester

Algebraic Geometry

8 ec

Semisimple Lie algebras

8 ec

Partial Differential Equations

8 ec

A selection of courses from the Physics MSc programme can be taken, such as Group

Theory, Classical Electrodynamics, Statistical Mechanics and Quantum Mechanics. Moreover related courses from Applied Stochastics, such as Spin Glasses and Neural Networks, Information Theory can also be taken. .

3.4 Applied Stochastics

Coördinator: Prof. dr. Frank Redig

Stochastics (from the Greek "stochos" (guess)) is the area of mathematics dealing with systems and processes where randomness plays a role. This is the case for almost all processes studied in the "real" world, in particular in economy and biology (where systems are very complex). Also in classical physics, however, even if the laws are deterministic, most systems depend so sensitively on initial conditions, that random processes provide the only effective description. Quantum physics has its own peculiar notion of randomness.

Probabilistic concepts were first introduced in relation to games of chance (in a famous correspondence between Fermat and Pascal), then to population statistics, economy and statistical physics. Boltzmann and others used probabilistic concepts to describe the equilibrium distribution of atoms and molecules, and provided a link between microscopic laws of motion and the laws of thermodynamics, via the concept of entropy.

The modern mathematical foundation of probability theory, based on measure theory, was created by Kolmogorov. This framework allows for introducing probability in abstract spaces, which is crucial in the theory of stochastic processes, in particular Brownian motion and the associated stochastic calculus (the basic tool for financial mathematics).

The general theory of Markov processes, their semigroups and generators links stochastics with functional analysis and partial differential equations. The theory of martingales developed by Doob (and others) gives the fundamental convergence theorems of probability and provides a link with potential theory and abstract harmonic analysis.

The theory of large deviations, developed by Donsker and Varadhan (Nobel prize 2007), studies the exponentially small probabilities of deviations on the scale of the law of large numbers. This theory is intimately related to statistical physics and information theory via the concept of entropy. At present, stochastics is an active and fast-developing field with connections to the natural sciences, as well as to other areas of mathematics such as analysis, combinatorics, geometry and number theory.

In order to validate a probabilistic model, one needs to find the parameters that optimally correspond to experimental data. This is the field of statistics: how to extract from data "optimal" information about the distribution. The large amount of data in e.g. biological experiments (microarrays, genomic data) represents new challenges in statistics. Statistics is also very promising in machine learning.

Research in Nijmegen

The research programme in Nijmegen is focused on interacting stochastic systems, quantum probability and statistics.

The first part focusses on random systems consisting of many interacting degrees of freedom. Examples are from statistical physics, such as the Ising model, percolation, or models of non-equilibrium (interacting particle systems self-organized criticality), and from biology (population dynamics, evolution of traits). A second focus is non-commutative probability theory, a generalization of Kolmogorov's formalism that can deal with quantum mechanical phenomena. Subjects here are quantum information handling, and stochastic versions of the Schrödinger equation in quantum mechanics. The programme in statistics is focused in developing techniques applicable in audit sampling, one of the methods available to auditors in auditing a financial report. We are also involved in risk assessments in environmental science. In development is a collaboration with the Donders centre where interacting stochastic systems will be applied to neuroscience (integrate and _re models, control theory and bayesian learning).

The research programme in Nijmegen is inbedded in the the STARcluster, which coordinates both research and master-level teaching in stochastics. More information about the STAR cluster can be found on the homepage of EURANDOM.

Master programme

The master programme is tailor made for each student taking the research track in Applied Stochastics. We advise the student to contact as soon as possible a supervisor in order to compose a programme for your master. In case you don't know who should act as your supervisor, please contact prof.dr. Frank Redig as soon as possible.

In 2010-2011 the following courses are given in Nijmegen that fit well into the research master Stochastics:

First Semester

Capita selecta stochastics

6 ec

Information theory

6 ec

Second Semester

Insurance Mathematics

6 ec

Spin glasses and neural networks

6 ec

Reading Seminar Neuroscience

6 ec

a course yet to determine

Furthermore in the National Master's Program the following courses are offered:

- The courses that are part of (i.e. strongly recommended!) for the research master Stochastics:

First Semester

Measure Theoretic Probability

8 ec

UvA

Second Semester

Stochastic Processes

8 ec

VU

- Other courses in the National Master's Programm are:

First Semester

Introduction to Stochastic Processes

4 ec

UU

Second Semester

Applied Statistics

6ec

UU

Asymptotic Statistics

8 ec

UvA

Stochastic Differential Equations

6 ec

UU

Queueing Theory

6 ec

UU

Empirical Processes and Statistical Learning

8 ec

UvA

3.5 Research Master in the Mathematical Foundations of Computer Science

Apart from choosing between one of the three mathematical specialisations offered in Nijmegen there is also the possibility to choose for a new interdisciplinary master's program in the theoretical foundations of computer science. This program will start from september 2009.

Introduction

Throughout the centuries there has been a fruitful and mutually inspiring interaction between physics and mathematics. A similarly fruitful and exciting interaction has existed right from the start between computer science and mathematics. This ranges from the use of mathematics to model the foundations and explore the potentials and limits of computer science to the use of computers to help solve mathematical problems with a discrete component. This Research Master Program places itself squarely on this exciting and quickly developing interdisciplinary edge of deep theoretical developments.

In this Research Master Program, mathematicians working in areas pertinent to (theoretical) computer science, like algebra and logic, and theoretical computer scientists, working in areas as formal methods and theorem proving, join forces to establish a master program in the

Mathematical Foundations of Computer Science, (MFoCS). The emphasis of the Master is on a combination of a genuine theoretical and up-to-date foundation in the pertinent mathematical subjects combined with an equally genuine and up-to-date training in key aspects of theoretical computer science. For this reason, the mathematics courses in this curriculum concentrate on Algebra, General Topology, Logic, Number Theory, and Combinatorics. The computer science courses concentrate on Formal Methods, Type Theory and Theorem Proving.

For this master program we solicit students with a bachelor in mathematics or computer science that have a strong mathematical background and theoretical interests. We will select students based on their motivation and their background.

Master Programme

It is intended that students of this master program obtain a broad knowledge and understanding over a wide range of material in mathematics and theoretical computer science, bringing them in contact with the research frontier of the field. Consequently, the curriculum consists of both lectures (with exercise classes) and of research projects, which are organized in a Research Seminar and a Research Lab. There are 6 fixed courses for all students and the rest can be chosen from a list of elective courses.

Year 1:

Semester 1		Semester 2	
3 x 6 ec fixed	18 ec	3 x 6 ec fixed	18 ec
Elective	6 ec	Elective	6 ec
Kaleidoscope*	6 ec	Research Seminar	6 ec
Total	30 ec	Total	30 ec

* Kaleidoscope consists of selected topics of semantics of programming languages, basic complexity theory and rings and fields. This course will provide a crash course of some of the basic knowledge that we assume the students to be familiar when starting this master.

** In Research Seminar, the various teachers of this Master will give a short introduction to their research and present some research projects that the students can select one from for a small project. *** In Research Lab, the students do a larger Research project. The aim is to select ones own project, write a short paper on it and present the result to the fellow students. The projects will be supervised by staff members. -->

Year 2:

Semester 1		Semester 2	
Philosophy	3 ec	3 x 6 ec fixed	18 ec

2 x 6 ec Electives	12 ec	Elective	6 ec
Master Thesis	6 ec	Research Seminar	6 ec
Total	30 ec	Total	30 ec

Fixed Courses (not definitive yet)

Type Theory and Theorem Proving	1	Geuvers and Wiedijk
Introduction Category Theory	1	Jacobs
Lattice Theory	1	Gehrke
Semantics and Domain Theory	2	Geuvers and McKinnon
Universal algebra	2	Gehrke
Computer Algebra	2	Bosma

Elective Courses (not definitive yet)

Here is a list of elective courses. The C/M denotes whether it is more a Computer Science or more a Mathematics course, or it can be seen as both. NB. Some of the elective courses may require specific advance knowledge. Not all the courses are offered every year.

Coalgebras	Rutten	CM
Complexity Theory	van Leijenhorst	C
Proof Assistants	Wiedijk	C
Analysis of Embedded Systems	Vaandrager	C
Term Rewriting Systems	Zantema	C
Advanced Lambda Calculus	Barendregt	C
Advanced Programming	Plasmeijer	C
Algebraic Topology	Clauwens	M
Groups and Representations	Souvignier	M
Commutative Algebra	Maubach	M
Duality Theory	Gehrke	M
Algorithmic Number Theory	Bosma	CM
Graph Theory	Bosma	CM
Recursion Theory	Veldman	CM
Intuitionistic Mathematics	Veldman	M
Axiomatic Set theory	Veldman	M
Model Theory	Veldman	M

Apart from the courses mentioned above, students can follow Master courses, at Mastermath, including courses offered by Diamant. It should be noted that the Mastermath courses are 8 ec, so choosing one (or two) Mastermath courses implies that you are doing more ecs in total. There's also the possibility of going abroad in the 3rd semester, for example there are possibilities to follow courses with the Radboud University's partners in the IRUN network,

notably the Theoretical Computer Science group at the Faculty of Mathematics and Computer Science of the Jagiellonian University in Krakow, Poland.

Grants

See the university's International Masters page for general information about doing a master at the Radboud University.

Students from an EEA country may apply for either a student grant within the Dutch student grants and loans system or a tuition fee allowance: Read more.... Students from the Netherlands can use their normal *studiefinanciering* from IB, as this Master curriculum officially falls under both the master of computer science and the master of mathematics of the Radboud University Nijmegen, which are CROHO-accredited.

The Radboud University has special scholarships for non-EEA students, like the Radboud Scholarship Programme. The university provides a special information page on scholarships and grants.

Students who need **financial support** may be interested to know that the Dutch government, runs special schemes to help students finance their education.

- **Scholarships from the Dutch government/Nuffic**

The Dutch government offers a broad range of scholarships for international students, for example the Huygensscholarship. Further information: www.nuffic.nl/

- All sorts of information on **grants** can be found on the student grantfinder: www.grantfinder.nl/content/index.asp

Contact

Prof.dr. Mai Gehrke, IMAPP
 Prof.dr. Herman Geuvers, ICIS
 Faculty of Science
 Radboud University Nijmegen
 Netherlands

Advice In case you are interested in doing this master program, please get in touch with Professor Gehrke or Professor Geuvers.

4 Dutch Master Program in Mathematics

4.1 Program and schedule

In this chapter you find a list of all Master courses offered in 2009/2010 in the framework of the **DUTCH MASTER PROGRAM IN MATHEMATICS**. For descriptions of these courses and further details see: <http://www.mastermath.nl> .

You have to register for these courses at: <http://www.mastermath.nl/registration/> .

Abbreviations:

- (LNMB)= these courses are organized by the Dutch Network on the Mathematics of Operations Research
- ((MRI) = these courses are organized by the Mathematics Research Institute and are more advanced. Some basic knowledge of complex function theory, differentiable manifolds and algebraic geometry is needed.
- (3TU)= these courses are part of a joint MSc program in Applied Mathematics of the 3 Dutch technical universities (Technische Universiteit Eindhoven, Universiteit Twente and Technische Universiteit Delft)

4.2 Course schedule fall 2010

10:15 - 14:45 hrs:	Introduction to Stochastic Processes (4 cp)
Instructors:	Adan, I.J.B.F. (Technische Universiteit Eindhoven) Boxma, O.J. (Technische Universiteit Eindhoven)
Venue:	Buys Ballot Lab, room 023, Utrecht.
11:00 - 12:45 hrs:	Continuous Optimization (6 cp)
Instructors:	Still, G. (Universiteit Twente)
Venue:	week 38-45: Aard groot. week 46-49: Minnaert building, room 211
13:00 - 14:45 hrs:	Discrete Optimization (6 cp)
Instructors:	Uetz, M. (Universiteit Twente)
Venue:	Room: Aard klein.
15:00 - 16:45 hrs:	Heuristic Methods in Operations Research (6 cp)
Instructors:	Hurink, J.L. (Universiteit Twente) Schutten, J.M.J. (Universiteit Twente)
Venue:	Buys Ballot Lab. room 061.

10:15 - 12:00 hrs: Instructors: Venue:	Systems and Control (intensive course) (6 cp) Polderman, J.W. (Universiteit Twente) This is an intensive course. See Courses and Exams for more information about the organization of the intensive courses. First meetings will be in Utrecht, the intensive week will be in Twente(Enschede). First meetings: room tba Intensive week: October 25-29, week 43
10:15 - 13:00 hrs: Instructors:	Algebraic Number Theory (8 cp) Smit, B. de (Universiteit Leiden) Top, J. (Rijksuniversiteit Groningen)
14:00 - 16:45 hrs: Instructors:	Representation Theory (8 cp) Lenstra, H.W. (Universiteit Leiden) Cuypers, F.G.M.T. (Technische Universiteit Eindhoven)
14:00 - 16:45 hrs: Instructors: Venue:	Conservative Dynamical Systems (8 cp) Hanßmann, H. (Universiteit Utrecht) Waalens, H. (Rijksuniversiteit Groningen) Mathematical building room 61 lab, Utrecht
10:15 - 13:00 hrs: Instructors: Venue:	Functional Analysis (8 cp) Ran, A.C.M. (Vrije Universiteit) Jeu, M.F.E. de (Universiteit Leiden) Buys Ballot Lab, room 065, Utrecht
10:15 - 13:00 hrs: Instructors: Venue:	Introduction to numerical bifurcation analysis of ODE's and Maps (8 cp) Kuznetsov, Yu.A. (Universiteit Utrecht) Mathematical Building room 61 lab, Utrecht
10:15 - 14:45 hrs: Instructors: Venue:	Introduction to Stochastic Processes (4 cp) Adan, I.J.B.F. (Technische Universiteit Eindhoven) Boxma, O.J. (Technische Universiteit Eindhoven) Buys Ballot Lab, room 023, Utrecht.
10:15 - 13:00 hrs: Instructors:	Symplectic Geometry (8 cp) Heckman, G.J. (Radboud Universiteit

Venue:	Nijmegen) Buys Ballot Lab room 069, Utrecht
14:00 - 16:45 hrs: Instructors:	Numerical Linear Algebra (8 cp) Gijzen, M.B. van (Technische Universiteit Delft) Sleijpen, G.L.G. (Universiteit Utrecht)
Venue:	Buys Ballot room 106(pc room, Utrecht)
14:00 - 16:45 hrs: Instructors: Venue:	Algebraic Topology (8 cp) Looijenga, E.J.N. (Universiteit Utrecht) Buys Ballot Lab room 069, Utrecht
10:15 - 13:00 hrs: Instructors:	Measure Theoretic Probability (8 cp) Spreij, P.J.C. (Universiteit van Amsterdam)
14:00 - 16:45 hrs: Instructors:	Asymptotic Statistics (8 cp) Kleijn, B.J.K. (Universiteit van Amsterdam)
10:15 - 13:00 hrs: Instructors: Venue:	Parallel Algorithms (8 cp) Bisseling, R.H. (Universiteit Utrecht) Mathematical building room 61 lab, Utrecht
10:15 - 13:00 hrs: Instructors:	Didaktiek (6 cp) Verhoef, N.C. (Universiteit Twente) Vos, F.P. (Universiteit van Amsterdam)
Venue:	Buys Ballot Lab, room 061, Utrecht.
14:15 - 17:00 hrs: Instructors:	Number Theory and Cryptography (6 cp) Lange, T. (Technische Universiteit Eindhoven)
Venue:	Minnaertbuilding room 211, Utrecht.

More advanced courses (MRI) fall 2010 are:

- Riemann surfaces (Gil Cavalcanti)
- Introduction to conformal field theory (Andre Henriques)

4.3 Course schedule spring 2011

10:15 - 12:00 hrs: Instructors:	Advanced Linear Programming (6 cp) Stougie, L. (Vrije Universiteit) Canzar, S. (CWI)
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10:15 - 13:00 hrs: Instructors:	Stochastic Differential Equations (6 cp) Weide, J.A.M. van der (Technische Universiteit Delft)
13:00 - 14:45 hrs: Instructors:	Nonlinear System Theory (6 cp) Schaft, A.J. van der (Rijksuniversiteit Groningen)
13:00 - 14:45 hrs: Instructors:	Scheduling (6 cp) Hurink, J.L. (Universiteit Twente)
13:00 - 14:45 hrs: Instructors:	Applied Statistics (6 cp) Meulen, F.H. van der (Technische Universiteit Delft)
15:00 - 16:45 hrs: Instructors:	Queueing Theory (6 cp) Scheinhardt, W.R.W. (Universiteit Twente)
10:15 - 12:00 hrs: Instructors:	Advanced Modelling in Science (6 cp) Heemink, A.W. (Technische Universiteit Delft)
13:00 - 15:45 hrs: Instructors:	Applied Finite Elements (6 cp) Vegt, J.J.W. van der (Universiteit Twente)
00:00 - 00:00 hrs: Instructors:	Complexity Theory (8 cp) Pietrzak, K. (CWI) Terwijn, S.A. (Radboud Universiteit Nijmegen)
10:15 - 13:00 hrs: Instructors:	Asymptotic Methods for Differential Equations (8 cp) Muntean, A. (Technische Universiteit Eindhoven) Zagaris, A. (Universiteit Twente)
14:00 - 16:45 hrs: Instructors:	Diophantine Equations (8 cp) Evertse, J.H. (Universiteit Leiden) Beukers, F. (Universiteit Utrecht)
14:00 - 16:45 hrs: Instructors:	Partial Differential Equations (8 cp) Vorst, R.C.A.M. van der (Vrije Universiteit)

10:15 - 13:00 hrs: Instructors:	Semisimple Lie Algebras (8 cp) Opdam, E.M. (Universiteit van Amsterdam) Stokman, J.V. (Universiteit van Amsterdam)
14:00 - 16:45 hrs: Instructors:	Algebraic Geometry (8 cp) Edixhoven, S.J. (Universiteit Leiden)
10:15 - 13:00 hrs: Instructors:	Numerical Methods for Time-dependent PDE's (8 cp) Zegelning, P. (Universiteit Utrecht)
10:15 - 13:00 hrs: Instructors:	Stochastic Processes (8 cp) Spijksma, F.M. (Universiteit Leiden)
14:00 - 16:45 hrs: Instructors:	Empirical Processes and Statistical Learning (8 cp) Vaart, A.W. van der (Vrije Universiteit)
10:15 - 13:00 hrs: Instructors:	Proof Theory (8 cp) Oosten, J. van (Universiteit Utrecht)
14:00 - 16:45 hrs: Instructors:	Set Theory (8 cp) Hart, K.P. (Technische Universiteit Delft) Löwe, B. (Universiteit van Amsterdam)
10:15 - 13:00 hrs: Instructors:	Geometry (6 cp) Spandaw, J.G. (Technische Universiteit Delft)
14:00 - 16:45 hrs: Instructors:	Historical Aspects of Classroom Mathematics (6 cp) Wepster, Steven (Universiteit Utrecht)

More advanced courses (MRI) spring 2011 are:

- The moduli space of abelian varieties (Gerard van der Geer)

5 Description of the Courses

Abstract Harmonic Analysis

Course ID: **WM077B** 6 ec

second semester

dr. M.H.A.H. Muger

Teaching methods

30 hours of lectures. Voluntary homework.

Prerequisites

Bachelor mathematics (In particular Analysis I+II, Topology, Symmetry). It is essential to have followed Introduction to Fourier Theory. Some background in Functional Analysis is helpful.

Objectives

The student knows

- the basics of topology and measure theory for locally compact groups,
- their applications to the duality and structure theory for abelian groups and
- the representation theory of compact groups.
- (S)he has some understanding of the new phenomena and difficulties arising for non-abelian and non-compact groups.
- The student will be able to approach the literature on more recent aspects of the theory.

Contents

Abstract Harmonic Analysis is a relatively recent mathematical theory; it started in the late 1920s and is still growing rapidly. It has close connections with many subjects in analysis, topology and mathematical physics. It also is the starting point of generalizations like "quantum groups".

Abstract Harmonic Analysis starts from the classical Fourier theory (involving the abelian groups \mathbb{Z} , \mathbb{S}^1 and \mathbb{R}) and from the representation theory of finite groups and combines them into a beautiful and powerful theory of harmonic analysis on and representation theory of locally compact groups. A crucial ingredient is the Haar measure, which allows to integrate over any locally compact group. In the abelian case, one obtains the duality theory of Pontrjagin which generalizes classical Fourier theory and has applications to the structure theory of such groups. On the other hand, one finds that the representation theory of compact groups has much in common with that of finite groups. For groups that are non-compact and non-abelian, very interesting new phenomena arise that are still the subject of much research.

Subjects

- Basics of topological groups, in particular locally compact ones.

- Haar measure: Existence, uniqueness, properties.
- Pontrjagin duality of locally compact abelian groups and applications to structure theory of such groups.
- Representation theory of compact groups: Characters, Peter-Weyl theorem.
- Time permitting: Some aspects of non-compact non-abelian groups, based on some crucial examples.

Literature

Anton Deitmar & Siegfried Echterhoff: Principles of harmonic analysis.
Springer Universitext, 2009. ISBN 978-0-387-85468-7. (42 Euro.)

Examination

Oral exam or mini thesis.

Advanced Differential Geometry

Course ID: **WM065B** 6 ec

second semester

prof. dr. J.H.M. Steenbrink

Teaching methods

2 hours tutorial with assignments

Prerequisites

Differential Geometry

Objectives

- The student has a firm knowledge of the theory of Lie groups.
- The student has a firm knowledge of vector bundles.
- He knows the role they play in the study of the Dirac and Yang-Mills equations.

Contents

The course is intended to provide a working knowledge of those parts of the theory of lie groups and vector bundles that are essential for a deeper understanding of both classical and modern physics.

Subjects

- Lie Groups, Bundles, and Chern Forms
- Vector Bundles in Geometry and Physics
- Fiber Bundles, Gauss-Bonnet, and Topological Quantization
- Connections and Associated Bundles
- The Dirac Equation
- Yang-Mills Fields
- Betti Numbers and Covering Spaces
- Chern Forms and Homotopy Groups

Literature

The book "The Geometry of Physics" is only recommended, not obligatory. The main text for the course is "Preparation for Gauge Theory" by George Svetlichny, to be found on [arXiv:math-ph/9902027v3](https://arxiv.org/abs/math-ph/9902027v3).

Examination

Oral

Applied Stochastics

Course ID: **WB064B** 6 ec

second semester

Prof. dr. F.H.J. Redig

Teaching methods

- 32 uur hoorcollege
- 32 uur werkcollege

Prerequisites

Probability (kansrekening), advanced probability (voortgezette kansrekening), useful (but not strictly necessary): measure and integral (maat en integraal).

Objectives

- Understand what are interacting particle systems and place them in the context of theory of Markov process as well as statistical physics.
- Understand the theory of semigroups and generators of Markov processes,
- To apply the theory of semigroups and generators of Markov processes, e.g. to find invariant and ergodic distributions.
- Understand and apply the basic techniques of interacting particle systems: coupling, duality, monotonicity.

Contents

Interacting particle systems are a class of Markov processes which are used as models in statistical mechanics, mathematical biology and neuroscience.

An important example is the exclusion process, which will be the main subject of this course.

In this model particles perform random walk on a lattice with the restriction that at every lattice site there is at most one particle.

The exclusion process is used as a paradigmatic model of non-equilibrium statistical mechanics, and serves to understand relaxation to equilibrium as well as the rigorous derivation of hydrodynamic equations.

The techniques which we use to analyse this particular model - duality, coupling and monotonicity - are general and can be used in many other models of interacting particle systems such as the contact process, the voter model, etc.

Literature

1. T.M. Liggett, Interacting particle systems, an introduction, available online.
2. T. Seppalainen, Translation invariant exclusion processes, available online.

Examination

Presentatie tijdens het werkcollege of een mondeling tentamen

Automatic Sequences

Course ID: **WM080B** 6 ec

first semester

dr. W. Bosma

Prerequisites

Discrete Mathematics (and/or Getallen)

Objectives

yet to determine

Contents

This course deals with a subject that links elementary number theory and theoretical computer science.

The main objects of study are infinite words (over a finite set of letters) and finite state automata; the automatic sequences are words recognized by such automata.

The link with number theory arises from the choice of words: they could for example be the digits in the binary (or decimal) expansion of real numbers, or the partial quotients in the continued fraction expansion of real numbers.

Literature

The course will largely follow the excellent book Automatic Sequences by Allouche and Shallit.

Examination

Homework exercises, oral or written exam

Capita Selecta Stochastics

Course ID: **WM074B** 6 ec

first semester

prof. dr. F.H.J. Redig

Teaching methods

32 hours course

32 hours exercise class

Prerequisites

Probability (kansrekening), advanced probability (voortgezette kansrekening), useful (but not strictly necessary): measure and integral (maat en integraal), applied stochastics (toegepaste stochastiek).

Objectives

1. Understand and apply the theory of large deviations for sums of iid random variables.
2. Understand and apply the abstract frameworks of the theory of large deviations, Varadhan's lemma, contraction principle.
3. Understand and apply theory of Brownian motion and diffusion processes, and large deviations in that context (Freidlin Wentzell theory).

Contents

The theory of large deviations, developed by Donsker and Varadhan (abel prize 2007) studies probabilities of deviations on the scale of the law of large numbers.

E.g. what is the probability that upon throwing a dice 6000 times, 2000 times six comes out, or what is the probability that a symmetric nearest neighbor random walk after 100 steps is at distance 50 from the origin? Such probabilities are exponentially small (in the number of random variables) and what is in the exponent can be computed precisely.

Using ideas going back to Cramer, one has to find "the most probable way to realize an improbable event".

Here entropy plays a crucial role, as well as concepts from convex analysis such as Legendre transform.

In infinite dimensional context, a typical large deviation question is the following: suppose a differential equation is perturbed by weak (Brownian) noise.

What can be said about the probability that the trajectory deviates from the solution of the equation? This problem is studied in Freidlin-Wentzell theory where a large deviation function on path space can be computed. This formalism is useful in stochastic control theory, physics (stochastic resonance, metastability) and neuroscience.

Literature

College nota's worden ter beschikking gesteld. Verder achtergrondmateriaal:

1. T. Seppalainen A Course on Large Deviations with an Introduction to Gibbs Measures, online beschikbaar
2. A. Dembo, O. Zeitouni, Large Deviations Techniques and Applications, Jones and Barlett Publishers, Boston (1993).

Examination

Mondeling tentamen of presentatie tijdens het werkcollege

Commutative Algebra

Course ID: **WM026B** 8 ec

first semester

dr. J.J.T. Berson

Teaching methods

- 28 hrs lecture
- 28 hrs problem session

Objectives

- The student understands the difference in structure of the main objects in Commutative Algebra: rings, ideals, modules and algebras
- The student can distinguish between different objects of the same type, like prime, maximal and nilpotent ideals, and Noetherian modules
- The student can apply standard operations to a specific object, like localization, taking quotients, and tensoring
- The student can apply results from Commutative Algebra to various problems encountered during this course

Contents

What is commutative algebra about? To make this clear let's start with a k -vector space V , where k is a field. So V is a set equipped with an addition, which makes V into an abelian group, and a scalar multiplication with scalars from k . Furthermore the classical distributive laws hold. If we replace k by an arbitrary commutative ring R we get a so-called R -module. This notion generalises most of the notions one meets during a Bachelor's study Mathematics. For example it will turn out that a \mathbb{Z} -module is the same as an abelian group, a $k[x]$ -module is the same as a k -vector space together with a linear transformation and an ideal I in a ring R is an example of a so-called R -submodule of R . Also the quotient ring R/I is an R -module etc. The theory of R -modules is much more complicated than the theory of vector spaces; many problems are still unsolved. The general philosophy is that the 'nicer' the ring R is, the more we know about its R -modules. The language of modules is an indispensable tool in nowadays Mathematics. In this course we discuss the most fundamental concepts and results of modern commutative algebra. Many of the notions introduced in this course will also be used in various other courses.

If you are planning to specialize in algebraic geometry, algebraic topology, number theory, computer algebra or polynomial mappings, this course is a must.

Literature

We follow the excellent book '*Introduction to commutative algebra*' by M.F. Atiyah and I.G. MacDonald.

Examination

The student has to make a series of exercises.

Information Theory

Course ID: **WM079B** 6 ec

first semester

dr. J.D.M. Maassen

Prerequisites

Probability theory (bachelor level),

Objectives

- The student will be able to devise optimal codes for data compression.
- To analyze the capacity of an information channel given noisy influences
- To quantify the amount of randomness in a stochastic process.
- He/she will be able to apply these concepts to networks and feedback loops.

Contents

In this course we study the classical theory of information, viewed as a quantifiable commodity.

Shannon's entropy concept is shown to be directly related to data compression and the capacity

of information channels. Coding schemes will be treated such as Huffman coding and zero-error codes.

A connection to quantum information theory will be sketched.

Literature

Thomas M. Cover and Joy A. Thomas: Information Theory, Wiley Interscience 2006.

Examination

Schriftelijk

Insurance Mathematics

Course ID: **WM022B** 6 ec

second semester

dr. H.W.M. Hendriks

Teaching methods

28 hours formal lecture, 14 hours tutorial

Prerequisites

Basic course in Probability theory or Stochastic processes

Objectives

- The student is familiar with utility functions and expected utility.
- He understands the individual and the collective risk model.
- He is familiar with Panjer's recursion. He understands the ruin theory according to Lundberg.
- He has insight in the properties of several risk premium principles.
- He understands the concept of reinsurance.

Contents

Utility functions, individual and collective risk model. Panjer's recursion. Cramér-Lundberg model for the surplus process, adjustment coefficient, Beekman's convolution formula for ruin probability. Various premium principles and their properties. Bonus-malus systems. First order and second order of stochastic dominance. In Insurance Mathematics methods are studied for determining premiums and for the management of the capital reserves, based on the data about the risks in a portfolio. In this course we will discuss several premium calculation principles, mathematical models for the process of claiming times and claim sizes and bonus-malus systems. A highlight is the derivation of an integral equation for the probability of ruin (bankruptcy). That is the probability that, given a certain premium income and initial capital, at any moment the received premiums together with the initial capital are insufficient to cover the claims up to that moment. In the near future insurance companies will have to satisfy a continuity requirement, for which obviously the above theory could be applied. The course is meant for students interested in applications of mathematics in the financial world. It is part of the standard curriculum of Financial Mathematics.

Literature

Kaas, R. et al., *Modern actuarial risk theory*, 1st ed., Springer/Kluwer. The course is based on this book.

Bühlmann, H., *Mathematical methods in risk theory*, Springer.

Examination

Written assignment with oral presentation.

Introduction to Differential Geometry

Course ID: **WM060B** 6 ec

dr. F.J.B.J. Clauwens

Teaching methods

- 28 hrs lecture
- 28 hrs problem session

Prerequisites

Some familiarity with the topological way of thinking is highly recommended.
A good knowledge of Calculus and (multi)linear algebra is indispensable.

Objectives

- The student should be able to explain the concepts Topological space, chart, atlas, differentiable manifold, smooth map, Tangent vector, tangent space, derivation, vector field, Lie derivative
- The student should be able to explain the concepts Cotangent vector, cotangent space, covector field, Tensors and tensor fields
- The student should be able to explain the concepts Differential form, exterior differentiation, Partition of Unity, volume form, integration on manifolds, Stokes theorem.
- The student should be able to explain the concepts (Semi)-Riemann structure, affine connection, Christoffel symbols, Levi-Civita connection, Curvature tensor, sectional curvature, Bianchi identities, Parallel displacement, geodesics, exponential map, normal coordinates.

Contents

A topological space is just a set together with some extra structure which enables one to talk about continuity of functions. Likewise a differentiable manifold is a set together with some extra structure which enables one to talk about differentiable functions and their derivatives. The idea of directional derivative leads to a construction which attaches a vector space to each point of the manifold, the so called tangent space. Using techniques of Linear Algebra one constructs numerous other vector spaces from this tangent space. Concepts like gradient, curl, divergence and their relations can thus be understood in a very general context. This provides a geometrical language in which one can describe configuration spaces and phase spaces, and in which one can formulate Maxwells theory of electromagnetism and Einsteins theory of general relativity.

Literature

Theodore Frankel: The geometry of physics, Cambridge Univeristy Press, ISBN 10-0-521-53927-7

There wil also be lecture notes available in pdf form (some 100 pages) with material complementary to the above book.

Examination

oral

Intuitionistic Mathematics

Course ID: **WM037A** 6 ec

second semester

dr. W.H.M. Veldman

Teaching methods

- 28 hrs lecture
- 28 hrs tutor session

Objectives

The student learns that the mathematics may be developed in other ways than the usual one, in particular, along the lines indicated by the famous Dutch mathematician L.E.J. Brouwer.

Contents

In this course we consider the criticism L.E.J. Brouwer (1881-1966) exercised on many results of classical real analysis, and explain why he refused to use the *principle of the excluded middle* in his own mathematical proofs. Brouwer not only wanted to restrict the logic of mathematical arguments but also proposed some new axioms. We will see that his new mathematics contains many delightful and convincing results.

We also treat *intuitionistic logic* as formalized by Heyting and Gentzen.

We will compare Brouwer's point of view with other conceptions of constructive mathematics.

Literature

A. Heyting, *Intuitionism, an Introduction*, North Holland Publ. Co., Amsterdam 1971.

E. Bishop, D. Bridges, *Constructive Analysis*, Springer Verlag, New York etc., 1985.

D. Bridges, F. Richman, *Varieties of Constructive Mathematics*, Cambridge UP, 1987.

A.S. Troelstra, D. van Dalen, *Constructivism in Mathematics*, Volumes I and II, North Holland Publ. Co., 1988.

Examination

After having completed and submitted a number of exercises, students have to pass an oral examination

Lie Algebras

Course ID: **NM028C** 9 ec

first semester

prof. dr. G.J. Heckman
prof. dr. H.T. Koelink

Teaching methods

- 42 hrs lecture
- 14 hrs problem session

Prerequisites

Symmetry or Introduction Group Theory

Objectives

- The student becomes familiar with Poisson algebras Universal enveloping algebras.
- He also knows the representation theory of $SL(2)$ Representations via constructions of linear algebra Reductive Lie algebras.
- The student knows Verma representations and the representation theory of $SL(3)$ Physical applications: Spin and quarks.
- The student knows the Weyl character formula Spherical harmonics.
- The student knows $SO(n)$ Physical application: The Kepler problem.

Contents

In this course we discuss the mathematics of Lie algebras and their representations. The basic examples are the Heisenberg algebra, the special linear algebra $SL(n)$ and the orthogonal algebra $SO(n)$. For each of these algebras we discuss the physical relevance which lie mainly in the realm of particle physics. We also discuss the link with invariant theory, an important subject in geometry. The course is interesting for students in both physics and mathematics, and standard for students in mathematical physics. The material of the course is useful for the courses "Beyond the Standard Model" and "Introduction to String Theory" of Prof. dr. B. Schellekens.

Literature

Lecture notes will be made available electronically via blackboard.

Examination

Oral exam

Extra information

The course will only be taught given a sufficient number of participants. Please register via blackboard.

Model Theory

Course ID: **WM036C** 8 ec

first semester

dr. W.H.M. Veldman

Objectives

The student becomes familiar with some results and techniques from model theory, the most important meeting point between mathematics and mathematical logic.

Contents

In mathematics one often studies the class of structures satisfying a given set of formal axioms, for instance the class of groups, the class of fields, or the class of linear orders. In *Model theory* one starts to restrict oneself to the still rather general case that the axioms are formulated in a *first-order* or *elementary* language. This means that, when interpreting the formulas of such a language, one only quantifies over the domain of a given structure, and not, for instance, over the power set of the domain. One then asks questions like: given a structure, is it possible to axiomatize it, that is, is it possible to indicate a *not too difficult* set of formulas valid in the structure such that every formula valid in the structure logically follows from the formulas in the set. Or: given structures A, B , under what circumstances are A, B *elementarily equivalent*, that is, when do they satisfy the same elementary formulas? Or: given a set of formulas, how many countable structures do there exist satisfying all formulas in the set?

Model theory at its best is a delightful blend of abstract and concrete reasoning.

Literature

C.C. Chang, H.J. Keisler, *Model Theory*, North Holland Publ. Co., Amsterdam, 1977.

G.E. Sacks, *Saturated Model Theory*, Benjamin, Reading, Mass., 1972.

B. Poizat, *Cours de théorie des Modèles*, Nur al-Matiq wal-Marifah, 1985.

W. Hodges, *A shorter Model Theory*, Cambridge University Press, 1997.

Examination

After having completed and submitted a number of exercises, students have to pass an oral examination

Philosophy of mathematics

Course ID: **WM040B** 3 ec

second semester

dr. W.H.M. Veldman

Teaching methods

- 30 hrs lecture

Objectives

- The student will learn to see that the question about the nature of mathematics is one of the most important questions in philosophy.
- The student will learn that meticulous mathematical thinking and philosophical contemplation can stimulate each other.

Contents

During the course we discuss: Plato's Ideas and the place of the mathematical objects, Aristotle's view, Kant's view on the nature of mathematical statements, Frege and Russell's logics, Russell's paradox, Cantor's discoveries, Brouwer's intuitionist criticism, Goedel's incompleteness thesis, Goedel's Platonism, Wittgenstein's thoughts.

Literature

The students will be given home texts that will be discussed in the lectures, during which one will be able to ask questions, or have discussions.

Examination

The student studies various texts of choice, and is assessed about them orally.

Seminar Stochastics Neuroscience

Course ID: **WM081B** 6 ec

second semester

prof. dr. F.H.J. Redig

Prerequisites

Contents

In this research seminar jointly between mathematics and the Donders centre for cognitive neuroscience, we explore the interface stochastics/neuroscience.

Subjects

People present recent research results and background material in the following subjects

- stochastic control theory and large deviations
- stochastic integrate-and-fire models
- dynamical systems and excitability of neurons

Literature

Books and papers will be made available during the seminar

Examination

Evaluation is on the basis of participation and presentation of a recent research paper or chapter of a recent book on neuroscience

Spin Geometry

Course ID: **WM078B** 6 ec

second semester

prof. dr. N.P. Landsman

Teaching methods

- 30 hrs lecture
- 30 hrs problem session

Prerequisites

Prerequisites: Basic differential geometry, topology, and group theory.

Courses in the Fall of 2010 by F. Clauwens and G. Heckman are highly recommended.

Objectives

- The students will be familiar with the basic aspects of Clifford algebras, Spin group, vector bundles.
- The students will be familiar with the basic aspects of KO-theory, spin manifolds, Clifford bundles.
- The students will be familiar with the basic aspects of spinor bundles, connections, Dirac operators.
- The students will be familiar with the basic aspects of charge conjugation, antiparticles, real/quaternionic structures, KO-dimension.

Contents

Spin geometry is a topic in differential geometry that is relevant to both pure mathematics (notably index theory and noncommutative geometry) and physics (in particular the Dirac equation). The course will reflect this dual importance and is intended for both mathematics students interested in quantum physics and theoretical physics students with a good background in mathematics. Indeed, the physical and mathematical sides of spin geometry reinforce each other. For example, charge conjugation in physics corresponds to a real or quaternionic structure in mathematics.

Subjects

Clifford algebras, Spin group, vector bundles, KO-theory, spin manifolds, Clifford bundles, spinor bundles, connections, Dirac operators, charge conjugation, antiparticles, real/quaternionic structures, KO-dimension

Literature

H. B. Lawson and M.-L. Michelsohn, Spin Geometry (Princeton University Press, 1989)

Examination

Written exam or possibly an essay.

Spin Glasses and Neural Networks

Course ID: **WM075B** 6 ec

second semester

prof. dr. F.H.J. Redig

Teaching methods

30 hours class

30 hours exercise class

Objectives

1. The student knows what are ferromagnetic spin systems such as the Ising model, the Curie Weiss model
2. The student understands the meaning of disordered spin systems such as spin-glass models and can make the link with models in neuroscience
3. The student can apply the Guerra interpolation method to obtain bounds on the Parisi free energy
4. The student can compute and/or analyze free energies and other basic properties of simplified models such as the random energy model and the generalized random energy model.
5. The student can numerically simulate some of the discussed models.

Contents

Spin glasses are models of statistical mechanics describing magnetic systems with disorder. Spin glass models are also used in combinatoric optimization problems, and in neuroscience (Hopfield model).

The course will give an introduction to classical lattice spin systems with ferromagnetic interaction, such as the Ising model, the Curie Weiss model.

In the second part we will introduce spin glasses and discuss recent interpolation techniques that lead to the mathematically rigorous proof of the Parisi solution, and gives rigorous meaning to the replica method.

Subjects

- Lattice Models for the Ferromagnetic transition. Ising model in 1 dimension: transfer matrix solution. Peierls argument in 2 dimensions. Griffiths inequalities.

- Models on the complete graph: Curie-Weiss model. Existence of the thermodynamic limit. Two solutions of the model: i) using large deviations; ii) using Hubbard-Stratonovich transformation.

Equivalence of the solutions. Mean-field equation. Probability distribution of the magnetization. Analysis at the critical point.

-Introduction to disordered systems. Spin glasses and replica trick. Magnetic alloys. Applications to combinatorial optimization problems, neural networks, etc..

- Models for the spin-glass transition. Edwards-Anderson model. Type I inequalities. Nishimori line.

Guerra's Lower Bound and interpolation techniques. Combinatorial properties of the Parisi solution. Ghirlanda-Guerra identities.

Three equivalent approaches: i) fluctuation methods and self-averaging; ii) stochastic stability; iii) replica equivalence.

- Numerical simulations of spin glasses. The parallel tempering algorithm: a Monte Carlo method with replica exchange.

Literature

Will be made available on the homepage of the visiting professor

Examination

oral exam or oral presentation

Symplectic Geometry (Dutch national master programme)

Course ID: **WM076B** 6 ec

first semester

prof. dr. G.J. Heckman

Prerequisites

This is a basic course for students in the first year of the master.
We only assume some familiarity with the concept of manifold.

Objectives

- Symplectic linear algebra
- Symplectic manifolds
- Hamilton formalism
- Integrable systems
- Moment map geometry

Contents

Symplectic geometry is the study of manifolds equipped with a closed nondegenerate two form. It is the modern language for classical mechanics, notably in the Hamilton formalism. The following subjects will be discussed in the lectures:

- Symplectic linear algebra
- Symplectic manifolds
- Hamilton formalism
- Integrable systems
- Moment map geometry

Literature

Lecture notes will handed out, and literature will be given during the lectures.

The Structure of Spacetime

Course ID: **WM058B** 6 ec

first semester

dr. W.D. van Suijlekom

Teaching methods

- 28 hrs lecture
- 28 hrs tutor session

Prerequisites

Tensoren en Toepassingen; Inleiding Algemene Relativiteitstheorie

Objectives

- The student has a conceptual understanding of the mathematical structure of General Relativity.
- Is familiar with the basic definitions and results in differential and Riemannian geometry.
- Is familiar with the classical tests of GR and the Friedmann-Lemaître-Robertson-Walker cosmological models, as well as black hole physics.
- Is able to read the research literature on gravitational physics.

Contents

We introduce the mathematical techniques necessary for applying Einstein's general theory of relativity. These include the concepts of manifolds, curvature, symmetries, differential forms, and conformal/causal structure. Using these, we will cover singularity theorems, integral theorems, and applications to cosmology and the death of stars.

Literature

R.M. Wald, General Relativity, University of Chicago Press, 1984, ISBN 9780226870335

Examination

Oral exam

Universal Algebra

Course ID: **WB058B** 6 ec

prof. dr. M Gehrke

Teaching methods

- 28 hrs lecture
- 28 hrs tutor session

Prerequisites

Ringen en lichamen 1

Objectives

- After this course the student is familiar with the notions of universal algebra.
- The student knows the notion of a general algebra, a homomorphism, the homomorphism theorems and free constructions.
- The student has seen Birkhoff's variety theorem including several applications in classical algebra and in logic.
- Universal algebra is the model theory of algebra and as such it is an important tool for the algebraist but it also serves as a gentle introduction to general model theory.

Contents

Universal algebra identifies the common features of algebras in general and makes clear that a large part of the structure theory of algebras as well as the nature and feel of algebraic thinking are common to all sorts of algebraic systems. Algebras are studied through manipulation of equational properties on the one hand, and through their structure theory on the other hand (including subalgebras, homomorphic images, and product constructions). Birkhoff's variety theorem states that these two seemingly different approaches are closely related through the notion of free algebras. After introducing the basic notions of universal algebra illustrated with examples from various areas of algebra including rings and groups, we will prove Birkhoff's variety theorem and give several applications.

Literature

S. N. Burris and H. P. Sankappannavar, *A Course in Universal Algebra*, millennium edn (freely available at <http://www.math.uwaterloo.ca/~snburris/htdocs/ualg.html>).

Examination

mondeling/huiswerk

Finance & Accounting

Course ID: **FMT005C** 5 ec

spring semester

drs. R.A. Minnaar
H. Vreugdenhil-de Klerk

Teaching methods

- +/- 15 lectures (see for detail Black Board)
- practices

Prerequisites

Master student FNWI

Objectives

The financial accounting part should give you a firm understanding and working knowledge of:

- The basic accounting terminology and the process for recording, summarizing and reporting economic events of a business enterprise;
 - The interpretation and analysis of financial statements as a basis for business decisions.
- The management accounting part is to develop the student's knowledge of the process of evaluating performance and decision making using accounting information as a basis. After taking this course you should be able to interpret, use and evaluate internal accounting information.

Contents

Accounting information is an integral part of the business environment and an understanding of accounting information is an essential tool in the process of making business decisions. The primary objective of this course is to develop the student's knowledge of accounting as a tool in making business decisions. The emphasis in this course will be on both the user and the preparation of accounting information in a business context.

Content:

This course consists of two parts. Financial- and management accounting.

In the financial accounting part, you will be introduced to accounting theory and practice using the models of sole proprietorships and corporations, with an emphasis on merchandising companies. The emphasis and focus of financial accounting is on financial information used by parties' external to the firm. Specific topics will include: the definition and scope of accounting; systems used to account for and control transactions; inventory costing; the measurement of income and equity; and a special emphasis on financial reporting and the analysis of financial statements.

The management accounting part of this course emphasizes the use of accounting information for internal planning and control purposes. As business managers, you will be involved in a variety of management decisions. Some examples of the issues that you might encounter include: "How much should we charge for this product or service?"; "What elements contribute the most to this business?"; "How is my company doing compared to the competitors?"; "Is this person a good manager?"; "Are my costs under control?" "Does this capital investment make sense?" A range of information may influence such decisions and management (internal) accounting information is among the most significant.

In this part, the fundamentals of managerial accounting, profit and cost accumulation are introduced. Specific topics covered include: cash flows, capital budgeting, cost allocation, product costing, differential costing for short and long-term decisions, performance evaluation, and the concepts related to the time value of money.

Literature

Horngren, Harrison and Oliver (2009). Accounting. Eighth edition. Pearson International Edition. ISBN: 0-136-11290-0

Examination

- A final written 3 hour exam with multiple choice questions.
- Online Assignments in MyAccountingLab

Business & Society

Course ID: **FMT001C** 5 ec

first semester

dr. G.A.N. Vissers

dr. J.W. van Rooij

H. Vreugdenhil-de Klerk

Teaching methods

- 28 hrs lecture

Prerequisites

Master student FNWI

Objectives

Business & Society is concerned with the processes of mutual influence that exist between firms, the economy and society. It specifically focuses on three industrial revolutions that fundamentally reshaped firms, technologies, and societies. Business & Society tries to understand how companies work, and it places them firmly in their context. By doing so, Business & Society introduces theories, models and concepts that aim to understand the relations between firms, the economy, and society.

Business & Society has the following specific objectives:

1. After completing this course, students understand the effects of society on business, and the effects of business on society, i.e.
 - a. Students are able to relate the behavior and characteristics of firms to characteristics of societies.
 - b. Students are able to analyze this relation using theories, models, and concepts from management science, business history, and institutional economics.
2. After completing this course, students understand the relevance of history for understanding business and society, i.e.
 - a. Students are able to analyze how events of the past have enabled and constrained future events, and as such have shaped the present.
 - b. Students are able to evaluate the role of history in the theories, models and concepts used to explain the relations between firms, the economy and society.

Contents

The master track Management & Technology focuses on the interface between science, technology and business. Subsequent courses focus on one aspect of this interface, but in Business & Society we focus on the interface itself, and provide a helicopter view of firms in their environment. It is essential to take a broad view of the workings of business. Inside firms, different disciplines do not work in isolation, but work together to provide value on a market. Moreover, firms do not operate in a vacuum, but operate in a context that shapes them; vice versa, firms shape their environment. Business & Society sets the scene for the courses of Management & Technology that follow.

Business & Society focuses on four leading capitalist nations, and particularly on leading firms from those nations, over a the course of three industrial revolutions up to the twenty-first century. The study of history provides the means to understand how firms and their environments shape each other. The study of history also underlines that each firm and each

society is different, and underlines that firms and their environments change. In this way, students are introduced into the workings of business in its economic, technological and societal context.

Subjects that are covered in this course include:

- Industrial revolutions;
- Innovation systems, business systems, and varieties of capitalism;
- Business history, particularly of leading firms in the 19th and 20th centuries;
- Entrepreneurship;
- The role of the state in the economy.

Literature

T. K. McCraw, Ed. (1997). Creating modern capitalism: How entrepreneurs, companies, and countries triumphed in three industrial revolutions. Harvard University Press.

Examination

Written exam, group work and individual assignments make up the final grade for this course. More details will be announced on Blackboard at the start of the course.

Introduction Science Communication

Course ID: **FC001B** 3 ec

first quarter

dr. J.G. van den Born
drs. E. van Rijswoud
S.A.J. Segers

Website

www.ru.nl/sciencecommunication

Teaching methods

- 14 hrs lecture
- 70 hrs individual study period

Prerequisites

This is the first course of the Mastertrack Science Communication. It is part of the obligatory programme of the Mastertrack. In addition the course is open as an optional course for all MSc. students.

Objectives

- Students are acquainted with science communication practices and theories
- students are able to use these theories to analyse classic examples of science communication
- Students are trained by a professional in presentation skills

Contents

Nowadays every scientist gets involved in science communication in his or her professional life. In this course we give an overview of science communication strategies and of seminal views on science communication practices and theories.

Focus is on communication with the public and with target groups within the general public on issues that involve scientific knowledge. Scientific communication (communication among scientists for instance at scientific meetings) is not the main issue, although the training in presentation techniques applies to those communication practices as well.

Students will also study and present classic examples of succesful popularization of scientific insights, in the shape of TV documentaries, films, fiction and non-fiction books, and 'visitables'.

Literature

Literature will be made available on blackboard

Examination

Written exam, participation and presentation

Extra information

This course will be taught in Dutch.

Beroepsoriëntatie

Vakcode: **FNWI001** 3 ec

eerste semester

drs. J.G.J. van den Broek

Werkvormen

Inleidingen, zelfstudieopdrachten, marktverkenningen, vaardigheidstrainingen, presentaties.

Vereiste voorkennis

De cursus is toegankelijk voor studenten uit de masterfase van alle bètaopleidingen.

Leerdoelen

Studenten

- krijgen meer inzicht in hun eigen competenties en ambities
- kunnen hun competenties en ambities relateren aan de eisen van het werkveld
- verzamelen op een interactieve manier informatie over relevante ontwikkelingen binnen hun zoekrichting
- verkennen de mogelijkheden om een passende baan te verwerven
- leren om zich in woord en geschrift te presenteren als "academisch professional"

Beschrijving

De cursus bestaat uit de volgende onderdelen:

- Zelfverkenning en zelfanalyse (wie ben ik, wat kan ik, wat wil ik?)
- Arbeidsmarktoriëntatie en actieve verkenning van de zoekrichting
- Vaardigheidstrainingen (met o.a. afstudeerplan) en sollicitatietrainingen (brief, c.v. en sollicitatiegesprek).

Literatuur

Ondersteunend cursusmateriaal wordt ter plekke uitgereikt.

Bijzonderheden

In verband met de vaardigheidstrainingen is aanwezigheid verplicht. Er is plaats voor 16 deelnemers per cursus. Schriftelijke opdrachten, mondelinge presentaties en eindverslag.

Tijdens de cursus "Beroepsoriëntatie" richten we ons in eerste instantie op de arbeidsmarkt voor afstuderende bèta's in Nederland. Omwille van de diepgang en de nuances in de persoonlijke reflecties, analyses en feedback is taal vereist op het niveau van "native speaker". Bij dit keuzevak gebruiken we daartoe de Nederlandse taal.

De cursus wordt twee keer per jaar aangeboden: in het najaarsemester op dinsdagmiddag (13.45 - 17.30 u.)

in het voorjaarsemester op vrijdagmiddag (13.45 - 17.30 u.).

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