# Opasraportti

# LuTK - Department of Mathematical Sciences (2012 - 2013)

# Tutkintorakenteet

## Master's degree (Major in Mathematics)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

### Compulsory advanced studies (vähintään 30 op)

Master's degree in mathematics contains advanced major studies 80 ECTS, which consists of master's thesis (30 ECTS) and other advanced studies (50 ECTS). The advanced courses can be selected from the list below (See "Optional advanced studies"). The student is encouraged to discuss the topic of the master's thesis with the student advisor or the supervisor. They will also help the student to choose suitable courses.

800698S: Pro gradu thesis, 30 op

### Optional advanced studies (vähintään 50 op)

Choose at least 50 ECTS of advanced studies. Special courses might not be in the course list. In this case, please contact department's administrative officer.

H325003: Mathematics, optional advanced studies, 0 - 120 op

*Electives*

- 802653S: Lebesgue Measure and Integration Theory, 5 op
- 801698S: Cryptography, 5 op
- 802655S: Continued Fractions, 5 op
- 802644S: Introduction to Functional Analysis, 10 op
- 802636S: Information Theory, 10 op
- 802635S: Introduction to partial differential equations, 10 op
- 802652S: Hilbert Spaces, 5 op
- 800651S: Functional analysis, 10 op
- 802629S: Function estimation, 10 op
- 800674S: Fourier transform and distributions, 10 op
- 802647S: Fourier series and the discrete Fourier transform, 10 op
- 802656S: Algebraic numbers, 5 op
- 802637S: Advanced Problem Solving, 2 - 6 op
- 802645S: Number Theory A, 5 op
- 802646S: Number Theory B, 5 op
- 802631S: Modern real analysis, 10 op
- 800688S: Theory of Optimization, 10 op

800660S: Group Theory, 10 op
802633S: Statistical Pattern Recognition, 10 op
801643S: Topology, 10 op
802651S: Abstract Measure Theory, 5 op
802650S: Fractal Geometry, 10 op

H326603: Statistics optional advanced studies, 0 - 120 op

*Electives*

805609S: Statistical methods in epidemiology, 9 op
805646S: Analysis of longitudial data, 5 op
805679S: Time series analysis, 5 op
805683S: The Statistical Foundation of Econometrics, 5 - 6 op
805681S: Generalized Linear Models, 9 op
805699S: Statistical methods in epidemiology, 8 op
806618S: Computationally intensive statistical methods, 9 op
806621S: Spatial Data Analysis, 10 op
806628S: Statistical Finance, 5 op
806629S: Introduction to Sampling Methods, 4 op
806630S: Market Risk Analysis, 5 op
805651S: Stochastic processes, 10 op
806622S: Probability, 10 op
805611S: Mathematical statistics II, 10 op

### Minor studies

This study line is intented, in particular, for students interested in a research career in mathematics. By selecting suitable minor subjects, student is able to work in a wide spectrum of research institutes. Suitable minor subjects are, for instance, computer sciences, statistics, economics and physics.

### Other studies

## Master's degree (Subject Teacher)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

### Compulsory advanced studies (vähintään 30 op)

Master's degree (line: subject teacher) contains advanced major studies 60 ECTS, which consists of master's thesis (20 ECTS), Special course for teachers of mathematics (10 op), and other advanced studies (30 ECTS). The advanced courses can be selected from the list below (See "Optional advanced studies").

The student is encouraged to discuss of the topic of the master's thesis and together with course selections with the student advisor or your supervisor.

**Note.** In this line, students can replace at most 10 ECTS advanced studies with intermediate level studies.

800698S: Pro gradu thesis, 30 op
802632S: Special course for teachers of mathematics, 10 op

### Optional advanced studies (vähintään 50 op)

Choose at least 30 ECTS of advanced studies. Special courses might not be in the course list. In this case, please contact department's administrative officer.

H325003: Mathematics, optional advanced studies, 0 - 120 op
*Electives*
802653S: Lebesgue Measure and Integration Theory, 5 op
801698S: Cryptography, 5 op
802655S: Continued Fractions, 5 op
802644S: Introduction to Functional Analysis, 10 op
802636S: Information Theory, 10 op
802635S: Introduction to partial differential equations, 10 op
802652S: Hilbert Spaces, 5 op
800651S: Functional analysis, 10 op
802629S: Function estimation, 10 op
800674S: Fourier transform and distributions, 10 op
802647S: Fourier series and the discrete Fourier transform, 10 op
802656S: Algebraic numbers, 5 op
802637S: Advanced Problem Solving, 2 - 6 op
802645S: Number Theory A, 5 op
802646S: Number Theory B, 5 op
802631S: Modern real analysis, 10 op
800688S: Theory of Optimization, 10 op
800660S: Group Theory, 10 op
802633S: Statistical Pattern Recognition, 10 op
801643S: Topology, 10 op
802651S: Abstract Measure Theory, 5 op
802650S: Fractal Geometry, 10 op
H326603: Statistics optional advanced studies, 0 - 120 op
*Electives*
805609S: Statistical methods in epidemiology, 9 op
805646S: Analysis of longitudial data, 5 op
805679S: Time series analysis, 5 op
805683S: The Statistical Foundation of Econometrics, 5 - 6 op
805681S: Generalized Linear Models, 9 op
805699S: Statistical methods in epidemiology, 8 op
806618S: Computationally intensive statistical methods, 9 op
806621S: Spatial Data Analysis, 10 op
806628S: Statistical Finance, 5 op
806629S: Introduction to Sampling Methods, 4 op
806630S: Market Risk Analysis, 5 op
805651S: Stochastic processes, 10 op
806622S: Probability, 10 op
805611S: Mathematical statistics II, 10 op

### Minor studies

The degree programme of subject teacher is comprised of compulsory major subject studies in mathematics and studies in the secondary teaching subject (compulsory minor subject 60 ECTS), which can be e.g. physics, chemistry or information technology. The degree must also include pedagogic studies of 60 ECTS credits (KTK - Pedagogical Studies for Teachers). Part of the pedagogical studies and minor subject studies are already included to the Bachelor degree.

**Compulsory minor studies**

- Pedagogical studies 60 ECTS
- Second teacher's subject 60 ECTS (e.g. physics, chemistry, computer sciences)

### Other studies

## Master's degree (Major in Applied Mathematics)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

## Compulsory advanced studies (vähintään 30 op)

Master's degree in mathematics contains advanced major studies 80 ECTS, which consists of master's thesis (30 ECTS) and other advanced studies (50 ECTS). The advanced course can be selected from the following list (See "Optional advanced studies"). The student is encouraged to discuss the topic of the master's thesis and course selections with the student advisor or supervisor.

**Complement studies**

If Bachelor's degree does not include one of the following courses, student must complete the following courses (one of the courses) as a supplement studies.

- Basic Course on Numerical Computation (801344A, 8 ECTS)
- Introduction to Mathematical Software (802364A, 6 ECTS)

800698S: Pro gradu thesis, 30 op

## Optional advanced studies (vähintään 50 op)

Choose at least 50 ECTS of advanced studies. Special courses might not be in the course list. In this case, please contact department's administrative officer. The student is encouraged to discuss the topic of the master's thesis and the course selections with the student advisor or supervisor.

H325003: Mathematics, optional advanced studies, 0 - 120 op
*Electives*
802653S: Lebesgue Measure and Integration Theory, 5 op
801698S: Cryptography, 5 op
802655S: Continued Fractions, 5 op
802644S: Introduction to Functional Analysis, 10 op
802636S: Information Theory, 10 op
802635S: Introduction to partial differential equations, 10 op
802652S: Hilbert Spaces, 5 op
800651S: Functional analysis, 10 op
802629S: Function estimation, 10 op
800674S: Fourier transform and distributions, 10 op
802647S: Fourier series and the discrete Fourier transform, 10 op
802656S: Algebraic numbers, 5 op
802637S: Advanced Problem Solving, 2 - 6 op
802645S: Number Theory A, 5 op
802646S: Number Theory B, 5 op
802631S: Modern real analysis, 10 op
800688S: Theory of Optimization, 10 op
800660S: Group Theory, 10 op
802633S: Statistical Pattern Recognition, 10 op
801643S: Topology, 10 op
802651S: Abstract Measure Theory, 5 op
802650S: Fractal Geometry, 10 op
H326603: Statistics optional advanced studies, 0 - 120 op
*Electives*
805609S: Statistical methods in epidemiology, 9 op
805646S: Analysis of longitudial data, 5 op
805679S: Time series analysis, 5 op
805683S: The Statistical Foundation of Econometrics, 5 - 6 op
805681S: Generalized Linear Models, 9 op
805699S: Statistical methods in epidemiology, 8 op

806618S: Computationally intensive statistical methods, 9 op
806621S: Spatial Data Analysis, 10 op
806628S: Statistical Finance, 5 op
806629S: Introduction to Sampling Methods, 4 op
806630S: Market Risk Analysis, 5 op
805651S: Stochastic processes, 10 op
806622S: Probability, 10 op
805611S: Mathematical statistics II, 10 op

### Minor studies

This line of expertise trains the student in the use mathematical modeling to solve problems that arise in the natural sciences, various fields of technology and economics. The graduates have found employment as industrial mathematicians, teachers and researchers. Suitable minor subjects include physics, computer science, statistics, information technology and economics.

### Other studies

## Master's degree (Major in Mathematics and Computer Sciences)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

### Compulsory advanced studies (vähintään 30 op)

Master's degree in mathematics contains advanced major studies 80 ECTS, which consists of master's thesis (30 ECTS) and other advanced studies (50 ECTS). The advanced courses can be selected from the list below (See "Optional advanced studies"). The student is encouraged to discuss of the topic of the master's thesis and course selections with the student advisor or supervisor.

**Complement studies (if needed):**

If needed, Bachelor’s degree is completed such that the following conditions hold:

1) Studies in statistics at least 10 ECTS (courses 806112P Basic methods of data analysis or 805310A Statistical interference I).

2) 60 ECTS minor subject in computer sciences.

800698S: Pro gradu thesis, 30 op

### Optional advanced studies (vähintään 50 op)

Choose at least 50 ECTS of advanced studies. The student is encouraged to discuss of the topic of the master's thesis and course selections with the student advisor or supervisor. Special courses might not be in the course list. In this case, please contact department's administrative officer.

H325003: Mathematics, optional advanced studies, 0 - 120 op
*Electives*
802653S: Lebesgue Measure and Integration Theory, 5 op

801698S: Cryptography, 5 op
802655S: Continued Fractions, 5 op
802644S: Introduction to Functional Analysis, 10 op
802636S: Information Theory, 10 op
802635S: Introduction to partial differential equations, 10 op
802652S: Hilbert Spaces, 5 op
800651S: Functional analysis, 10 op
802629S: Function estimation, 10 op
800674S: Fourier transform and distributions, 10 op
802647S: Fourier series and the discrete Fourier transform, 10 op
802656S: Algebraic numbers, 5 op
802637S: Advanced Problem Solving, 2 - 6 op
802645S: Number Theory A, 5 op
802646S: Number Theory B, 5 op
802631S: Modern real analysis, 10 op
800688S: Theory of Optimization, 10 op
800660S: Group Theory, 10 op
802633S: Statistical Pattern Recognition, 10 op
801643S: Topology, 10 op
802651S: Abstract Measure Theory, 5 op
802650S: Fractal Geometry, 10 op

H326603: Statistics optional advanced studies, 0 - 120 op

*Electives*

805609S: Statistical methods in epidemiology, 9 op
805646S: Analysis of longitudial data, 5 op
805679S: Time series analysis, 5 op
805683S: The Statistical Foundation of Econometrics, 5 - 6 op
805681S: Generalized Linear Models, 9 op
805699S: Statistical methods in epidemiology, 8 op
806618S: Computationally intensive statistical methods, 9 op
806621S: Spatial Data Analysis, 10 op
806628S: Statistical Finance, 5 op
806629S: Introduction to Sampling Methods, 4 op
806630S: Market Risk Analysis, 5 op
805651S: Stochastic processes, 10 op
806622S: Probability, 10 op
805611S: Mathematical statistics II, 10 op

### Minor studies

This line of expertise trains specialists in mathematical methods of information technology for both industry and research. The emphasis is on a deep and broad grasp of mathematical methods, supported by applied courses towards the end of the studies as well as a sufficiently strong background in computer science. The graduates have found employment for example in telecommunications companies, software houses, polytechnic universities and research institutes. Suitable minor subjects include computer science (mandatory), statistics, communications engineering, economics and physics.

### Other studies

## Bachelor of Science (mathematics)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

## Compulsory general studies (vähintään 8 op)

902002Y: English 1 (Reading for Academic Purposes), 2 op
902004Y: English 2 (Scientific Communication), 2 op
800008Y: Orientation for New Students, 2 op
901004Y: Swedish, 2 - 3 op

## Compulsory major studies (69 op)

The following studies are compulsory for everyone.

802155P: Continuity and limit, 4 op
802156P: Derivative, 4 op
802154P: Elementary functions, 3 op
802352A: Euclidean Topology, 4 op
806113P: Introduction to Statistics, 5 op
802151P: Introduction to mathematical deduction, 5 op
802118P: Linear Algebra I, 4 op
802119P: Linear Algebra II, 5 op
800300A: Maturity test, 0 op
800322A: Multidimensional analysis, 8 op
802354A: Number Theory and Groups, 5 op
801195P: Probability Theory, 5 op
802355A: Rings, Fields and Polynomials, 5 op
801323A: Seminar, 6 op
802353A: Series and Integrals, 6 op

## Optional major studies (vähintään 4 op)

In addition to compulsory major studies, students must choose optional studies in major subject as follows:

- students planning teachers studies at least **4 cr**
- others at least **11 cr**

When choosing the optional major studies, student is adviced to take possible demands in the coming master program into account. Notice also that, in the teachers master degree, it is possible to replace (at most) 10 cr advanced courses  with intermediate courses in mathematics.

**Remark.** If optional courses contains courses in statistics, these courses cannot be used in a possible minor subject in statistics.

H325035: Optional intermediate studies in mathematics, 0 - 180 op
*Electives*
800329A: Topology, 8 op
800343A: Permutations, Fields and Galois' Theory, 8 op
800345A: Differential Equations I, 4 op
800346A: Differential Equations II, 4 op
801344A: Basic Course on Numerical Computation, 8 op
801387A: Basic Course on Numerical Analysis, 6 op
802362A: Introduction to computational inverse problems, 5 op
801386A: Complex Analysis II, 4 op
801390A: History of Mathematics, 6 op
801389A: Basic Geometry, 6 op
802328A: Basics in Number Theory, 5 op
802331A: Principles to Mathematical Modelling, 8 op
802360A: Introduction to inverse problems, 4 op
801385A: Complex Analysis I, 4 op
801396A: Introduction to Probability Theory II, 5 op
802363A: Metric Spaces, 6 op
801346A: Introduction to Cryptography, 4 op

H326635: Optional intermediate studies in statistics, 0 - 180 op
*Electives*
805324A: Time series analysis, 5 op
806351A: Introduction to Independent Component Analysis, 4 op
805334A: Analysis of categorical data, 9 op
805328A: Multivariate analysis, 9 op
805333A: Robust methods, 6 op
805398A: An introduction to stochastic modelling, 8 op
805380A: Clinical biostatistics, 6 op
806330A: Analysis of Market Risk, 5 op
805309A: Statistical methods in epidemiology, 9 op
805339A: The Statistical Foundation of Econometrics, 5 - 6 op
805332A: Design of experiments, 9 op
805308A: Analysis of longitudinal data, 5 op
806357A: Statistical finance, 5 op

### Minor subjects (vähintään 50 op)

Bachelor studies contains also studies in major and minor subjects. The minimum requirement is that student does either two smaller minor subjects (at least 25 cr each) *OR* one larger minor subject (at least 60 cr).

**Minor studies for students in teacher education**

The choice of minor subjects defines how students qualify as teachers. Pedagogical studies for teachers forms a natural 30 cr minor subject for those students who are doing teachers studies. The other minor subject should be either physics, chemistry or computer sciences. Any other compinations should be applied separately from the Faculty of Sciences. Notice that when minimum requirements are fullfilled, one is free to choose other minor subjects (taking the study permissions into account).

**Remark.** Master studies in different programs might contain different requirements for major and minor studies. These requirements should be taken into account when choosing minor studies in Bachelor's degree. More information can be found in the Study Guide.

**Physics as a minor subject**

**Chemistry as a minor subject**

**Computer sciences as a minor subject**

**Pedagogical studies**

**Other minor studies**

### Other studies

This part contains all courses which are not minor studies, such as, single courses in different subjects, extra language courses, etc. (Also the course "Introduction to LaTeX" belongs here.)

## Bachelor of Science (statistics)

Tutkintorakenteen tila: archived

Lukuvuosi: 2012-13

Lukuvuoden alkamispäivämäärä: 01.08.2012

### Compulsory general studies (vähintään 8 op)

902002Y: English 1 (Reading for Academic Purposes), 2 op
902004Y: English 2 (Scientific Communication), 2 op
800008Y: Orientation for New Students, 2 op
901004Y: Swedish, 2 - 3 op

## Compulsory major studies (69 op)

The following studies are compulsory for everyone.

802155P: Continuity and limit, 4 op
802156P: Derivative, 4 op
802154P: Elementary functions, 3 op
802352A: Euclidean Topology, 4 op
806113P: Introduction to Statistics, 5 op
802151P: Introduction to mathematical deduction, 5 op
802118P: Linear Algebra I, 4 op
802119P: Linear Algebra II, 5 op
800300A: Maturity test, 0 op
800322A: Multidimensional analysis, 8 op
802354A: Number Theory and Groups, 5 op
801195P: Probability Theory, 5 op
802355A: Rings, Fields and Polynomials, 5 op
801323A: Seminar, 6 op
802353A: Series and Integrals, 6 op

## Compulsory major studies

The following studies are also compulsory for students major in statistics:

806112P: Basic Methods of Data Analysis, 10 op
801396A: Introduction to Probability Theory II, 5 op
806359A: Regression modelling, 10 op
805310A: Statistical Inference I, 10 op
805340A: Statistical Software, 4 op

## Optional intermediate studies in statistics (vähintään 15 op)

Other intermediate level courses in statistics (at least 15 ECTS) from the list below

H326635: Optional intermediate studies in statistics, 0 - 180 op
- *Electives*
  - 805324A: Time series analysis, 5 op
  - 806351A: Introduction to Independent Component Analysis, 4 op
  - 805334A: Analysis of categorical data, 9 op
  - 805328A: Multivariate analysis, 9 op
  - 805333A: Robust methods, 6 op
  - 805398A: An introduction to stochastic modelling, 8 op
  - 805380A: Clinical biostatistics, 6 op
  - 806330A: Analysis of Market Risk, 5 op
  - 805309A: Statistical methods in epidemiology, 9 op
  - 805339A: The Statistical Foundation of Econometrics, 5 - 6 op
  - 805332A: Design of experiments, 9 op
  - 805308A: Analysis of longitudinal data, 5 op
  - 806357A: Statistical finance, 5 op

## Minor subjects (vähintään 50 op)

Bachelor studies contains also studies in major and minor subjects. The minimum requirement is that student does either two smaller minor subjects (at least 25 cr each) *OR* one larger minor subject (at least 60 cr).

**Remark.** Master studies in different programs might contain different requirements for major and minor studies. These requirements should be taken into account when choosing minor studies in Bachelor's degree. More information can be found in the Study Guide.

### Other studies

This part contains all courses which are not minor studies, such as, single courses in different subjects, extra language courses, etc.

# Tutkintorakenteisiin kuulumattomat opintokokonaisuudet ja -jaksot

806623S: An introduction to stochastic modelling, 8 op
806627S: Linear mixed models in the analysis of panel data, 6 op
806625S: Multivariate analysis, 6 op
806617S: Nonparametric and robust methods, 8 op
806604S: Principles of bayesian inference, 10 op
806603S: Robust methods, 6 op

# Opintojaksojen kuvaukset

## Tutkintorakenteisiin kuuluvien opintokohteiden kuvaukset

### 800698S: Pro gradu thesis, 30 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Diploma thesis

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
30 cr
**Language of instruction:**
Finnish (also English)
**Learning outcomes:**
After writing the Master's degree, student has written an analytical and logical study of a problem or theory in a field of mathematics, applied mathematics or statistics. Completing the thesis succesfully, student is able to write scientific articles and texts in mathematics.
**Contents:**
The scope of the Master's thesis is 20 cr for Teacher students and 30 cr in other disciplines. In Master's thesis, the student engages in researching a specific mathematical area or problem in the field of mathematics, appliead mathematics or statistics.
**Mode of delivery:**
Thesis
**Learning activities and teaching methods:**

Own work, meetings with the supervisor
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or equivalent), 20-50 cr advanced studies
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Thesis
**Grading:**
1-5
**Person responsible:**
Professors and other teaching personnel
**Working life cooperation:**
-

## H325003: Mathematics, optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 802653S: Lebesgue Measure and Integration Theory, 5 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mikael Lindström
**Opintokohteen kielet:** Finnish

### 801698S: Cryptography, 5 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen oppimateriaali:**
**Trappe, Wade; Washington, Lawrence C.**, , 2005
**Menezes, Alfred J.; van Oorschot, Paul C.; Vanstone, Scott A.** , , 1997
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

As usual in my mathematical studies I shall be able to solve problems arising from the subject and to prove essential theorems starting from the given definitions using the tools applied in the course. More detailed;

For example, when I pass the course with the grade 1/5, I shall recognize most definitions and I am able to solve closely related problems. Also I am able to rewrite short proofs with some understanding. When I pass the course with the grade 5/5, then I shall understand well the given definitions with the proofs of the theorems deduced from them. Further, I am able to solve challenging problems which demand independent deductions with several stages and applications of appropriate tools.

**Contents:**

In our lectures we study mathematical basics of encrypting, key exchange and signature systems. As examples, we mention elementary group and number theory used in primality tests and factoring, complexity estimates of computations-in particular in finite fields, repeated squaring and discrete logarithm in finite cyclic groups- applied in multiplicative groups of finite fields and addition groups of elliptic curves. Deduction of addition formulae in projective and affine Weierstrass elliptic curves. Diffie-Hellman key exchange, ElGamal encrypting and signature systems in finite cyclic groups applied in finite fields or in elliptic curves defined over finite fields. DSA, ECDSA, Massey-Omura. Some algorithms and tests: AKS, Fermat, Lenstra , Lucas, Miller-Rabin, Pohlig-Hellman, Pollard's p-1 and rho, pseudoprimes, quadratic sieve, Solovay-Srassen.

### 802655S: Continued Fractions, 5 op

**Voimassaolo:** 01.01.2011 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802644S: Introduction to Functional Analysis, 10 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

If we think of functional analysis as infinite dimensional linear algebra, then the course offers the tools and the ways to handle this infinite dimension. After completing the course successfully, the student will be able to follow almost any material on functional analysis.

**Contents:**

After recalling some basic definitions on linear algebra and giving the basic definitions concerning normed spaces, we present the uniform boundedness principle and the open mapping theorem. In this first part of the course, the relative compactness of the unit ball in a normed space is studied under the norm topology. Hahn-Banach Theorem is presented in its various forms: algebraic, analytic and geometric, and followed by Krein-Milman Theorem. We end up with the weak topology on normed spaces and the weak* topology on Banach duals. The relative compactness of the unit ball is studied with respect to these two topologies.

**Person responsible:**

Mahmoud Filali

### 802636S: Information Theory, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**

**Ash, Robert**, , 1990
**Cover, Thomas M.; Joy, Thomas A.**, , 2006
**Gallager, Robert G.**, , 1968
**MacKay, David J. C.**, , 2003

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- explain the basic concepts and results of information theory
- solve mathematical information theoretic problems
- derive the central results of the theory

**Contents:**

The course is an introduction Claude Shannon's mathematical theory of communication. The focus is on the information content of an information source, compression of information, coding, transmission of coded information through an information channel as well as decoding of the received message.

**Person responsible:**

Lasse Holmström

### 802635S: Introduction to partial differential equations, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**

**Colton, David**, , 1988
**Kress, Rainer**, , 1999
**Folland, Gerald B.** , , 1995

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- solve linear and quasi-linear partial differential equations of first order using the method of characteristics
- apply the method of separation of variables to solve initial-boundary value problems for heat, wave and Laplace equations
- verify that a given function is a fundamental solution of a partial differential operator
- use single and double layer potentials to solve boundary value problems for Laplacian

**Contents:**

Linear and nonlinear equations of the first order, trigonometric Fourier series, Laplace equation in $R^n$ and in bounded domains, potential theory, Green's function, Heat equation in $R^n$ and in bounded domains, Wave equation in $R^n$ and in bounded domans, d'Alembert formula for any dimensions, Fourier method.

**Person responsible:**

Valeriy Serov

### 802652S: Hilbert Spaces, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800624S Analysis III 10.0 op

**ECTS Credits:**

5 ECTS credits

**Assessment methods and criteria:**

Read more about assessment criteria at the University of Oulu webpage.

### 800651S: Functional analysis, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish (English if neede)

**Timing:**

4-5 year of studies. Timig varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results in functional analysis.
- apply the results and methods of the course in various problems both in pure and applied mathematics.

**Contents:**

The course presents the theory of Banach and Hilbert spaces, Banach fixed point theorem, basic theory of operators, Baire category theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Hahn-Banach theorem, compact operators and their spectrum.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 24h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes
E. Kreyszig: Introductory Functional Analysis with Applications, Wiley Classics Library, 1989
K. Astala, P. Piiroinen, H.-O. Tylli, Funktionaalianalyysin peruskurssi, Helsingin yliopisto, luentomoniste 2008.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Mikael Lindström

**Working life cooperation:**

-

### 802629S: Function estimation, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Lasse Holmström
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the basic characteristics of nonparametric function estimation methods
- apply these estimation methods to practical problems
- derive some of the basic theoretical results for kernel estimators

**Contents:**

The course is an introduction to nonparametric estimation of functions with a particlular emphasis on kernel methods. The objects of estimation are the probability density function and the regression function.

**Person responsible:**

Lasse Holmström

### 800674S: Fourier transform and distributions, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Valeriy Serov
**Opintokohteen oppimateriaali:**
**Stein, Elias M.; Shakarchi R.**, , 2003
**Taylor, Michael E.**, , 1996
**Grafakos Loukas**, , 2004
**Stakgold, Ivar** , , 1998
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- calculate the Fourier transform of a given integrable function on the line
- perform basic operations, such as differentiation, convolution and Fourier transformation, on distributions
- use Fourier transform to find, and provide estimates for, fundamental solutions of partial differential operators
- formulate direct and inverse scattering problems for the Schrödinger operator

**Contents:**

Fourier transform in Schwartz spaces, Riemann - Lebesgue lemma, Hausdorff - Young inequality, tempered distributions and their Fourier transform, Sobolev spaces, homogeneous distributions, fundamental solution of PDO, Schrödinger operator with singular potential, inverse scattering problem, Born approximation.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidiean topology, Series and integrals, Multidimensional analysis, Complex analysis I and II, and Linear algebra I and II.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luentomoniste
E.M. Stein & R. Shakarchi: Fourier Analysis (an Introduction), Princeton University Press, 2003;
L. Grafakos: Classical and Modern Fourier Analysis, Pearson Education, 2004;
I. Stakgold: Green's Functions and Boundary Value Problems, 2nd edition, Wiley, 1998;
M. Taylor: Partial Differential Equations (Basic Theory), Springer, 1996.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Valeriy Serov

**Working life cooperation:**

-

### 802647S: Fourier series and the discrete Fourier transform, 10 op

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Valeriy Serov
**Opintokohteen kielet:** English

Ei opintojaksokuvauksia.

### 802656S: Algebraic numbers, 5 op

**Voimassaolo:** 01.01.2012 -

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802637S: Advanced Problem Solving, 2 - 6 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Peter Hästö
**Opintokohteen kielet:** English

**802645S: Number Theory A, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802646S: Number Theory B, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802631S: Modern real analysis, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results of modern real analysis.

- apply the results and methods of modern real analysis in different topics of mathematics, like in the theory of partial differential equations.

**Contents:**

The course presents Lebesgue spaces (Hölder's and Minkowski's inequalities, completeness, dual spaces), the Vitali covering theorem, the Hardy-Littlewood maximal function, approximation with smooth functions using convolution, Lebesgue's density theorem, Sobolev's inequalities.

### 800688S: Theory of Optimization, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Erkki Laitinen

**Opintokohteen oppimateriaali:**
**Luenberger, David G.** , , 1984
**Peressini, Anthony L.** , , 1988

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802666S Linear Optimization 5.0 op

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- identify the correct methods for solving the conventional optimization problems
- implement the most typical numerical algorithms for solving linear and nonlinear optimization problems

**Contents:**

The lecture course is focused to methods, which can apply for solving essential optimization problems of technical and economical sciences. The lectures consist of following topics: Linear programming, convex sets and functions and nonlinear convex optimization. The topics are considered theoretically and also numerical algorithms for problem solution are presented.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidean topology, Series and integrals, and Linear algebra I and II

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luenberger D.G.: Linear and Nonlinear Programming, Addison-Wesley, 1984. Peressini A.L., Sullivan F.E. and Uhl, J.J.Jr.: The Mathematics of Nonlinear Pro-gramming, Springer, 1988.

**Assessment methods and criteria:**

Mid-term exam or final exam

**Grading:**

1-5

**Person responsible:**

Erkki Laitinen

**Working life cooperation:**

-

### 800660S: Group Theory, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Niemenmaa Markku
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4-5 year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- use different proving techniques related to the theory
- prove the Sylow theorems and deal with their applications
- prove important results in the theory of finite solvable groups

**Contents:**

Aim: To provide the student with the basics of group theory and its development during the past hundred years. Basics of group theory, permutations, studies on the arithmetical

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures 56 h, exercises 28 h.

**Target group:**

Major students

**Prerequisites and co-requisites:**

802355A Number theory and groups
802355A Rings, Fields and  polynomials
800343A Permutations, fields and Galois' theory

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exam or final exam.

**Grading:**

1-5

**Person responsible:**

Markku Niemenmaa

**Working life cooperation:**

-

### 802633S: Statistical Pattern Recognition, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**
**Duda, Richard O.** , , 2001
**Theodoridis, Sergios** , , 2002
**Webb, A. R** , , 2002
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the most important classical classification and feature extraction methods that are based on continous distributions.
- apply these methods to practical problems.
- derive the mathematical results that motivate some of the classification and feature extraction methods.

**Contents:**

Pattern recognition consists of measuring and observing natural objects, analysis of these measurements and recognition of objects on the basis this analysis. The course is an introduction to the concepts and theory of statistical pattern recognition which focuses on the automatic, probability theory based classification of objects based on features derived from the measurements.

**Person responsible:**

Lasse Holmström

### 801643S: Topology, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mahmoud Filali

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English (also Finnish)

**Timing:**

3.-5. year of studies. Timing varies.

**Learning outcomes:**

After completion of the course, the student should be able to follow more advanced courses or seminars on abstract harmonic analysis.

**Contents:**

This is an advanced course, aimed to final year students and to postgraduate students. The course covers topological groups and their uniform structures; subgroups, Quotient groups and product groups; and

invariant pseudo-metrics on groups. The last part of the course presents some basics on compact semigroups with some examples such as Ellis group and semigroup compactifications

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics, 800329A Topologia I

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exams or final exam

**Grading:**

1-5

**Person responsible:**

Mahmoud Filai

### 802651S: Abstract Measure Theory, 5 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Esa Järvenpää
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802650S: Fractal Geometry, 10 op

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

## H326603: Statistics optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

**805609S: Statistical methods in epidemiology, 9 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Santos Silva, Isabel dos** , , 1999
**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998
**Opintokohteen kielet:** Finnish

**805646S: Analysis of longitudial data, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Peter J. Diggle et al.**, , 2002
**Hsiao, Cheng** , , 2003
**McCulloch, Charles E.** , , 2001
**Fitzmaurice, Garrett M.** , , 2004
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with so-called mixed models for both discrete and continuous dependent variables
- be able to make use of these mixed models while studying longitudinal data

**Contents:**

The purpose of the course is to teach the students, how one can simultaneously study depedencies between observed variables and variations between individuals in the panel. Linear and non-linear mixed models, variograms and so-called growth curve models are introduced as central inferential tools for these studies. Model diagnostics, dynamic ARX-type models and the GMM estimation principle also get a lot of attention. A major part of the course deals with modelling continuous dependent variables, but cases of qualitative, ordinal and count depedendent variables are covered as well. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab

**Person responsible:**

Jussi Klemelä

**805679S: Time series analysis, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis:
stationarity, autocorrelation, spectral distribution and periodogram.
Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities.
Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.
A. Harvey: Time Series Models, Philip Allan (2. painos) H. Lutkepohl: Introduction to Multiple Time Series Analysis, Springer (2. painos) J. Hamilton: Time Series, Princeton University Press The MIT Press.

**Person responsible:**

Jussi Klemelä

### 805683S: The Statistical Foundation of Econometrics, 5 - 6 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1990
**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805339A | The statistical foundations ofeconometrics | 5.0 op |

**ECTS Credits:**

5/6 cr

**Language of instruction:**

Finnish

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both

linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä.

### 805681S: Generalized Linear Models, 9 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805699S: Statistical methods in epidemiology, 8 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806618S: Computationally intensive statistical methods, 9 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806621S: Spatial Data Analysis, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806628S: Statistical Finance, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806629S: Introduction to Sampling Methods, 4 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806630S: Market Risk Analysis, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

806330A Analysis of Market Risk 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating

- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Jussi Klemelä

**Working life cooperation:**

-

**Other information:**

Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

### 805651S: Stochastic processes, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806622S: Probability, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805611S: Mathematical statistics II, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Lehmann, E. L.** , , 2001
**Migon, H. S.** , , 1999
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

| | | |
|---|---|---|
| 805627S | Theory of Statistical Inference | 5.0 op |

Ei opintojaksokuvauksia.

## 800698S: Pro gradu thesis, 30 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Diploma thesis
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

**ECTS Credits:**
30 cr
**Language of instruction:**
Finnish (also English)
**Learning outcomes:**
After writing the Master's degree, student has written an analytical and logical study of a problem or theory in a field of mathematics, applied mathematics or statistics. Completing the thesis succesfully, student is able to write scientific articles and texts in mathematics.
**Contents:**
The scope of the Master's thesis is 20 cr for Teacher students and 30 cr in other disciplines. In Master's thesis, the student engages in researching a specific mathematical area or problem in the field of mathematics, appliead mathematics or statistics.
**Mode of delivery:**
Thesis
**Learning activities and teaching methods:**
Own work, meetings with the supervisor
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or equivalent), 20-50 cr advanced studies
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Thesis
**Grading:**
1-5
**Person responsible:**
Professors and other teaching personnel
**Working life cooperation:**
-

## 802632S: Special course for teachers of mathematics, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Pekka Salmi

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802641S | Special Course for Teachers of Mathematics: Training | 2.0 op |
| 802640S | Special Course for Teachers of Mathematics: High School Mathematics | 3.0 op |
| 802639S | Special Course for Teachers of Mathematics: Content Planning | 5.0 op |

**ECTS Credits:**
10 cr
**Language of instruction:**
Finnish
**Timing:**
4.-5. year of studies. Timing varies.
**Learning outcomes:**
On successful completion of this course, the student will be able to
- combine mathematical thinking and teaching
- plan mathematical tasks which support profound mathematical understanding rather than computational proceedures
**Contents:**
This module aims at bridging the gap between the mathematical content in the BSc with the skills needed for teaching at schools. It consists of the following parts:

Content planning (4 cr)

This part involves planning and implementing tutorials for conceptual understanding for freshmen. The planning is done as group work and it is supported by a seminar.

Matriculation exam questions (3 cr)

This part is delivered by the normal school teachers. It covers scoring of the national exam's questions.

Other (3 cr)

This part contains practical experience of working as a teacher of mathematics, e.g. as a tutor.

**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Lectures, seminars (depending the selected modules)
**Target group:**
Teacher students
**Prerequisites and co-requisites:**
Studies required in Bachelor's degree
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Modules included have different types of criterias.
**Grading:**
Pass/Fail
**Person responsible:**
Pekka Salmi
**Working life cooperation:**
-

## H325003: Mathematics, optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 802653S: Lebesgue Measure and Integration Theory, 5 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mikael Lindström
**Opintokohteen kielet:** Finnish

### 801698S: Cryptography, 5 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen oppimateriaali:**
**Trappe, Wade; Washington, Lawrence C.**, , 2005
**Menezes, Alfred J.; van Oorschot, Paul C.; Vanstone, Scott A.** , , 1997
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

As usual in my mathematical studies I shall be able to solve problems arising from the subject and to prove essential theorems starting from the given definitions using the tools applied in the course. More detailed; For example, when I pass the course with the grade 1/5, I shall recognize most definitions and I am able to solve closely related problems. Also I am able to rewrite short proofs with some understanding. When I pass the course with the grade 5/5, then I shall understand well the given definitions with the proofs of the theorems deduced from them. Further, I am able to solve challenging problems which demand independent deductions with several stages and applications of appropriate tools.

**Contents:**

In our lectures we study mathematical basics of encrypting, key exchange and signature systems. As examples, we mention elementary group and number theory used in primality tests and factoring, complexity estimates of computations-in particular in finite fields, repeated squaring and discrete logarithm in finite cyclic groups- applied in multiplicative groups of finite fields and addition groups of elliptic curves. Deduction of addition formulae in projective and affine Weierstrass elliptic curves. Diffie-Hellman key exchange, ElGamal encrypting and signature systems in finite cyclic groups applied in finite fields or in elliptic curves defined over finite fields. DSA, ECDSA, Massey-Omura. Some algorithms and tests: AKS, Fermat, Lenstra , Lucas, Miller-Rabin, Pohlig-Hellman, Pollard's p-1 and rho, pseudoprimes, quadratic sieve, Solovay-Srassen.

### 802655S: Continued Fractions, 5 op

**Voimassaolo:** 01.01.2011 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802644S: Introduction to Functional Analysis, 10 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

If we think of functional analysis as infinite dimensional linear algebra, then the course offers the tools and the ways to handle this infinite dimension. After completing the course successfully, the student will be able to follow almost any material on functional analysis.

**Contents:**

After recalling some basic definitions on linear algebra and giving the basic definitions concerning normed spaces, we present the uniform boundedness principle and the open mapping theorem. In this first part of the course, the relative compactness of the unit ball in a normed space is studied under the norm topology. Hahn-Banach Theorem is presented in its various forms: algebraic, analytic and geometric, and followed by Krein-Milman Theorem. We end up with the weak topology on normed spaces and the weak* topology on Banach duals. The relative compactness of the unit ball is studied with respect to these two topologies.

**Person responsible:**

Mahmoud Filali

### 802636S: Information Theory, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Lasse Holmström
**Opintokohteen oppimateriaali:**
**Ash, Robert**, , 1990
**Cover, Thomas M.; Joy, Thomas A.**, , 2006
**Gallager, Robert G.**, , 1968
**MacKay, David J. C.**, , 2003
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- explain the basic concepts and results of information theory
- solve mathematical information theoretic problems
- derive the central results of the theory

**Contents:**

The course is an introduction Claude Shannon's mathematical theory of communication. The focus is on the information content of an information source, compression of information, coding, transmission of coded information through an information channel as well as decoding of the received message.

**Person responsible:**

Lasse Holmström

### 802635S: Introduction to partial differential equations, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**
**Colton, David**, , 1988
**Kress, Rainer**, , 1999
**Folland, Gerald B.** , , 1995
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- solve linear and quasi-linear partial differential equations of first order using the method of characteristics
- apply the method of separation of variables to solve initial-boundary value problems for heat, wave and Laplace equations
- verify that a given function is a fundamental solution of a partial differential operator
- use single and double layer potentials to solve boundary value problems for Laplacian

**Contents:**

Linear and nonlinear equations of the first order, trigonometric Fourier series, Laplace equation in $R^n$ and in bounded domains, potential theory, Green's function, Heat equation in $R^n$ and in bounded domains, Wave equation in $R^n$ and in bounded domans, d'Alembert formula for any dimensions, Fourier method.

**Person responsible:**

Valeriy Serov

### 802652S: Hilbert Spaces, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800624S | Analysis III | 10.0 op |

**ECTS Credits:**

5 ECTS credits

**Assessment methods and criteria:**

Read more about assessment criteria at the University of Oulu webpage.

### 800651S: Functional analysis, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish (English if neede)

**Timing:**

4-5 year of studies. Timig varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results in functional analysis.
- apply the results and methods of the course in various problems both in pure and applied mathematics.

**Contents:**

The course presents the theory of Banach and Hilbert spaces, Banach fixed point theorem, basic theory of operators, Baire category theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Hahn-Banach theorem, compact operators and their spectrum.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 24h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes
E. Kreyszig: Introductory Functional Analysis with Applications, Wiley Classics Library, 1989
K. Astala, P. Piiroinen, H.-O. Tylli, Funktionaalianalyysin peruskurssi, Helsingin yliopisto, luentomoniste 2008.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Mikael Lindström

**Working life cooperation:**

-

### 802629S: Function estimation, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the basic characteristics of nonparametric function estimation methods
- apply these estimation methods to practical problems
- derive some of the basic theoretical results for kernel estimators

**Contents:**

The course is an introduction to nonparametric estimation of functions with a particlular emphasis on kernel methods. The objects of estimation are the probability density function and the regression function.

**Person responsible:**

Lasse Holmström

### 800674S: Fourier transform and distributions, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**
**Stein, Elias M.; Shakarchi R.**, , 2003
**Taylor, Michael E.**, , 1996
**Grafakos Loukas**, , 2004
**Stakgold, Ivar** , , 1998
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- calculate the Fourier transform of a given integrable function on the line
- perform basic operations, such as differentiation, convolution and Fourier transformation, on distributions
- use Fourier transform to find, and provide estimates for, fundamental solutions of partial differential operators
- formulate direct and inverse scattering problems for the Schrödinger operator

**Contents:**

Fourier transform in Schwartz spaces, Riemann - Lebesgue lemma, Hausdorff - Young inequality, tempered distributions and their Fourier transform, Sobolev spaces, homogeneous distributions, fundamental solution of PDO, Schrödinger operator with singular potential, inverse scattering problem, Born approximation.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidiean topology, Series and integrals, Multidimensional analysis, Complex analysis I and II, and Linear algebra I and II.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luentomoniste
E.M. Stein & R. Shakarchi: Fourier Analysis (an Introduction), Princeton University Press, 2003;
L. Grafakos: Classical and Modern Fourier Analysis, Pearson Education, 2004;
I. Stakgold: Green's Functions and Boundary Value Problems, 2nd edition, Wiley, 1998;
M. Taylor: Partial Differential Equations (Basic Theory), Springer, 1996.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Valeriy Serov

**Working life cooperation:**

-

### 802647S: Fourier series and the discrete Fourier transform, 10 op

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Valeriy Serov
**Opintokohteen kielet:** English

Ei opintojaksokuvauksia.

### 802656S: Algebraic numbers, 5 op

**Voimassaolo:** 01.01.2012 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802637S: Advanced Problem Solving, 2 - 6 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Peter Hästö
**Opintokohteen kielet:** English

### 802645S: Number Theory A, 5 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802646S: Number Theory B, 5 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802631S: Modern real analysis, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results of modern real analysis.
- apply the results and methods of modern real analysis in different topics of mathematics, like in the theory of partial differential equations.

**Contents:**

The course presents Lebesgue spaces (Hölder’s and Minkowski’s inequalities, completeness, dual spaces), the Vitali covering theorem, the Hardy-Littlewood maximal function, approximation with smooth functions using convolution, Lebesgue’s density theorem, Sobolev’s inequalities.

### 800688S: Theory of Optimization, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Erkki Laitinen

**Opintokohteen oppimateriaali:**
**Luenberger, David G.** , , 1984
**Peressini, Anthony L.** , , 1988
**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802666S Linear Optimization 5.0 op

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- identify the correct methods for solving the conventional optimization problems
- implement the most typical numerical algorithms for solving linear and nonlinear optimization problems

**Contents:**

The lecture course is focused to methods, which can apply for solving essential optimization problems of technical and economical sciences. The lectures consist of following topics: Linear programming, convex sets and functions and nonlinear convex optimization. The topics are considered theoretically and also numerical algorithms for problem solution are presented.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidean topology, Series and integrals, and Linear algebra I and II

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luenberger D.G.: Linear and Nonlinear Programming, Addison-Wesley, 1984. Peressini A.L., Sullivan F.E. and Uhl, J.J.Jr.: The Mathematics of Nonlinear Pro-gramming, Springer, 1988.

**Assessment methods and criteria:**

Mid-term exam or final exam

**Grading:**

1-5

**Person responsible:**

Erkki Laitinen

**Working life cooperation:**

-

### 800660S: Group Theory, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Niemenmaa Markku

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4-5 year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- use different proving techniques related to the theory
- prove the Sylow theorems and deal with their applications
- prove important results in the theory of finite solvable groups

**Contents:**

Aim: To provide the student with the basics of group theory and its development during the past hundred years. Basics of group theory, permutations, studies on the arithmetical

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures 56 h, exercises 28 h.

**Target group:**

Major students

**Prerequisites and co-requisites:**

802355A Number theory and groups
802355A Rings, Fields and polynomials
800343A Permutations, fields and Galois' theory

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exam or final exam.

**Grading:**

1-5

**Person responsible:**

Markku Niemenmaa

**Working life cooperation:**

-

### 802633S: Statistical Pattern Recognition, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**
**Duda, Richard O.** , , 2001
**Theodoridis, Sergios** , , 2002

**Webb, A. R** , , 2002
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the most important classical classification and feature extraction methods that are based on continous distributions.
- apply these methods to practical problems.
- derive the mathematical results that motivate some of the classification and feature extraction methods.

**Contents:**

Pattern recognition consists of measuring and observing natural objects, analysis of these measurements and recognition of objects on the basis this analysis. The course is an introduction to the concepts and theory of statistical pattern recognition which focuses on the automatic, probability theory based classification of objects based on features derived from the measurements.

**Person responsible:**

Lasse Holmström

### 801643S: Topology, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English (also Finnish)

**Timing:**

3.-5. year of studies. Timing varies.

**Learning outcomes:**

After completion of the course, the student should be able to follow more advanced courses or seminars on abstract harmonic analysis.

**Contents:**

This is an advanced course, aimed to final year students and to postgraduate students. The course covers topological groups and their uniform structures; subgroups, Quotient groups and product groups; and invariant pseudo-metrics on groups. The last part of the course presents some basics on compact semigroups with some examples such as Ellis group and semigroup compactifications

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics, 800329A Topologia I

**Recommended optional programme components:**

-

**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Mid-term exams or final exam
**Grading:**
1-5
**Person responsible:**
Mahmoud Filai

**802651S: Abstract Measure Theory, 5 op**

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Esa Järvenpää
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802650S: Fractal Geometry, 10 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

## H326603: Statistics optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

**805609S: Statistical methods in epidemiology, 9 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Santos Silva, Isabel dos** , , 1999

**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998
**Opintokohteen kielet:** Finnish

### 805646S: Analysis of longitudial data, 5 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Peter J. Diggle et al.**, , 2002
**Hsiao, Cheng** , , 2003
**McCulloch, Charles E.** , , 2001
**Fitzmaurice, Garrett M.** , , 2004
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with so-called mixed models for both discrete and continuous dependent variables
- be able to make use of these mixed models while studying longitudinal data

**Contents:**

The purpose of the course is to teach the students, how one can simultaneously study depedencies between observed variables and variations between individuals in the panel. Linear and non-linear mixed models, variograms and so-called growth curve models are introduced as central inferential tools for these studies. Model diagnostics, dynamic ARX-type models and the GMM estimation principle also get a lot of attention. A major part of the course deals with modelling continuous dependent variables, but cases of qualitative, ordinal and count depedendent variables are covered as well. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab

**Person responsible:**

Jussi Klemelä

### 805679S: Time series analysis, 5 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis:
stationarity, autocorrelation, spectral distribution and periodogram.
Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities.
Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.
A. Harvey: Time Series Models, Philip Allan (2. painos) H. Lutkepohl: Introduction to Multiple Time Series Analysis, Springer (2. painos) J. Hamilton: Time Series, Princeton University Press The MIT Press.

**Person responsible:**

Jussi Klemelä

### 805683S: The Statistical Foundation of Econometrics, 5 - 6 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1990
**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805339A | The statistical foundations ofeconometrics | 5.0 op |

**ECTS Credits:**

5/6 cr

**Language of instruction:**

Finnish

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä.

### 805681S: Generalized Linear Models, 9 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805699S: Statistical methods in epidemiology, 8 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806618S: Computationally intensive statistical methods, 9 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806621S: Spatial Data Analysis, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806628S: Statistical Finance, 5 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806629S: Introduction to Sampling Methods, 4 op

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806630S: Market Risk Analysis, 5 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

806330A Analysis of Market Risk 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating
- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Jussi Klemelä

**Working life cooperation:**

-

**Other information:**

Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

### 805651S: Stochastic processes, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806622S: Probability, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805611S: Mathematical statistics II, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Lehmann, E. L.** , , 2001
**Migon, H. S.** , , 1999
**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

805627S Theory of Statistical Inference 5.0 op

Ei opintojaksokuvauksia.

## 800698S: Pro gradu thesis, 30 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Diploma thesis

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
30 cr
**Language of instruction:**
Finnish (also English)
**Learning outcomes:**
After writing the Master's degree, student has written an analytical and logical study of a problem or theory in a field of mathematics, applied mathematics or statistics. Completing the thesis succesfully, student is able to write scientific articles and texts in mathematics.
**Contents:**
The scope of the Master's thesis is 20 cr for Teacher students and 30 cr in other disciplines. In Master's thesis, the student engages in researching a specific mathematical area or problem in the field of mathematics, appliead mathematics or statistics.
**Mode of delivery:**
Thesis
**Learning activities and teaching methods:**
Own work, meetings with the supervisor
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or equivalent), 20-50 cr advanced studies
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Thesis
**Grading:**
1-5
**Person responsible:**
Professors and other teaching personnel
**Working life cooperation:**
-

## H325003: Mathematics, optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Study module

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

**802653S: Lebesgue Measure and Integration Theory, 5 op**

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mikael Lindström
**Opintokohteen kielet:** Finnish

**801698S: Cryptography, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen oppimateriaali:**
**Trappe, Wade; Washington, Lawrence C.**, , 2005
**Menezes, Alfred J.; van Oorschot, Paul C.; Vanstone, Scott A.** , , 1997
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

As usual in my mathematical studies I shall be able to solve problems arising from the subject and to prove essential theorems starting from the given definitions using the tools applied in the course. More detailed; For example, when I pass the course with the grade 1/5, I shall recognize most definitions and I am able to solve closely related problems. Also I am able to rewrite short proofs with some understanding. When I pass the course with the grade 5/5, then I shall understand well the given definitions with the proofs of the theorems deduced from them. Further, I am able to solve challenging problems which demand independent deductions with several stages and applications of appropriate tools.

**Contents:**

In our lectures we study mathematical basics of encrypting, key exchange and signature systems. As examples, we mention elementary group and number theory used in primality tests and factoring, complexity estimates of computations-in particular in finite fields, repeated squaring and discrete logarithm in finite cyclic groups- applied in multiplicative groups of finite fields and addition groups of elliptic curves. Deduction of addition formulae in projective and affine Weierstrass elliptic curves. Diffie-Hellman key exchange, ElGamal encrypting and signature systems in finite cyclic groups applied in finite fields or in elliptic curves defined over finite fields. DSA, ECDSA, Massey-Omura. Some algorithms and tests: AKS, Fermat, Lenstra , Lucas, Miller-Rabin, Pohlig-Hellman, Pollard's p-1 and rho, pseudoprimes, quadratic sieve, Solovay-Srassen.

**802655S: Continued Fractions, 5 op**

**Voimassaolo:** 01.01.2011 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802644S: Introduction to Functional Analysis, 10 op**

**Voimassaolo:** 01.08.2009 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mahmoud Filali

**Opintokohteen kielet:** Finnish

**Learning outcomes:**

If we think of functional analysis as infinite dimensional linear algebra, then the course offers the tools and the ways to handle this infinite dimension. After completing the course successfully, the student will be able to follow almost any material on functional analysis.

**Contents:**

After recalling some basic definitions on linear algebra and giving the basic definitions concerning normed spaces, we present the uniform boundedness principle and the open mapping theorem. In this first part of the course, the relative compactness of the unit ball in a normed space is studied under the norm topology. Hahn-Banach Theorem is presented in its various forms: algebraic, analytic and geometric, and followed by Krein-Milman Theorem. We end up with the weak topology on normed spaces and the weak* topology on Banach duals. The relative compactness of the unit ball is studied with respect to these two topologies.

**Person responsible:**

Mahmoud Filali

### 802636S: Information Theory, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**
**Ash, Robert**, , 1990
**Cover, Thomas M.; Joy, Thomas A.**, , 2006
**Gallager, Robert G.**, , 1968
**MacKay, David J. C.**, , 2003

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- explain the basic concepts and results of information theory
- solve mathematical information theoretic problems
- derive the central results of the theory

**Contents:**

The course is an introduction Claude Shannon's mathematical theory of communication. The focus is on the information content of an information source, compression of information, coding, transmission of coded information through an information channel as well as decoding of the received message.

**Person responsible:**

Lasse Holmström

### 802635S: Introduction to partial differential equations, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**
**Colton, David**, , 1988
**Kress, Rainer**, , 1999
**Folland, Gerald B.** , , 1995
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- solve linear and quasi-linear partial differential equations of first order using the method of characteristics
- apply the method of separation of variables to solve initial-boundary value problems for heat, wave and Laplace equations
- verify that a given function is a fundamental solution of a partial differential operator
- use single and double layer potentials to solve boundary value problems for Laplacian

**Contents:**

Linear and nonlinear equations of the first order, trigonometric Fourier series, Laplace equation in $R^n$ and in bounded domains, potential theory, Green's function, Heat equation in $R^n$ and in bounded domains, Wave equation in $R^n$ and in bounded domans, d'Alembert formula for any dimensions, Fourier method.

**Person responsible:**

Valeriy Serov

### 802652S: Hilbert Spaces, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800624S | Analysis III | 10.0 op |

**ECTS Credits:**

5 ECTS credits

**Assessment methods and criteria:**

Read more about assessment criteria at the University of Oulu webpage.

### 800651S: Functional analysis, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish (English if neede)

**Timing:**

4-5 year of studies. Timig varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results in functional analysis.
- apply the results and methods of the course in various problems both in pure and applied mathematics.

**Contents:**

The course presents the theory of Banach and Hilbert spaces, Banach fixed point theorem, basic theory of operators, Baire category theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Hahn-Banach theorem, compact operators and their spectrum.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 24h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes
E. Kreyszig: Introductory Functional Analysis with Applications, Wiley Classics Library, 1989
K. Astala, P. Piiroinen, H.-O. Tylli, Funktionaalianalyysin peruskurssi, Helsingin yliopisto, luentomoniste 2008.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Mikael Lindström

**Working life cooperation:**

-

### 802629S: Function estimation, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the basic characteristics of nonparametric function estimation methods
- apply these estimation methods to practical problems
- derive some of the basic theoretical results for kernel estimators

**Contents:**

The course is an introduction to nonparametric estimation of functions with a particlular emphasis on kernel methods. The objects of estimation are the probability density function and the regression function.

**Person responsible:**

Lasse Holmström

### 800674S: Fourier transform and distributions, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**
**Stein, Elias M.; Shakarchi R.**, , 2003
**Taylor, Michael E.**, , 1996
**Grafakos Loukas**, , 2004
**Stakgold, Ivar** , , 1998

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- calculate the Fourier transform of a given integrable function on the line
- perform basic operations, such as differentiation, convolution and Fourier transformation, on distributions
- use Fourier transform to find, and provide estimates for, fundamental solutions of partial differential operators
- formulate direct and inverse scattering problems for the Schrödinger operator

**Contents:**

Fourier transform in Schwartz spaces, Riemann - Lebesgue lemma, Hausdorff - Young inequality, tempered distributions and their Fourier transform, Sobolev spaces, homogeneous distributions, fundamental solution of PDO, Schrödinger operator with singular potential, inverse scattering problem, Born approximation.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidiean topology, Series and integrals, Multidimensional analysis, Complex analysis I and II, and Linear algebra I and II.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luentomoniste
E.M. Stein & R. Shakarchi: Fourier Analysis (an Introduction), Princeton University Press, 2003;
L. Grafakos: Classical and Modern Fourier Analysis, Pearson Education, 2004;

I. Stakgold: Green's Functions and Boundary Value Problems, 2nd edition, Wiley, 1998;
M. Taylor: Partial Differential Equations (Basic Theory), Springer, 1996.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Valeriy Serov

**Working life cooperation:**

-

### 802647S: Fourier series and the discrete Fourier transform, 10 op

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Valeriy Serov
**Opintokohteen kielet:** English

Ei opintojaksokuvauksia.

### 802656S: Algebraic numbers, 5 op

**Voimassaolo:** 01.01.2012 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802637S: Advanced Problem Solving, 2 - 6 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Peter Hästö
**Opintokohteen kielet:** English

### 802645S: Number Theory A, 5 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802646S: Number Theory B, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802631S: Modern real analysis, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results of modern real analysis.
- apply the results and methods of modern real analysis in different topics of mathematics, like in the theory of partial differential equations.

**Contents:**

The course presents Lebesgue spaces (Hölder's and Minkowski's inequalities, completeness, dual spaces), the Vitali covering theorem, the Hardy-Littlewood maximal function, approximation with smooth functions using convolution, Lebesgue's density theorem, Sobolev's inequalities.

**800688S: Theory of Optimization, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Erkki Laitinen
**Opintokohteen oppimateriaali:**
**Luenberger, David G.** , , 1984
**Peressini, Anthony L.** , , 1988
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

802666S Linear Optimization 5.0 op

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- identify the correct methods for solving the conventional optimization problems
- implement the most typical numerical algorithms for solving linear and nonlinear optimization problems

**Contents:**

The lecture course is focused to methods, which can apply for solving essential optimization problems of technical and economical sciences. The lectures consist of following topics: Linear programming, convex sets and functions and nonlinear convex optimization. The topics are considered theoretically and also numerical algorithms for problem solution are presented.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidean topology, Series and integrals, and Linear algebra I and II

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luenberger D.G.: Linear and Nonlinear Programming, Addison-Wesley, 1984. Peressini A.L., Sullivan F.E. and Uhl, J.J.Jr.: The Mathematics of Nonlinear Pro-gramming, Springer, 1988.

**Assessment methods and criteria:**

Mid-term exam or final exam

**Grading:**

1-5

**Person responsible:**

Erkki Laitinen

**Working life cooperation:**

-

### 800660S: Group Theory, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Niemenmaa Markku
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4-5 year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- use different proving techniques related to the theory
- prove the Sylow theorems and deal with their applications
- prove important results in the theory of finite solvable groups

**Contents:**

Aim: To provide the student with the basics of group theory and its development during the past hundred years. Basics of group theory, permutations, studies on the arithmetical

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures 56 h, exercises 28 h.

**Target group:**

Major students

**Prerequisites and co-requisites:**

802355A Number theory and groups
802355A Rings, Fields and polynomials
800343A Permutations, fields and Galois' theory

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exam or final exam.

**Grading:**

1-5

**Person responsible:**

Markku Niemenmaa

**Working life cooperation:**

-

### 802633S: Statistical Pattern Recognition, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Lasse Holmström
**Opintokohteen oppimateriaali:**
**Duda, Richard O.** , , 2001
**Theodoridis, Sergios** , , 2002
**Webb, A. R** , , 2002
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the most important classical classification and feature extraction methods that are based on continous distributions.
- apply these methods to practical problems.
- derive the mathematical results that motivate some of the classification and feature extraction methods.

**Contents:**

Pattern recognition consists of measuring and observing natural objects, analysis of these measurements and recognition of objects on the basis this analysis. The course is an introduction to the concepts and theory of statistical pattern recognition which focuses on the automatic, probability theory based classification of objects based on features derived from the measurements.

**Person responsible:**

Lasse Holmström

### 801643S: Topology, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mahmoud Filali

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English (also Finnish)

**Timing:**

3.-5. year of studies. Timing varies.

**Learning outcomes:**

After completion of the course, the student should be able to follow more advanced courses or seminars on abstract harmonic analysis.

**Contents:**

This is an advanced course, aimed to final year students and to postgraduate students. The course covers topological groups and their uniform structures; subgroups, Quotient groups and product groups; and invariant pseudo-metrics on groups. The last part of the course presents some basics on compact semigroups with some examples such as Ellis group and semigroup compactifications

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics, 800329A Topologia I

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exams or final exam

**Grading:**

1-5

**Person responsible:**

Mahmoud Filai

**802651S: Abstract Measure Theory, 5 op**

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Esa Järvenpää
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802650S: Fractal Geometry, 10 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

## H326603: Statistics optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

**805609S: Statistical methods in epidemiology, 9 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Santos Silva, Isabel dos** , , 1999
**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998
**Opintokohteen kielet:** Finnish

**805646S: Analysis of longitudial data, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Peter J. Diggle et al.**, , 2002
**Hsiao, Cheng** , , 2003
**McCulloch, Charles E.** , , 2001
**Fitzmaurice, Garrett M.** , , 2004

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with so-called mixed models for both discrete and continuous dependent variables
- be able to make use of these mixed models while studying longitudinal data

**Contents:**

The purpose of the course is to teach the students, how one can simultaneously study depedencies between observed variables and variations between individuals in the panel. Linear and non-linear mixed models, variograms and so-called growth curve models are introduced as central inferential tools for these studies. Model diagnostics, dynamic ARX-type models and the GMM estimation principle also get a lot of attention. A major part of the course deals with modelling continuous dependent variables, but cases of qualitative, ordinal and count depedendent variables are covered as well. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab

**Person responsible:**

Jussi Klemelä

### 805679S: Time series analysis, 5 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis:
stationarity, autocorrelation, spectral distribution and periodogram.
Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities.
Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.
A. Harvey: Time Series Models, Philip Allan (2. painos) H. Lutkepohl: Introduction to Multiple Time Series Analysis, Springer (2. painos) J. Hamilton: Time Series, Princeton University Press The MIT Press.

**Person responsible:**

Jussi Klemelä

### 805683S: The Statistical Foundation of Econometrics, 5 - 6 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Harvey, Andrew C.** , , 1990
**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805339A | The statistical foundations ofeconometrics | 5.0 op |

**ECTS Credits:**

5/6 cr

**Language of instruction:**

Finnish

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä.

### 805681S: Generalized Linear Models, 9 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805699S: Statistical methods in epidemiology, 8 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806618S: Computationally intensive statistical methods, 9 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806621S: Spatial Data Analysis, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806628S: Statistical Finance, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806629S: Introduction to Sampling Methods, 4 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806630S: Market Risk Analysis, 5 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

806330A Analysis of Market Risk 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating
- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Jussi Klemelä
**Working life cooperation:**
-
**Other information:**
Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

**805651S: Stochastic processes, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806622S: Probability, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805611S: Mathematical statistics II, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Lehmann, E. L.** , , 2001
**Migon, H. S.** , , 1999
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**
805627S Theory of Statistical Inference 5.0 op

Ei opintojaksokuvauksia.

## 800698S: Pro gradu thesis, 30 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Diploma thesis
**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
30 cr
**Language of instruction:**
Finnish (also English)
**Learning outcomes:**
After writing the Master's degree, student has written an analytical and logical study of a problem or theory in a field of mathematics, applied mathematics or statistics. Completing the thesis succesfully, student is able to write scientific articles and texts in mathematics.
**Contents:**
The scope of the Master's thesis is 20 cr for Teacher students and 30 cr in other disciplines. In Master's thesis, the student engages in researching a specific mathematical area or problem in the field of mathematics, appliead mathematics or statistics.
**Mode of delivery:**
Thesis
**Learning activities and teaching methods:**
Own work, meetings with the supervisor
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or equivalent), 20-50 cr advanced studies
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Thesis
**Grading:**
1-5
**Person responsible:**
Professors and other teaching personnel
**Working life cooperation:**
-

## H325003: Mathematics, optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Study module

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 802653S: Lebesgue Measure and Integration Theory, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mikael Lindström

**Opintokohteen kielet:** Finnish

**801698S: Cryptography, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen oppimateriaali:**
**Trappe, Wade; Washington, Lawrence C.**, , 2005
**Menezes, Alfred J.; van Oorschot, Paul C.; Vanstone, Scott A.** , , 1997
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

As usual in my mathematical studies I shall be able to solve problems arising from the subject and to prove essential theorems starting from the given definitions using the tools applied in the course. More detailed; For example, when I pass the course with the grade 1/5, I shall recognize most definitions and I am able to solve closely related problems. Also I am able to rewrite short proofs with some understanding. When I pass the course with the grade 5/5, then I shall understand well the given definitions with the proofs of the theorems deduced from them. Further, I am able to solve challenging problems which demand independent deductions with several stages and applications of appropriate tools.

**Contents:**

In our lectures we study mathematical basics of encrypting, key exchange and signature systems. As examples, we mention elementary group and number theory used in primality tests and factoring, complexity estimates of computations-in particular in finite fields, repeated squaring and discrete logarithm in finite cyclic groups- applied in multiplicative groups of finite fields and addition groups of elliptic curves. Deduction of addition formulae in projective and affine Weierstrass elliptic curves. Diffie-Hellman key exchange, ElGamal encrypting and signature systems in finite cyclic groups applied in finite fields or in elliptic curves defined over finite fields. DSA, ECDSA, Massey-Omura. Some algorithms and tests: AKS, Fermat, Lenstra , Lucas, Miller-Rabin, Pohlig-Hellman, Pollard's p-1 and rho, pseudoprimes, quadratic sieve, Solovay-Srassen.

**802655S: Continued Fractions, 5 op**

**Voimassaolo:** 01.01.2011 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802644S: Introduction to Functional Analysis, 10 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen kielet:** Finnish

**Learning outcomes:**

If we think of functional analysis as infinite dimensional linear algebra, then the course offers the tools and the ways to handle this infinite dimension. After completing the course successfully, the student will be able to follow almost any material on functional analysis.

**Contents:**

After recalling some basic definitions on linear algebra and giving the basic definitions concerning normed spaces, we present the uniform boundedness principle and the open mapping theorem. In this first part of the course, the relative compactness of the unit ball in a normed space is studied under the norm topology. Hahn-Banach Theorem is presented in its various forms: algebraic, analytic and geometric, and followed by Krein-Milman Theorem. We end up with the weak topology on normed spaces and the weak* topology on Banach duals. The relative compactness of the unit ball is studied with respect to these two topologies.

**Person responsible:**

Mahmoud Filali

### 802636S: Information Theory, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**

**Ash, Robert**, , 1990
**Cover, Thomas M.; Joy, Thomas A.**, , 2006
**Gallager, Robert G.**, , 1968
**MacKay, David J. C.**, , 2003

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- explain the basic concepts and results of information theory
- solve mathematical information theoretic problems
- derive the central results of the theory

**Contents:**

The course is an introduction Claude Shannon's mathematical theory of communication. The focus is on the information content of an information source, compression of information, coding, transmission of coded information through an information channel as well as decoding of the received message.

**Person responsible:**

Lasse Holmström

### 802635S: Introduction to partial differential equations, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**

**Colton, David**, , 1988
**Kress, Rainer**, , 1999
**Folland, Gerald B.** , , 1995

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- solve linear and quasi-linear partial differential equations of first order using the method of characteristics
- apply the method of separation of variables to solve initial-boundary value problems for heat, wave and Laplace equations
- verify that a given function is a fundamental solution of a partial differential operator
- use single and double layer potentials to solve boundary value problems for Laplacian

**Contents:**

Linear and nonlinear equations of the first order, trigonometric Fourier series, Laplace equation in $R^n$ and in bounded domains, potential theory, Green's function, Heat equation in $R^n$ and in bounded domains, Wave equation in $R^n$ and in bounded domans, d'Alembert formula for any dimensions, Fourier method.

**Person responsible:**

Valeriy Serov

### 802652S: Hilbert Spaces, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800624S Analysis III 10.0 op

**ECTS Credits:**

5 ECTS credits

**Assessment methods and criteria:**

Read more about assessment criteria at the University of Oulu webpage.

### 800651S: Functional analysis, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish (English if neede)

**Timing:**

4-5 year of studies. Timig varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results in functional analysis.
- apply the results and methods of the course in various problems both in pure and applied mathematics.

**Contents:**

The course presents the theory of Banach and Hilbert spaces, Banach fixed point theorem, basic theory of operators, Baire category theorem, principle of uniform boundedness, open mapping theorem, closed graph theorem, Hahn-Banach theorem, compact operators and their spectrum.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 24h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes
E. Kreyszig: Introductory Functional Analysis with Applications, Wiley Classics Library, 1989
K. Astala, P. Piiroinen, H.-O. Tylli, Funktionaalianalyysin peruskurssi, Helsingin yliopisto, luentomoniste 2008.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Mikael Lindström

**Working life cooperation:**

-

### 802629S: Function estimation, 10 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Lasse Holmström
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the basic characteristics of nonparametric function estimation methods
- apply these estimation methods to practical problems
- derive some of the basic theoretical results for kernel estimators

**Contents:**

The course is an introduction to nonparametric estimation of functions with a particlular emphasis on kernel methods. The objects of estimation are the probability density function and the regression function.

**Person responsible:**

Lasse Holmström

### 800674S: Fourier transform and distributions, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Valeriy Serov

**Opintokohteen oppimateriaali:**

**Stein, Elias M.; Shakarchi R.**, , 2003
**Taylor, Michael E.**, , 1996
**Grafakos Loukas**, , 2004
**Stakgold, Ivar** , , 1998

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- calculate the Fourier transform of a given integrable function on the line
- perform basic operations, such as differentiation, convolution and Fourier transformation, on distributions
- use Fourier transform to find, and provide estimates for, fundamental solutions of partial differential operators
- formulate direct and inverse scattering problems for the Schrödinger operator

**Contents:**

Fourier transform in Schwartz spaces, Riemann - Lebesgue lemma, Hausdorff - Young inequality, tempered distributions and their Fourier transform, Sobolev spaces, homogeneous distributions, fundamental solution of PDO, Schrödinger operator with singular potential, inverse scattering problem, Born approximation.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidiean topology, Series and integrals, Multidimensional analysis, Complex analysis I and II, and Linear algebra I and II.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luentomoniste
E.M. Stein & R. Shakarchi: Fourier Analysis (an Introduction), Princeton University Press, 2003;
L. Grafakos: Classical and Modern Fourier Analysis, Pearson Education, 2004;
I. Stakgold: Green's Functions and Boundary Value Problems, 2nd edition, Wiley, 1998;
M. Taylor: Partial Differential Equations (Basic Theory), Springer, 1996.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Valeriy Serov

**Working life cooperation:**

-

**802647S: Fourier series and the discrete Fourier transform, 10 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Valeriy Serov
**Opintokohteen kielet:** English

Ei opintojaksokuvauksia.

**802656S: Algebraic numbers, 5 op**

**Voimassaolo:** 01.01.2012 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802637S: Advanced Problem Solving, 2 - 6 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Peter Hästö
**Opintokohteen kielet:** English

**802645S: Number Theory A, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802646S: Number Theory B, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Tapani Matala-aho

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802631S: Modern real analysis, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove basic results of modern real analysis.
- apply the results and methods of modern real analysis in different topics of mathematics, like in the theory of partial differential equations.

**Contents:**

The course presents Lebesgue spaces (Hölder's and Minkowski's inequalities, completeness, dual spaces), the Vitali covering theorem, the Hardy-Littlewood maximal function, approximation with smooth functions using convolution, Lebesgue's density theorem, Sobolev's inequalities.

### 800688S: Theory of Optimization, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Erkki Laitinen

**Opintokohteen oppimateriaali:**
**Luenberger, David G.** , , 1984
**Peressini, Anthony L.** , , 1988

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802666S Linear Optimization 5.0 op

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4.-5. year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- identify the correct methods for solving the conventional optimization problems
- implement the most typical numerical algorithms for solving linear and nonlinear optimization problems

**Contents:**

The lecture course is focused to methods, which can apply for solving essential optimization problems of technical and economical sciences. The lectures consist of following topics: Linear programming, convex sets and functions and nonlinear convex optimization. The topics are considered theoretically and also numerical algorithms for problem solution are presented.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Euclidean topology, Series and integrals, and Linear algebra I and II

**Recommended optional programme components:**

-

**Recommended or required reading:**

Luenberger D.G.: Linear and Nonlinear Programming, Addison-Wesley, 1984. Peressini A.L., Sullivan F.E. and Uhl, J.J.Jr.: The Mathematics of Nonlinear Pro-gramming, Springer, 1988.

**Assessment methods and criteria:**

Mid-term exam or final exam

**Grading:**

1-5

**Person responsible:**

Erkki Laitinen

**Working life cooperation:**

-

### 800660S: Group Theory, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Niemenmaa Markku

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

Finnish

**Timing:**

4-5 year of studies. Timing varies.

**Learning outcomes:**

On successful completion of this course, the student will be able to
- use different proving techniques related to the theory
- prove the Sylow theorems and deal with their applications
- prove important results in the theory of finite solvable groups

**Contents:**

Aim: To provide the student with the basics of group theory and its development during the past hundred years. Basics of group theory, permutations, studies on the arithmetical

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Lectures 56 h, exercises 28 h.

**Target group:**

Major students

**Prerequisites and co-requisites:**

802355A Number theory and groups
802355A Rings, Fields and polynomials
800343A Permutations, fields and Galois' theory

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exam or final exam.

**Grading:**

1-5

**Person responsible:**

Markku Niemenmaa

**Working life cooperation:**

-

### 802633S: Statistical Pattern Recognition, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Lasse Holmström

**Opintokohteen oppimateriaali:**
**Duda, Richard O.** , , 2001
**Theodoridis, Sergios** , , 2002
**Webb, A. R** , , 2002

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- describe the most important classical classification and feature extraction methods that are based on continous distributions.
- apply these methods to practical problems.
- derive the mathematical results that motivate some of the classification and feature extraction methods.

**Contents:**

Pattern recognition consists of measuring and observing natural objects, analysis of these measurements and recognition of objects on the basis this analysis. The course is an introduction to the concepts and theory of statistical pattern recognition which focuses on the automatic, probability theory based classification of objects based on features derived from the measurements.

**Person responsible:**

Lasse Holmström

### 801643S: Topology, 10 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

10 cr

**Language of instruction:**

English (also Finnish)

**Timing:**

3.-5. year of studies. Timing varies.

**Learning outcomes:**

After completion of the course, the student should be able to follow more advanced courses or seminars on abstract harmonic analysis.

**Contents:**

This is an advanced course, aimed to final year students and to postgraduate students. The course covers topological groups and their uniform structures; subgroups, Quotient groups and product groups; and invariant pseudo-metrics on groups. The last part of the course presents some basics on compact semigroups with some examples such as Ellis group and semigroup compactifications

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56h lectures, 28h exercises

**Target group:**

Major students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics, 800329A Topologia I

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Mid-term exams or final exam

**Grading:**

1-5

**Person responsible:**

Mahmoud Filai

**802651S: Abstract Measure Theory, 5 op**

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Esa Järvenpää
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**802650S: Fractal Geometry, 10 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

## H326603: Statistics optional advanced studies, 0 - 120 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 805609S: Statistical methods in epidemiology, 9 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Santos Silva, Isabel dos** , , 1999
**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998
**Opintokohteen kielet:** Finnish

### 805646S: Analysis of longitudial data, 5 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Peter J. Diggle et al.**, , 2002
**Hsiao, Cheng** , , 2003
**McCulloch, Charles E.** , , 2001
**Fitzmaurice, Garrett M.** , , 2004
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with so-called mixed models for both discrete and continuous dependent variables
- be able to make use of these mixed models while studying longitudinal data

**Contents:**

The purpose of the course is to teach the students, how one can simultaneously study depedencies between observed variables and variations between individuals in the panel. Linear and non-linear mixed models, variograms and so-called growth curve models are introduced as central inferential tools for these studies. Model diagnostics, dynamic ARX-type models and the GMM estimation principle also get a lot of attention. A major part of the course deals with modelling continuous dependent variables, but cases of qualitative, ordinal and count depedendent variables are covered as well. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab

**Person responsible:**

Jussi Klemelä

### 805679S: Time series analysis, 5 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis:
stationarity, autocorrelation, spectral distribution and periodogram.
Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities.
Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.
A. Harvey: Time Series Models, Philip Allan (2. painos) H. Lutkepohl: Introduction to Multiple Time Series Analysis, Springer (2. painos) J. Hamilton: Time Series, Princeton University Press The MIT Press.

**Person responsible:**

Jussi Klemelä

### 805683S: The Statistical Foundation of Econometrics, 5 - 6 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Harvey, Andrew C.** , , 1990
**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

805339A The statistical foundations ofeconometrics 5.0 op

**ECTS Credits:**

5/6 cr

**Language of instruction:**

Finnish

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä.

### 805681S: Generalized Linear Models, 9 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805699S: Statistical methods in epidemiology, 8 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806618S: Computationally intensive statistical methods, 9 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806621S: Spatial Data Analysis, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806628S: Statistical Finance, 5 op**

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806629S: Introduction to Sampling Methods, 4 op**

**Voimassaolo:** 01.01.2010 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806630S: Market Risk Analysis, 5 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

806330A Analysis of Market Risk 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating
- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Jussi Klemelä

**Working life cooperation:**

-

**Other information:**

Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

**805651S: Stochastic processes, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806622S: Probability, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805611S: Mathematical statistics II, 10 op**

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen oppimateriaali:**
**Lehmann, E. L.** , , 2001
**Migon, H. S.** , , 1999
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

805627S Theory of Statistical Inference 5.0 op

Ei opintojaksokuvauksia.

## 902002Y: English 1 (Reading for Academic Purposes), 2 op

**Voimassaolo:** 01.08.1995 -
**Opiskelumuoto:** Language and Communication Studies
**Laji:** Course
**Vastuuyksikkö:** Language Centre
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** English

**Proficiency level:**
B2/C1 on the Common European Framework of Reference scale.
**Status:**
In the Faculty of Science, this course is mandatory for all degree programmes except Geography. Please consult the Faculty Study Guide to establish the language requirements for your own degree programme.
**Required proficiency level:**
English must have been the A1 or A2 language at school or equivalent English skills should have been acquired otherwise.
**ECTS Credits:**
2 ECTS credits (total work load 54 hours including classroom meetings.

**Language of instruction:**
Both English and Finnish are used.
**Timing:**
Biological Sciences: 1st year spring term
Chemistry: 1st year autumn term
Geology: 1st year spring term
Information Processing Science: 1st year spring term
Mathematical Sciences: 1st year spring term
Physical Sciences: 1st year autumn term
**Learning outcomes:**
In this course, students improve their understanding of written academic English used in texts in Natural Sciences as well as expand their general and scientific vocabulary. Students become aware of their own role in learning and will be able to find and take advantage of useful study materials available on the Internet in order to develop their own language learning strategies, which will enhance their academic English. Students show their awareness and their own responsibility by reflecting on their achievements in a study journal.

**Learning outcomes:** By completing the tasks of the course, students will

- have acquired effective vocabulary learning techniques by being able to distinguish parts of words to infer meanings
- expand their academic vocabulary by using Internet resources such as on-line dictionaries
- understand and be able to construct basic grammatical structures used in formal written English
- be able to utilize text structure and cohesion markers when reading academic texts
- be able to apply effective reading techniques and have necessary skills to extract global and detailed information with considerable ease and speed from general texts related to Natural Sciences as well as texts /textbooks of their own field

**Contents:**
See above
**Mode of delivery:**
See below
**Learning activities and teaching methods:**
The course is carried out in multi-mode, with instruction and student tasks both in class and in the Optima learning environment.
**Target group:**
1st year students of Biology, Chemistry, Geology, Information Processing Science, Physics, and Mathematics.
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
See 902004Y Scientific Communication
**Recommended or required reading:**
Set books for substance studies; journal articles in print and on-line. Further information will be given in the first lesson.
**Assessment methods and criteria:**
Active and regular participation in classroom sessions, completing the learning tasks (in class and Optima Learning Environment ) including the study journal. These are prerequisites for participation in the end of term examination. Exemptions from the examination can be given for excellent work during the course.
**Grading:**
Pass/Fail
**Person responsible:**
Jolene Gear
**Working life cooperation:**
none
**Other information:**
N.B. Students with grades laudatur or eximia in their A1 English school-leaving examination can be exempted from this course and will be granted the credits by the Faculty of Science.
**Resit examinations:** Two resit examinations are allowed on the dates set by the Extension School unit of Languages and Communication.

## 902004Y: English 2 (Scientific Communication), 2 op

**Voimassaolo:** 01.08.1995 -

**Opiskelumuoto:** Language and Communication Studies

**Laji:** Course

**Vastuuyksikkö:** Language Centre

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** English

**Leikkaavuudet:**

ay902004Y English 2 (Scientific Communication) (OPEN UNI) 2.0 op

**Proficiency level:**
B2/C1 on the CEFR scales
**Status:**
This course is mandatory for all 2nd year students (except **geographers**) who will have English as their foreign language in their B.Sc. degree. This includes the students who were exempted from 'Reading for Academic Purposes'(902002Y). Please consult the faculty study guide to establish the language requirements on your own degree programme.
**Required proficiency level:**
Students taking this course must have had English as the A1 or A2 language at school or the equivalent English skills should have been acquired otherwise. The course 'Reading for Academic Purposes' (902002Y) is a pre-requisite, unless exempted.
**ECTS Credits:**
**The student workload is** 53 hrs work/ 2 ECTS credits.
**Language of instruction:**
English
**Timing:**
Biology : 2nd year autumn term
Chemistry: 2nd year spring term
Geosciences : 2nd year spring term
Information Processing Science : 2nd year autumn term
Mathematical Sciences : 2nd year spring term
Physical Sciences : 2nd year autumn term
**Learning outcomes:**
The aim of this course is to develop students' oral/aural fluency in a range of general, scientific and academic communication situations.
Skills in pronunciation, listening and speaking are practised in the course.

**Learning outcomes:** By the end of the course, you are expected to have:

1. provided evidence of oral fluency in pair work communication and small group discussions.
2. developed effective language learning strategies through autonomous homework.
3. demonstrated the ability to present scientific subjects, using appropriate field-related vocabulary.
4. demonstrated lecture listening skills in field related situations.

**Contents:**
Skills in listening, speaking, and giving presentations are practised in the course. Homework tasks include autonomous work to support the classroom learning and the task of preparing and presenting a scientific presentation.
**Mode of delivery:**
Contact teaching
**Learning activities and teaching methods:**
See above
**Target group:**
See timing above
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-
**Recommended or required reading:**
Course materials will be provided by the teacher and a copy fee will be charged.
**Assessment methods and criteria:**
*Pass / fail*. Assessment is based on regular attendance, active participation in all lessons and the successful completion of all homework tasks.
***Alternative method of course completion*** : An optional exemption test is offered twice per year. The student can only participate in the exemption exam once.
**Grading:**
*Pass / fail*.
**Person responsible:**
Jolene Gear
**Working life cooperation:**

none
**Other information:**
-

## 800008Y: Orientation for New Students, 2 op

**Opiskelumuoto:** General Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
2 ECTS
**Language of instruction:**
Finnish
**Timing:**
First year (autumn term)
**Learning outcomes:**
After the course, student is familiar with objectives and curriculum of the degree program. Moreover, the student is familiarized with the correct study methods and learning environment. After the course, the student is also able to search information from, for instance, university library and databases. After the course, student has planned future studies (study plan).
**Contents:**
The aim of the course is to familiarise the student with university studies, learning environment, provide the student with information on the history and current weight of mathematical sciences in the society as well as the objectives and curriculum of the degree programme. During the course, student makes the study plan.
**Mode of delivery:**
Face-to-face teaching (tutoring group)
**Learning activities and teaching methods:**
Group working
**Target group:**
Major students
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Taking part to the group meetings and making the Personal Study Plan.
**Grading:**
Pass/Fail
**Person responsible:**
Student advisor
**Working life cooperation:**
-

## 901004Y: Swedish, 2 - 3 op

**Voimassaolo:** 01.08.1995 -

**Opiskelumuoto:** Language and Communication Studies

**Laji:** Course

**Vastuuyksikkö:** Language Centre

**Opintokohteen kielet:** Swedish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 901035Y | Second Official Language (Swedish), Oral Skills | 1.0 op |
| 901034Y | Second Official Language (Swedish), Written Skills | 1.0 op |

ay901004Y Swedish (OPEN UNI) 2.0 op

**Proficiency level:**
B1/B2/C1 (CEFR scale)
**Status:**
This course unit is compulsory to all students except those who have at least 60 ECTS credits of Swedish studies in their degrees. The language proficiency provided by the course unit is equivalent to the language proficiency required of a state official with an academic degree working in a bilingual municipality area (Act 424/03 and Decree 481/03).
**Required proficiency level:**
The required starting proficiency level for students of all faculties is a grade of 7 or higher from the Swedish studies at secondary school (B-syllabus) or matriculation examination grade A - L or a passing grade from the Brush up course in Swedish 901018Y.
If a student doesn't meet these requirements or his/her language skills are otherwise lacking, he/she must achieve the required proficiency level BEFORE taking this compulsory Swedish course unit. Information about brushing up on one's language skills can be found in Finnish here.
**ECTS Credits:**
2 ECTS credits (Biochemistry 3 ECTS credits)
**Language of instruction:**
Swedish
**Timing:**
See the study guide of the Faculty of Science.
**Learning outcomes:**
Upon completion of the course unit the student should have acquired the necessary proficiency level in Swedish to be able to manage in the most common communication situations related to his/her professional work tasks. He/she should be able to use basic grammatical structures fairly well in both speech and writing. He/she should be able to use the most common situational phrases understandably in various communication situations. He/she should be able to find the main points in general academic texts and texts related to his/her field of study and relay this information to colleagues or an audience of laymen using Swedish. He/she should be able to write short texts relating to his/her field of study.
**Contents:**
Communicative oral and written exercises, which aim to develop the student's Swedish proficiency in areas relevant to his/her academic field and future professional tasks. The student practises oral presentation and pronunciation. Situational oral exercises done individually and in pairs and groups. Discussions in small groups. Current texts about the student's special field. Listening comprehension exercises. Written exercises relating to the student's professional field.
**Mode of delivery:**
Contact teaching
**Learning activities and teaching methods:**
2 ECTS credits: 28 hours of contact teaching (1 x 180 minutes per week) and related exercises, self-directed study. The course unit's total workload is 53 hours.
3 ECTS credits (biochemistry): 45 hours of contact teaching (2 x 90 minutes per week) and related exercises, 35 hours of self-directed study. The course unit's total workload is 80 hours.
**Target group:**
Students of the Faculty of Science
**Prerequisites and co-requisites:**
See Required Porficiency Level
**Recommended optional programme components:**
-
**Recommended or required reading:**
The material, which is special field-specific, authentic and up to date, is distributed during the course. Students must pay for their course material.
**Assessment methods and criteria:**
The course unit focuses on improving both oral and written language skills and requires active attendance and participation in exercises, which also require preparation time. 100% attendance is required. The course unit tests both oral and written language skills. Students participate in the teaching in either autumn semester or spring semester.

**Grading:**
Assessment is based on continuous assessment and exams. Approved completion of the course unit requires that the student achieves at least satisfactory oral and written language skills. The grades are based on continuous assessment and the course exams. Oral and written language skills are graded separately. The possible grades are satisfactory skills (CERF proficiency level B1) and good skills (CERF proficiency levels B2-C1). For more information on the proficiency levels of oral and written language skills, see Assessment Criteria (in Finnish).
**Person responsible:**

Lecturer Rauno Varonen
**Working life cooperation:**
-
**Other information:**
Teaching will begin according to the schedule

## 802155P: Continuity and limit, 4 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800119P | Analysis 1 | 5.0 op |
| 802162P | Continuity and Limit | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |
| 800147P | Basic Methods in Mathematics I / appl. | 8.0 op |

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 1. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results of the course
- use different types of proof techniques
- define the limit of function and the continuity of function
- derive and proof the limit using different proof techniques
- deduce the continuity of functions using different proof techniques

**Contents:**
The main concept of the course are the limit of a real-valued function and the continuity of real-valued function. Interrelations between these concepts are also studied.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Main and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802156P: Derivative, 4 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800317A | Analysis 2 | 5.0 op |
| 802163P | Derivative | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 2. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results of the course
- use different types of proof techniques
- use and apply the concept of derivative in different types of problems

**Contents:**
The course considers the concept of derivative of real-valued function and applies this concept to different types oif situations.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
802154P Elementary functions
802155P Limits and continuity

**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802154P: Elementary functions, 3 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802161P | Introduction to Real Functions | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |
| 800147P | Basic Methods in Mathematics I / appl. | 8.0 op |

**ECTS Credits:**
3 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 1. period
**Learning outcomes:**
After completing the course, student is able to
- prove essential result in the course
- use and apply different types of proof techniques
- handle elementary functions

**Contents:**
Course introduces basic concepts and definitions related to real-valued functions. Definitions and proofs are essential part of the course.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
21h luentoja, 10 h harjoituksia
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802352A: Euclidean Topology, 4 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Maarit Järvenpää

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802357A | Euclidean Spaces | 5.0 op |
| 802356A | Metric Topology | 5.0 op |

**ECTS Credits:**
4 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
First year, 3. period
**Learning outcomes:**
After the course student is able to

- define elementary topological concepts (open and closed sets, accumulation point, etc)
- handle sequences of real numbers
- proof fundamental theorems related to continuous functions

**Contents:**
The courses goal is to expand students knowledge and understanding of continuous functions. Course considers basic topology of n-dimensional Euclidean space. Important concepts are, for instance, open and closed sets, compactness and completeness.

**Mode of delivery:**
Face-to-face teaching

**Learning activities and teaching methods:**
28h lectures, 14h exercises

**Target group:**
Major and minor students

**Prerequisites and co-requisites:**
802154P Elementary functions
802155P Limit and continuity
802156P Derivative

**Recommended optional programme components:**
-

**Recommended or required reading:**
-

**Assessment methods and criteria:**
Midterm exam or final exam

**Grading:**
1-5

**Person responsible:**
Maarit Järvenpää

**Working life cooperation:**
-

## 806113P: Introduction to Statistics, 5 op

**Voimassaolo:** 01.01.2011 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Läärä Esa

**Opintokohteen oppimateriaali:**
**Wild, Christopher J.** , , 2000
**Grönroos, Matti (2)** , , 2003

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 806118P | Introduction to Statistics | 5.0 op |
| 806119P | A Second Course in Statistics | 5.0 op |
| 806116P | Statistics for Economic Sciences | 5.0 op |

**ECTS Credits:**
5 cr

**Language of instruction:**
Finnish

**Timing:**
First year, 3. period

**Learning outcomes:**
On successful completion of this course, the student will be able to
- present the dataset by using graphics, tables and statistics
- apply appropriate statistical techniques for analyzing solutions to simple real-world problems
- interpret listing of some statistical software

**Contents:**

The course presents probabilistic techniques for studying uncertainty, and to illustrate how such techniques can be applied to make statistical analysis and interpretation of data in simple one variable
settings. Topics include descriptive statistics, basics of probability theory, random variables and their distributions, sampling distributions, estimation, confidence intervals, and hypothesis testing. One
aim is also to get basic knowledge from some statistical software.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
32 h lectures, 24 h exercises from which 16 h are normal exercises and 8 h computer exercises.
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
801195P Introduction to probability theory
802118P Linear algebra I

**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Hanna Heikkinen
**Working life cooperation:**
No

## 802151P: Introduction to mathematical deduction, 5 op

**Voimassaolo:** 01.08.2009 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| ay802151P | Introduction to mathematical deduction (OPEN UNI) | 5.0 op |

**ECTS Credits:**
5 ECTS
**Language of instruction:**
Finnish
**Timing:**
First period at the first semester.
**Learning outcomes:**
After completing the course, student
- is able to use different methods proving techniques
- is able to use basic set theoretic concepts and definitions
- is able to define and apply basic definitions related to functions

**Contents:**
The course in an introduction to mathematical deduction and introduces different types of proof techniques. The course covers the concepts familiar from upper secondary school studies more profound way. Main concepts in this course are basic set theory and functions.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Lectures 30h, exercises 18h
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-

**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Final exam
**Grading:**
Pass/Fail
**Person responsible:**
Tero Vedenjuoksu
**Working life cooperation:**
-

## 802118P: Linear Algebra I, 4 op

**Voimassaolo:** 16.10.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Lay, David C.** , , 2003

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802120P Introduction to Matrices 5.0 op

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
First semester, 2. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- solve linear systems of equations ja apply them to linear algebraic problems
- know matrices and their basic properties
- know basic properties of linear spaces
**Contents:**
The aim is to familiarise the student with the basics of linear algebra: systems of linear equations, vector space $R^n$ and matrix algebra.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
35 h lectures, 21 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Tero Vedenjuoksu
**Working life cooperation:**
-

## 802119P: Linear Algebra II, 5 op

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Lay, David C.** , , 2003

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802320A Linear Algebra 5.0 op

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
First year, 4. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- basic properties of inner product spaces
- linear mappings, their matrix representation, and eigen values
- determinants and apply them to problems relating to matrices and linear mappings
**Contents:**
The aim of the course is to provide the student with the knowledge needed in almost all later courses in mathematics: Abstract vector spaces and subspaces, Linear independence and bases, Inner product spaces, Linear mappings, Determinants, Eigenvalues and Eigenvectors, Hermitian matrices and quadratic forms.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
35 h lectures, 21 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802119P Linear algebra I
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Esa Järvenpää
**Working life cooperation:**
-

## 800300A: Maturity test, 0 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
0 cr
**Language of instruction:**
Finnish/Swedish

**Timing:**
Third year
**Learning outcomes:**
Maturity test
**Contents:**
Students must take a written maturity test to demonstrate their language skills and how well they know the topic of their thesis. The maturity test is taken in the language in which the student has received his or her education in Finland. If the student has received his or her education in a language other than Finnish or Swedish, the degree programme determines the language of the maturity test. In such cases only the contents of the maturity test is evaluated, not the language.
**Mode of delivery:**
Maturity test written in examination room.
**Learning activities and teaching methods:**
Maturity test
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or similar)
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Maturity test
**Grading:**
Pass/Fail
**Person responsible:**
Supervisor of thesis
**Working life cooperation:**
-

## 800322A: Multidimensional analysis, 8 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800328A | Calculus of several variables | 5.0 op |
| 802351A | Vector Calculus | 5.0 op |

**ECTS Credits:**
8 cr
**Language of instruction:**
Finnish
**Timing:**
Second year, periods 1-2
**Learning outcomes:**
On successful completion of this course, the student will be able to
- differentiate multivariate functions
- apply the derivative to minimization problems
- define and use multidimensional integrals
**Contents:**
The course deals with multidimensional real calculus. The topology of $R^n$ is reviewed, after which differential and integral calculus is derived for vector-valued functions of multiple arguments are derived.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
56 h lectures, 28 h exercises
**Target group:**

Major and minor students
**Prerequisites and co-requisites:**
Linear algebra I
Linear algebra II
Euclidean topology
Series and integrals

**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
No

## 802354A: Number Theory and Groups, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Kari Myllylä

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| ay802354A | Number Theory and Groups (OPEN UNI) | 5.0 op |
| 800333A | Algebra I | 8.0 op |

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
1. year, 3. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results in the course
- use and apply different proof techniques
- recognize algebraic structures and the concepts
- see connections and differences between different algebraic structures

**Contents:**
The course includes basics in arithmetics and algebraic structures, such as, congruence, residue classes, prime numbres, Euclidean algorithm, the fundamental theorem of arithmetic, Euler-Fermat formula, groups and morphisms. The course gives an understanding of algebraic terms and concepts used in mathematics and physics.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**

Lecture notes
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Kari Myllylä
**Working life cooperation:**
-

## 801195P: Probability Theory, 5 op

**Voimassaolo:** 01.01.2011 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Tuominen, P.**, , 1993

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish (possible also in English)
**Timing:**
First year, 2. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- solve simple practical problems associated with probability
- solve simple theoretical problems associated with probability
- derive the basic properties of probability, starting from the axioms
**Contents:**
The course is an introduction to Probability. After review of high school curriculum material, the axiomatic approach to Probability is introduced. The most important concepts are the probability space, conditional probability, independence, a random variable as well as its distribution and expected value.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
32 h lectures, 16 h exercises
**Target group:**
Major students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
802154P Elementary functions
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Lasse Holmström
**Working life cooperation:**
-

## 802355A: Rings, Fields and Polynomials, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Kari Myllylä

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800333A Algebra I 8.0 op

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
Second year, 1. period
**Learning outcomes:**
After completing the course, student is able to

- derive and proof main results in the course
- use and apply different proof techniques
- recognize algebraic structures and the concepts
- see connections and differences between different algebraic structures

**Contents:**
The course introduces algebraic structures, such as rings, polynomial rings, ideals, integral domains, fields, finite fields, field extensions and quotient field. The course gives an understanding of algebraic terms and concepts used in mathematics and physics.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Major students
**Prerequisites and co-requisites:**
802354A Number theory and groups
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Kari Myllylä
**Working life cooperation:**
-

## 801323A: Seminar, 6 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800331A Proseminar 10.0 op

**ECTS Credits:**

6 cr
**Language of instruction:**
Finnish (also English)
**Timing:**
2.-3. year of studies
**Learning outcomes:**
After completing the Bachelor's thesis, student
- is able to form a clear and logical
- is able to concentrate to important and essential details in the subject of thesis
- gain experience presenting mathematical concept and research studies.

**Contents:**
Proseminar (Bachelor's thesis) is a small mathematical study based on literature. Student is familiarized to write mathematical texts and obtain information using literature. Thesis includes a oral presentation from the subject of the thesis.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Seminars and own work
**Target group:**
Major students
**Prerequisites and co-requisites:**
Compulsory basic and intermediate studies.
**Recommended optional programme components:**
Maturity test is written from the topic of Bachelor's thesis.
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Opinnäytetyö
**Grading:**
Pass/Fail
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802353A: Series and Integrals, 6 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Peter Hästö

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800318A | Analysis 3 | 5.0 op |
| 802164P | Series and Integral | 5.0 op |

**ECTS Credits:**
6 ECTS credits
**Language of instruction:**
Finnish (possible also in English)
**Timing:**
First year, 4. period
**Learning outcomes:**
After completing the course, student is able to
- operate with real series
- separate the concept of continuity and uniform continuity
- define and calculate Riemann integrals
- derive and operate function sequences and function series

- calculate derivate and integrate function series

**Contents:**
The course is a continuum for the courses Limits and continuity and Derivative. Basic topological methods (presented in Euclidean Topology) are heavily used in proofs and methods involving continuous functions. The goal is the same as in the prerequisite courses, that is, to develop mathematical thinking and extend the knowledge of mathematical analysis.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
30h exercises, 14h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802154P Elementary functions
802155P Limit and continuity
802156P Derivative
802352A Euclidean topology

**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Peter Hästö
**Working life cooperation:**
-

## H325035: Optional intermediate studies in mathematics, 0 - 180 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 800329A: Topology, 8 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Mahmoud Filali
**Opintokohteen oppimateriaali:**
**Vala K., Suominen K.**, , 1990
**Opintokohteen kielet:** Finnish

**ECTS Credits:**
8 cr

**Language of instruction:**

English (also Finnish)

**Timing:**

Second year or later. Fall/spring term

**Learning outcomes:**

On successful completion of this course, the student will be able to follow more advanced topology and analysis.

**Contents:**

The course presents the very basics of topology that mathematics students should know. It starts with elementary set theory, then it goes on covering metric spaces including Baire's theorem; topological spaces and convergence in topological spaces; separation axioms including Urysohn's lemma and Tietze extension theorem; compact spaces including Tyconoff theorem; and ends with connected spaces.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56 hours lecture, 28 h exercises

**Target group:**

Major and minor students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics.

**Recommended optional programme components:**

-

**Recommended or required reading:**

S. Willard: General Topology;
K. Suominen & K. Vala: Topologia;
R. Engelking: Outline of General Topology.

**Assessment methods and criteria:**

Final exam, or mid-term exams

**Grading:**

1-5

**Person responsible:**

Mahmoud Filali

**Working life cooperation:**

-

### 800343A: Permutations, Fields and Galois' Theory, 8 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Niemenmaa Markku
**Opintokohteen oppimateriaali:**
**Herstein, I. N.**, , 1996
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

| | | |
|---|---|---|
| 800323A | Field extensions | 5.0 op |
| 802333A | Permutations, Fields and Galois Theory | 10.0 op |

**ECTS Credits:**

8 cr

**Language of instruction:**

Finnish

**Timing:**

2. year or later. Periods 3-4 (Spring term)

**Learning outcomes:**

On successful completion of this course, the student will be able to
- compute with permutations and deal with their applications
- solve equations of third and fourth degree
- work with the structures of different finite fields

**Contents:**

The aim is to introduce three main topics which are related to each other: Elementary number theory: division algorithm, greatest common divisor, prime numbers and congruences. Group theory: group axioms, subgroups. Lagrange's theorem, homomorphisms and factor groups. Commutative ring theory: fields, polynomial rings, quotient rings and finite fields.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

56 h lectures, 28 h exercises

**Target group:**

Major- and minor students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics.

**Recommended optional programme components:**

-

**Recommended or required reading:**

I. N. Herstein: Abstract Algebra, Prentice Hall, Inc., 1996.

**Assessment methods and criteria:**

Final exam, mid-term exams

**Grading:**

1-5

**Person responsible:**

Markku Niemenmaa

**Working life cooperation:**

-

### 800345A: Differential Equations I, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Boyce, William E.**, , 2005
**Nagle, R. Kent**, , 1996
**Zill, Dennis G.**, , 2001

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800320A | Differential equations | 5.0 op |

**ECTS Credits:**

4 cr

**Language of instruction:**

Finnish

**Timing:**

2. year or later, 3. period

**Learning outcomes:**

On successful completion of this course, the student will be able to
- recognize the concerning differential equation and choose the proper method and solve it
- notice the conditions that guarantee the uniqueness of the solution
- understand what implicit solution means

**Contents:**

The course consist ordinary differential equations. First order differential equations like separable, homogeneous, linear, exact and those that can be transform to them with suitable substitutions are studied and solved by algebraic methods (for example separation of variables). Iterative methods and numerical methods are applied in some cases to obtained an approximate solution or a numerical solution. Higher order linear differential equations with constant coefficients that appear in applications are considered and also second order linear differential equations with continuous coefficients. The basis of how to solve finite systems of differential equations is given. Power series method is applied to solve some second order linear differential equations like Legendre equation.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

30 h lectures, 16 h exercises

**Target group:**

Major- and minor students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics.

**Recommended optional programme components:**

-

**Recommended or required reading:**

Boyce and Di Prima: Elementary Differential Equations and Boundary Value Problems, Wiley, Anton: Calculus, Wiley. R. Kent Nagle & E. B. Saff: Fundamentals of Differential Equations and Boundary Value Problems, Addison-Wesley, 1996 C. Henry & David E. Penney: : Differential Equations and Boundary Value Problems, Prenticw Hall, 2000 Dennis G. Zill & Michael R. Cullen: Differen-tial Equations with Boundary Value Prob-lems, Brooks/Cole, 2001.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Martti Kumpulainen

**Working life cooperation:**

-

**800346A: Differential Equations II, 4 op**

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Nagle, R. Kent**, , 1996

**Folland, Gerald B.**, , 1992
**Zill, Dennis G.**, , 2001

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802334A A Second Course in Differential Equations 5.0 op

**ECTS Credits:**

4 cr

**Language of instruction:**

Finnish

**Timing:**

2. year or later, 4. period

**Learning outcomes:**

On successful completion of this course, the student will be able to
- apply method of Frobenius to solve second order linear differential equations
- proof the basic properties of Bessel functions, Legendre polynomials and Hermite polynomials
- calculate the Fourier-series of a given piecewise continuous function
- apply integral transformations to solve some integral equations and ordinary differential equations with constant coefficients
- recognize heat and wave equations and choose the proper method to solve them

**Contents:**

The course consist second order ordinary differential equation that are important in applications and partial differential equations like heat and wave eqautions. Method of Frobenius is introduced to solve second order ordinary differential equation. Some special functions (like Gamma function and Bessel functions) are considered and also orthogonal polynomials (Legendre polynomials and Hermite polynomials). The basics how to calculate Fourier-series for a piecewise continuous function is given. Last, basics of integral transformations (Laplace-transformation and Fourier-transformation) are studied, and how to apply them and the method of separation of variable in some cases to heat and wave equations.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

30 h lectures, 16 h exercises.

**Target group:**

Major and minor students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics

**Recommended optional programme components:**

-

**Recommended or required reading:**

R. Kent Nagle & E. B. Saff, Fundamentals of Differential Equations and Boundary Value Problems, Addison-Wesley, 1996; Dennis G. Zill & Michael R. Cullen: Differential Equations with Boundary Value Problems, Brooks/Cole, 2001, Strauss: Partial Diffferential Equations. An Introduction, Wiley 1992 . Enrique A. Gonzales-Velasco, E. Gonzales-Velasco: Fourier Anaysis and Boundary Value Problems, Academic Press, 1995 Gerald B. Folland: Fourier Analysis and Its Applications, Brooks / Cole, 1996.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Martti Kumpulainen

**Working life cooperation:**

-

**801344A: Basic Course on Numerical Computation, 8 op**

**Voimassaolo:** 01.03.2011 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Erkki Laitinen
**Opintokohteen oppimateriaali:**
**Haataja Juha, Rahola J., Ruokolainen J.**, , 1998
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

8 cr

**Language of instruction:**

Finnish

**Learning outcomes:**

On successful completion of this course, the student will be able to
- program using Fortran the basic numerical problems
- exploit the libraries of the University's IT center for solving numerical problems

**Contents:**

The lecture course is focused to methods how to program and solve numerical problems by computer. The lectures consist of following topics: Fortran95 programming language related to numeric, basics of Unix operating system, numerical and graphical libraries in solving numerical problems.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

20h lectures, 40h computer exercises and practical work

**Target group:**

Major and minor students

**Prerequisites and co-requisites:**

Basics in computer programming

**Recommended optional programme components:**

-

**Recommended or required reading:**

Available Fortran Manuals.

**Assessment methods and criteria:**

Exam, Practical work

**Grading:**

1-5

**Person responsible:**

Erkki Laitinen

**Working life cooperation:**

-

**801387A: Basic Course on Numerical Analysis, 6 op**

**Voimassaolo:** 01.03.2011 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Erkki Laitinen

**Opintokohteen oppimateriaali:**
**Atkinson, Kendall**, , 1993
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

6 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- implement efficient numerical algorithms for solving basic numerical problems
- approximate the error of numerical results

**Contents:**

The lecture course is focused to numerical methods, which can be used for solving numerically mathematical problems which analytical solution is unknown or complicated to construct. The lectures consist of following topics: Computer arithmetic, nonlinear equations, systems of linear equations, interpolation, integration, derivation and differential equations.

**Person responsible:**

Erkki Laitinen

### 802362A: Introduction to computational inverse problems, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mikko Orispää

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 801386A: Complex Analysis II, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Lang, Serge**, , 1999
**Spiegel, Murray R.**, , 1964
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

4 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- derive and prove core results of complex analysis
- apply theory of complex analysis to many structures of analysis

**Contents:**

The course deals with fundamendal results on complex analysis such as Cauchy integral theorem and Cauchy integral formulas. As application some important corollaries of them will be proved such as Liouville Theorem, Fundamental theorem of algebra and Maximum principle. Further, after brief introduction to power series the presentaion of analtic functions by using power series will be studied. After

Laurent repsentation of complex functions theory of residues will be considered and as applicatio this theory wiil be used to calculate certain type of definite integrals.

**Person responsible:**

Jorma Arhippainen

### 801390A: History of Mathematics, 6 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Matti Lehtinen

**Opintokohteen oppimateriaali:**
**Boyer, Carl B.**, , 1994
**Boyer, Carl B.**, , 1994
**Fauvel John, Gray J.**, , 1990

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800332A | History of Mathematics | 5.0 op |

**ECTS Credits:**

6 cr

**Contents:**

The aim of the course is to provide the student a general conception of the history of mathematics. The main emphasis is on the calculations. Contents: Egyptian and Babylonian mathematics; Euclid and the Elements, Archimedes and Apollonius; Roman era; India and China; the islamic world; medieval mathematics; the rise of algebra; Descartes, Fermat; Newton and Leibniz, the beginning of calculus.

### 801389A: Basic Geometry, 6 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 801399A | Geometry | 5.0 op |

**ECTS Credits:**

6 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- prove simple geometric claims
- solve simple geometric problems with the help of ruler and compass
- solve basic applied problems of school geometry

**Contents:**

School geometry (801389A) The course presents the core material in Finnish junior high school and high school geometry courses. It is mainly meant for those students who study to become mathematics, physics and chemistry teachers. The first part of this course is classic Euclidean plane geometry and the second part is solid geometry. Students become familiar with geometric proof and how to solve simple geometric problems with the help of ruler and compass. Geometric results are used to solve problems. The second part considers spatial geometry and starts with how lines and planes can situate in ordinary three dimensional space. Basic geometric properties of solids like cube, ball and cone are considered and methods how to calculate their surface aries and volumes are presented.

**Person responsible:**

Martti Kumpulainen

### 802328A: Basics in Number Theory, 5 op

**Voimassaolo:** 01.06.2011 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Tapani Matala-aho
**Opintokohteen oppimateriaali:**
**Hardy, G. H.**, , 1979
**Rosen, Kenneth H.**, , 1993
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

2.-3. year of studies. Timing varies.

**Learning outcomes:**

As usual in my mathematical studies I shall be able to solve problems arising from the subject and to prove essential theorems starting from the given definitions using the tools applied in the course. More detailed; For example, when I pass the course with the grade 1/5, I shall recognize most definitions and I am able to solve closely related problems. Also I am able to rewrite short proofs with some understanding. When I pass the course with the grade 5/5, then I shall understand well the given definitions with the proofs of the theorems deduced from them. Further, I am able to solve challenging problems which demand independent deductions with several stages and applications of appropriate tools.

**Contents:**

In our lectures we consider arithmetical properties of the common numbers involved in studing mathematics and in particular number theory. Also the methods will get a special interest. Examples of the numbers under the research will be binomials, continued fractions, sums of powers and some numbers sharing a name with the mathematicians Bernoulli, Euler, Fermat, Fibonacci, Heron, Lucas, Mersenne, Neper, Pythagoras, Stirling, Wilson and Wolstenholme. From the tools we mention congruences of rational numbers and polynomials, difference operators, generating series, irrationality considerations, matrix presentations, recurrences and telescopes.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

36h lectures, 18h exercises

**Target group:**

Major and minor students

**Prerequisites and co-requisites:**

802354A Lukuteoria ja ryhmät,
802355A Rings, fields and polynomials
802118P Linear algebra I
802119P Linear algebra II
802352A Euclidean topology
802353A Series and integrals

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes,
G.H. Hardy ja E.M. Wright: An Introduction to the Theory of Numbers;
Kenneth H. Rosen: Elementary number theory and its applications.

**Assessment methods and criteria:**

Mid-term exams or final exam

**Grading:**

1-5

**Person responsible:**

Tapani Matala-aho

**Working life cooperation:**

-

### 802331A: Principles to Mathematical Modelling, 8 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Martti Kumpulainen
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 802360A: Introduction to inverse problems, 4 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Sari Lasanen
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

4 cr

**Language of instruction:**

Finnish. Alternatively, a book examination in English.

**Learning outcomes:**

Upon completion, the student will be able to

- recognise several inverse problems
- describe typical properties of inverse problems
- solve simple inverse problems with accurate and inaccurate data

**Contents:**

1. Examples of inverse problems and their typical properties
2. Well-posed and ill-posed problems
3. Least squares solutions
4. Tikhonov regularization
5. Statistical inverse problems

**Learning activities and teaching methods:**

Lectures 4x45 min / week. Exercises 2x45 min /week.

**Target group:**

Suitable for major and minor students.

**Prerequisites and co-requisites:**

- 802118P Linear Algebra I
- 802119P Linear Algebra II

Also recommended:

- 800322A Multidimensional Analysis (or Analysis II)
- 801396A Introduction to Probability Theory II
- 802352A Euclidian Topology
- 800345A Differential Equations I

**Assessment methods and criteria:**

Exam.

**Other information:**

This course does not contain numerical programming tasks. Computer-aided computations are contained in a separate course
802362A Introduction to Computational Inverse Problems.

### 801385A: Complex Analysis I, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Arhippainen, Jorma Eemil

**Opintokohteen oppimateriaali:**

**Lang, Serge**, , 1999
**Spiegel, Murray R.**, , 1964

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

4 cr

**Learning outcomes:**

On successful completion of this course, the student will be able to
- know the basic properties of algebrai and toplogical structure of complex numbers
- know the basic properties of complex functions
- be able to apply theory of complex numbers to different fields of pure and applied mathematics

**Contents:**

The course deals basic theory of complex numbers. After a brief introduction to algebraic properties of complex numbers, such basic results as polar coordinate representation, De Moivre formulas and topology on complex plane will be considered. For the complex functions the concepts of limit, continuity and derivate will be studied. Some basic properties of analytic functions will be considered and Cauchy-Riemann formulas will be proved. Finally basic theory of pathintegral of complex functions will be studied.

**Person responsible:**

Jorma Arhippainen

### 801396A: Introduction to Probability Theory II, 5 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Tuominen, P.**, , 1993

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

4 cr

**Language of instruction:**

Finnish

**Timing:**

2. year, Fall semester

**Learning outcomes:**

On successful completion of this course, the student will be able to
- understand probability theory deeper than before
- apply various stocastic models
- derive the basic results associated with the new concepts introduced

**Contents:**

The course is a direct continuation for the course Probability Theory I. The new concepts include for instance the moments of a distribution, the probability generating function, the Law of Large Numbers, the Central Limit Theorem as well as two-dimensional distibutions.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

24h lectures, 12h exercises

**Target group:**

Major- and minor students. Recommended for students aiming to Master's degree with major in statistics or major in mathematics and computer sciences.

**Prerequisites and co-requisites:**

801195P Introduction to propability I
802352A Euclidean topology
802353A Series and integrals

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Lasse Holmström

### 802363A: Metric Spaces, 6 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Mahmoud Filali

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Language of instruction:**

English (also in Finnish)

**Timing:**

2.-3. year studies. Timing varies.

**Learning outcomes:**

After completing the course, student is able to participate fully for more advanced courses in topology and analysis.

**Contents:**

Course includes basic definitions and results in metric spaces. Keywords are: interior, closure, convergence in metric spaces, continuity in metric spaces, Baire's theorem, compactness, contraction, implicit function theorem. Course takes known and classical results in real analysis and generalizes them to metric spaces.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

28h lectures, 14h exercises

**Target group:**

Major studies

**Recommended optional programme components:**

-

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Mahmoud Filali

**Working life cooperation:**

-

### 801346A: Introduction to Cryptography, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802336A | Introduction to Cryptography | 5.0 op |

**ECTS Credits:**

4 cr

**Language of instruction:**

Finnish

**Timing:**

2. year or later, Fall term (1. or 2. period)

**Learning outcomes:**

After completeing the course, student
- knows the principles of sime traditianl symmetric key methods
- knows how public key methods (RSA, discrete logarithm, knapsack) work
- is familiar with the possibility to use and apply number theory in cryptography

**Contents:**

The course considers some traditianl symmetric key methods (affine system, matrix cryptography) and three public key methods, namely RSA, discrete logarithm and knapsack.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

27 h lectures, 15 h exercises

**Target group:**

Major and minor students

**Prerequisites and co-requisites:**

Compulsory basic and intermediate studies in mathematics.

**Recommended or required reading:**

Lecture notes

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Tapani Matala-aho

## H326635: Optional intermediate studies in statistics, 0 - 180 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Study module
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 805324A: Time series analysis, 5 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**
**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis: stationarity, autocorrelation, spectral distribution and periodogram. Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric

smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities. Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.

**Person responsible:**

Jussi Klemelä

### 806351A: Introduction to Independent Component Analysis, 4 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805334A: Analysis of categorical data, 9 op

**Voimassaolo:** - 28.02.2011
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen oppimateriaali:**
**Agresti, Alan** , , 1990
**Christensen, Ronald** , , 1990
**McCullagh, Peter** , , 1989
**McCulloch, Charles E.** , , 2001
**Opintokohteen kielet:** Finnish

**ECTS Credits:**

9 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with generalized linear models and to be able to use them when studying discrete data
- be able to model the behaviour of ordinal dependent variables
- be able to make use of so-called mixed models while studying discrete or ordinal data

**Contents:**

The course deals with the analysis of contingency tables and with models for qualitative and ordinal dependent variables. Models for truncated dependent variables are also briefly touched. A majority of these models can be interpreted as generalised linear models (GLIM). This is why the essentials of the GLIM-theory and the corresponding phraseology is presented. So-called generalised mixed linear models (including random effects) and the estimation of their parameters by the GEE and the ML methods are also discussed. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab.

**Person responsible:**

Markku Rahiala

### 805328A: Multivariate analysis, 9 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805333A: Robust methods, 6 op**

**Voimassaolo:** - 31.07.2007
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805398A: An introduction to stochastic modelling, 8 op**

**Voimassaolo:** - 01.09.2012
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Severini, Thomas A.** , , 2005
**Mood, Alexander M.** , , 1974
**Giri, Narayan C.** , , 1975
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805380A: Clinical biostatistics, 6 op**

**Voimassaolo:** - 01.09.2012
**Opiskelumuoto:** Basic Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806330A: Analysis of Market Risk, 5 op**

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish
**Leikkaavuudet:**

806630S Market Risk Analysis 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating
- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Jussi Klemelä

**Working life cooperation:**

-

**Other information:**

Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

**805309A: Statistical methods in epidemiology, 9 op**

**Voimassaolo:** 01.06.2009 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Läärä Esa

**Opintokohteen oppimateriaali:**

**Santos Silva, Isabel dos** , , 1999
**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998

**Opintokohteen kielet:** Finnish

### 805339A: The Statistical Foundation of Econometrics, 5 - 6 op

**Voimassaolo:** 01.06.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995
**Harvey, Andrew C.** , , 1990

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805683S | The statistical foundations ofeconometrics | 5.0 op |

**ECTS Credits:**

5/6 cr

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä

### 805332A: Design of experiments, 9 op

**Voimassaolo:** - 31.07.2007
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**805308A: Analysis of longitudinal data, 5 op**

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

**806357A: Statistical finance, 5 op**

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 902002Y: English 1 (Reading for Academic Purposes), 2 op

**Voimassaolo:** 01.08.1995 -
**Opiskelumuoto:** Language and Communication Studies
**Laji:** Course
**Vastuuyksikkö:** Language Centre
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** English

**Proficiency level:**
B2/C1 on the Common European Framework of Reference scale.
**Status:**
In the Faculty of Science, this course is mandatory for all degree programmes except Geography. Please consult the Faculty Study Guide to establish the language requirements for your own degree programme.
**Required proficiency level:**
English must have been the A1 or A2 language at school or equivalent English skills should have been acquired otherwise.
**ECTS Credits:**
2 ECTS credits (total work load 54 hours including classroom meetings.
**Language of instruction:**
Both English and Finnish are used.
**Timing:**
Biological Sciences: 1st year spring term
Chemistry: 1st year autumn term

Geology: 1st year spring term
Information Processing Science: 1st year spring term
Mathematical Sciences: 1st year spring term
Physical Sciences: 1st year autumn term

**Learning outcomes:**
In this course, students improve their understanding of written academic English used in texts in Natural Sciences as well as expand their general and scientific vocabulary. Students become aware of their own role in learning and will be able to find and take advantage of useful study materials available on the Internet in order to develop their own language learning strategies, which will enhance their academic English. Students show their awareness and their own responsibility by reflecting on their achievements in a study journal.

**Learning outcomes:** By completing the tasks of the course, students will

- have acquired effective vocabulary learning techniques by being able to distinguish parts of words to infer meanings
- expand their academic vocabulary by using Internet resources such as on-line dictionaries
- understand and be able to construct basic grammatical structures used in formal written English
- be able to utilize text structure and cohesion markers when reading academic texts
- be able to apply effective reading techniques and have necessary skills to extract global and detailed information with considerable ease and speed from general texts related to Natural Sciences as well as texts /textbooks of their own field

**Contents:**
See above
**Mode of delivery:**
See below
**Learning activities and teaching methods:**
The course is carried out in multi-mode, with instruction and student tasks both in class and in the Optima learning environment.
**Target group:**
1st year students of Biology, Chemistry, Geology, Information Processing Science, Physics, and Mathematics.
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
See 902004Y Scientific Communication
**Recommended or required reading:**
Set books for substance studies; journal articles in print and on-line. Further information will be given in the first lesson.
**Assessment methods and criteria:**
Active and regular participation in classroom sessions, completing the learning tasks (in class and Optima Learning Environment ) including the study journal. These are prerequisites for participation in the end of term examination. Exemptions from the examination can be given for excellent work during the course.
**Grading:**
Pass/Fail
**Person responsible:**
Jolene Gear
**Working life cooperation:**
none
**Other information:**
N.B. Students with grades laudatur or eximia in their A1 English school-leaving examination can be exempted from this course and will be granted the credits by the Faculty of Science.
**Resit examinations:** Two resit examinations are allowed on the dates set by the Extension School unit of Languages and Communication.

## 902004Y: English 2 (Scientific Communication), 2 op

**Voimassaolo:** 01.08.1995 -

**Opiskelumuoto:** Language and Communication Studies

**Laji:** Course

**Vastuuyksikkö:** Language Centre

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** English

**Leikkaavuudet:**

ay902004Y English 2 (Scientific Communication) (OPEN UNI) 2.0 op

**Proficiency level:**
B2/C1 on the CEFR scales
**Status:**
This course is mandatory for all 2nd year students (except **geographers**) who will have English as their foreign language in their B.Sc. degree. This includes the students who were exempted from ‘Reading for Academic Purposes'(902002Y). Please consult the faculty study guide to establish the language requirements on your own degree programme.
**Required proficiency level:**
Students taking this course must have had English as the A1 or A2 language at school or the equivalent English skills should have been acquired otherwise. The course 'Reading for Academic Purposes' (902002Y) is a pre-requisite, unless exempted.
**ECTS Credits:**
**The student workload is** 53 hrs work/ 2 ECTS credits.
**Language of instruction:**
English
**Timing:**
Biology : 2nd year autumn term
Chemistry: 2nd year spring term
Geosciences : 2nd year spring term
Information Processing Science : 2nd year autumn term
Mathematical Sciences : 2nd year spring term
Physical Sciences : 2nd year autumn term
**Learning outcomes:**
The aim of this course is to develop students' oral/aural fluency in a range of general, scientific and academic communication situations.
Skills in pronunciation, listening and speaking are practised in the course.

**Learning outcomes:** By the end of the course, you are expected to have:

1. provided evidence of oral fluency in pair work communication and small group discussions.
2. developed effective language learning strategies through autonomous homework.
3. demonstrated the ability to present scientific subjects, using appropriate field-related vocabulary.
4. demonstrated lecture listening skills in field related situations.

**Contents:**
Skills in listening, speaking, and giving presentations are practised in the course. Homework tasks include autonomous work to support the classroom learning and the task of preparing and presenting a scientific presentation.
**Mode of delivery:**
Contact teaching
**Learning activities and teaching methods:**
See above
**Target group:**
See timing above
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-
**Recommended or required reading:**
Course materials will be provided by the teacher and a copy fee will be charged.
**Assessment methods and criteria:**
*Pass / fail*. Assessment is based on regular attendance, active participation in all lessons and the successful completion of all homework tasks.
***Alternative method of course completion*** : An optional exemption test is offered twice per year. The student can only participate in the exemption exam once.
**Grading:**
*Pass / fail*.
**Person responsible:**
Jolene Gear
**Working life cooperation:**
none
**Other information:**
-

## 800008Y: Orientation for New Students, 2 op

**Opiskelumuoto:** General Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
2 ECTS
**Language of instruction:**
Finnish
**Timing:**
First year (autumn term)
**Learning outcomes:**
After the course, student is familiar with objectives and curriculum of the degree program. Moreover, the student is familiarized with the correct study methods and learning environment. After the course, the student is also able to search information from, for instance, university library and databases. After the course, student has planned future studies (study plan).
**Contents:**
The aim of the course is to familiarise the student with university studies, learning environment, provide the student with information on the history and current weight of mathematical sciences in the society as well as the objectives and curriculum of the degree programme. During the course, student makes the study plan.
**Mode of delivery:**
Face-to-face teaching (tutoring group)
**Learning activities and teaching methods:**
Group working
**Target group:**
Major students
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Taking part to the group meetings and making the Personal Study Plan.
**Grading:**
Pass/Fail
**Person responsible:**
Student advisor
**Working life cooperation:**
-

## 901004Y: Swedish, 2 - 3 op

**Voimassaolo:** 01.08.1995 -

**Opiskelumuoto:** Language and Communication Studies

**Laji:** Course

**Vastuuyksikkö:** Language Centre

**Opintokohteen kielet:** Swedish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 901035Y | Second Official Language (Swedish), Oral Skills | 1.0 op |
| 901034Y | Second Official Language (Swedish), Written Skills | 1.0 op |
| ay901004Y | Swedish (OPEN UNI) | 2.0 op |

**Proficiency level:**
B1/B2/C1 (CEFR scale)

**Status:**
This course unit is compulsory to all students except those who have at least 60 ECTS credits of Swedish studies in their degrees. The language proficiency provided by the course unit is equivalent to the language proficiency required of a state official with an academic degree working in a bilingual municipality area (Act 424/03 and Decree 481/03).
**Required proficiency level:**
The required starting proficiency level for students of all faculties is a grade of 7 or higher from the Swedish studies at secondary school (B-syllabus) or matriculation examination grade A - L or a passing grade from the Brush up course in Swedish 901018Y.
If a student doesn't meet these requirements or his/her language skills are otherwise lacking, he/she must achieve the required proficiency level BEFORE taking this compulsory Swedish course unit. Information about brushing up on one's language skills can be found in Finnish here.
**ECTS Credits:**
2 ECTS credits (Biochemistry 3 ECTS credits)
**Language of instruction:**
Swedish
**Timing:**
See the study guide of the Faculty of Science.
**Learning outcomes:**
Upon completion of the course unit the student should have acquired the necessary proficiency level in Swedish to be able to manage in the most common communication situations related to his/her professional work tasks. He/she should be able to use basic grammatical structures fairly well in both speech and writing. He/she should be able to use the most common situational phrases understandably in various communication situations. He/she should be able to find the main points in general academic texts and texts related to his/her field of study and relay this information to colleagues or an audience of laymen using Swedish. He/she should be able to write short texts relating to his/her field of study.
**Contents:**
Communicative oral and written exercises, which aim to develop the student's Swedish proficiency in areas relevant to his/her academic field and future professional tasks. The student practises oral presentation and pronunciation. Situational oral exercises done individually and in pairs and groups. Discussions in small groups. Current texts about the student's special field. Listening comprehension exercises. Written exercises relating to the student's professional field.
**Mode of delivery:**
Contact teaching
**Learning activities and teaching methods:**
2 ECTS credits: 28 hours of contact teaching (1 x 180 minutes per week) and related exercises, self-directed study. The course unit's total workload is 53 hours.
3 ECTS credits (biochemistry): 45 hours of contact teaching (2 x 90 minutes per week) and related exercises, 35 hours of self-directed study. The course unit's total workload is 80 hours.
**Target group:**
Students of the Faculty of Science
**Prerequisites and co-requisites:**
See Required Porficiency Level
**Recommended optional programme components:**
-
**Recommended or required reading:**
The material, which is special field-specific, authentic and up to date, is distributed during the course. Students must pay for their course material.
**Assessment methods and criteria:**
The course unit focuses on improving both oral and written language skills and requires active attendance and participation in exercises, which also require preparation time. 100% attendance is required. The course unit tests both oral and written language skills. Students participate in the teaching in either autumn semester or spring semester.

**Grading:**
Assessment is based on continuous assessment and exams. Approved completion of the course unit requires that the student achieves at least satisfactory oral and written language skills. The grades are based on continuous assessment and the course exams. Oral and written language skills are graded separately. The possible grades are satisfactory skills (CERF proficiency level B1) and good skills (CERF proficiency levels B2-C1). For more information on the proficiency levels of oral and written language skills, see Assessment Criteria (in Finnish).
**Person responsible:**
Lecturer Rauno Varonen
**Working life cooperation:**
-
**Other information:**

Teaching will begin according to the schedule

## 802155P: Continuity and limit, 4 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800119P | Analysis 1 | 5.0 op |
| 802162P | Continuity and Limit | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |
| 800147P | Basic Methods in Mathematics I / appl. | 8.0 op |

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 1. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results of the course
- use different types of proof techniques
- define the limit of function and the continuity of function
- derive and proof the limit using different proof techniques
- deduce the continuity of functions using different proof techniques

**Contents:**
The main concept of the course are the limit of a real-valued function and the continuity of real-valued function. Interrelations between these concepts are also studied.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Main and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802156P: Derivative, 4 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800317A | Analysis 2 | 5.0 op |
| 802163P | Derivative | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 2. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results of the course
- use different types of proof techniques
- use and apply the concept of derivative in different types of problems

**Contents:**
The course considers the concept of derivative of real-valued function and applies this concept to different types oif situations.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
802154P Elementary functions
802155P Limits and continuity

**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802154P: Elementary functions, 3 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802161P | Introduction to Real Functions | 5.0 op |
| 801111P | Basic Methods in Mathematics I / math | 10.0 op |
| 800147P | Basic Methods in Mathematics I / appl. | 8.0 op |

**ECTS Credits:**
3 cr
**Language of instruction:**
Finnish
**Timing:**
1. year, 1. period
**Learning outcomes:**
After completing the course, student is able to
- prove essential result in the course
- use and apply different types of proof techniques
- handle elementary functions

**Contents:**
Course introduces basic concepts and definitions related to real-valued functions. Definitions and proofs are essential part of the course.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
21h luentoja, 10 h harjoituksia
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802352A: Euclidean Topology, 4 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Maarit Järvenpää

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 802357A | Euclidean Spaces | 5.0 op |
| 802356A | Metric Topology | 5.0 op |

**ECTS Credits:**
4 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
First year, 3. period
**Learning outcomes:**
After the course student is able to
- define elementary topological concepts (open and closed sets, accumulation point, etc)
- handle sequences of real numbers
- proof fundamental theorems related to continuous functions

**Contents:**

The courses goal is to expand students knowledge and understanding of continuous functions. Course considers basic topology of n-dimensional Euclidean space. Important concepts are, for instance, open and closed sets, compactness and completeness.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802154P Elementary functions
802155P Limit and continuity
802156P Derivative
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 806113P: Introduction to Statistics, 5 op

**Voimassaolo:** 01.01.2011 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Läärä Esa

**Opintokohteen oppimateriaali:**
**Wild, Christopher J.** , , 2000
**Grönroos, Matti (2)** , , 2003

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 806118P | Introduction to Statistics | 5.0 op |
| 806119P | A Second Course in Statistics | 5.0 op |
| 806116P | Statistics for Economic Sciences | 5.0 op |

**ECTS Credits:**
5 cr
**Language of instruction:**
Finnish
**Timing:**
First year, 3. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- present the dataset by using graphics, tables and statistics
- apply appropriate statistical techniques for analyzing solutions to simple real-world problems
- interpret listing of some statistical software
**Contents:**
The course presents probabilistic techniques for studying uncertainty, and to illustrate how such techniques can be applied to make statistical analysis and interpretation of data in simple one variable

settings. Topics include descriptive statistics, basics of probability theory, random variables and their distributions, sampling distributions, estimation, confidence intervals, and hypothesis testing. One
aim is also to get basic knowledge from some statistical software.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
32 h lectures, 24 h exercises from which 16 h are normal exercises and 8 h computer exercises.
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
801195P Introduction to probability theory
802118P Linear algebra I

**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Hanna Heikkinen
**Working life cooperation:**
No

## 802151P: Introduction to mathematical deduction, 5 op

**Voimassaolo:** 01.08.2009 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| ay802151P | Introduction to mathematical deduction (OPEN UNI) | 5.0 op |

**ECTS Credits:**
5 ECTS
**Language of instruction:**
Finnish
**Timing:**
First period at the first semester.
**Learning outcomes:**
After completing the course, student
- is able to use different methods proving techniques
- is able to use basic set theoretic concepts and definitions
- is able to define and apply basic definitions related to functions

**Contents:**
The course in an introduction to mathematical deduction and introduces different types of proof techniques. The course covers the concepts familiar from upper secondary school studies more profound way. Main concepts in this course are basic set theory and functions.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Lectures 30h, exercises 18h
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
-
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes

**Assessment methods and criteria:**
Final exam
**Grading:**
Pass/Fail
**Person responsible:**
Tero Vedenjuoksu
**Working life cooperation:**
-

## 802118P: Linear Algebra I, 4 op

**Voimassaolo:** 16.10.2012 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**

**Lay, David C.** , , 2003

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802120P Introduction to Matrices 5.0 op

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
First semester, 2. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- solve linear systems of equations ja apply them to linear algebraic problems
- know matrices and their basic properties
- know basic properties of linear spaces
**Contents:**
The aim is to familiarise the student with the basics of linear algebra: systems of linear equations, vector space $R^n$ and matrix algebra.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
35 h lectures, 21 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Tero Vedenjuoksu
**Working life cooperation:**
-

## 802119P: Linear Algebra II, 5 op

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Lay, David C.** , , 2003
**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

802320A Linear Algebra 5.0 op

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
First year, 4. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- basic properties of inner product spaces
- linear mappings, their matrix representation, and eigen values
- determinants and apply them to problems relating to matrices and linear mappings
**Contents:**
The aim of the course is to provide the student with the knowledge needed in almost all later courses in mathematics: Abstract vector spaces and subspaces, Linear independence and bases, Inner product spaces, Linear mappings, Determinants, Eigenvalues and Eigenvectors, Hermitian matrices and quadratic forms.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
35 h lectures, 21 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802119P Linear algebra I
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Esa Järvenpää
**Working life cooperation:**
-

## 800300A: Maturity test, 0 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
0 cr
**Language of instruction:**
Finnish/Swedish
**Timing:**
Third year

**Learning outcomes:**
Maturity test
**Contents:**
Students must take a written maturity test to demonstrate their language skills and how well they know the topic of their thesis. The maturity test is taken in the language in which the student has received his or her education in Finland. If the student has received his or her education in a language other than Finnish or Swedish, the degree programme determines the language of the maturity test. In such cases only the contents of the maturity test is evaluated, not the language.
**Mode of delivery:**
Maturity test written in examination room.
**Learning activities and teaching methods:**
Maturity test
**Target group:**
Major students
**Prerequisites and co-requisites:**
Bachelor's degree (or similar)
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Maturity test
**Grading:**
Pass/Fail
**Person responsible:**
Supervisor of thesis
**Working life cooperation:**
-

## 800322A: Multidimensional analysis, 8 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800328A | Calculus of several variables | 5.0 op |
| 802351A | Vector Calculus | 5.0 op |

**ECTS Credits:**
8 cr
**Language of instruction:**
Finnish
**Timing:**
Second year, periods 1-2
**Learning outcomes:**
On successful completion of this course, the student will be able to
- differentiate multivariate functions
- apply the derivative to minimization problems
- define and use multidimensional integrals
**Contents:**
The course deals with multidimensional real calculus. The topology of $R^n$ is reviewed, after which differential and integral calculus is derived for vector-valued functions of multiple arguments are derived.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
56 h lectures, 28 h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**

Linear algebra I
Linear algebra II
Euclidean topology
Series and integrals

**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
No

## 802354A: Number Theory and Groups, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Kari Myllylä

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| ay802354A | Number Theory and Groups (OPEN UNI) | 5.0 op |
| 800333A | Algebra I | 8.0 op |

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
1. year, 3. period
**Learning outcomes:**
After completing the course, student is able to
- derive and proof main results in the course
- use and apply different proof techniques
- recognize algebraic structures and the concepts
- see connections and differences between different algebraic structures

**Contents:**
The course includes basics in arithmetics and algebraic structures, such as, congruence, residue classes, prime numbres, Euclidean algorithm, the fundamental theorem of arithmetic, Euler-Fermat formula, groups and morphisms. The course gives an understanding of algebraic terms and concepts used in mathematics and physics.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**

Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Kari Myllylä
**Working life cooperation:**
-

## 801195P: Probability Theory, 5 op

**Voimassaolo:** 01.01.2011 -

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Tuominen, P.**, , 1993

**Opintokohteen kielet:** Finnish

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish (possible also in English)
**Timing:**
First year, 2. period
**Learning outcomes:**
On successful completion of this course, the student will be able to
- solve simple practical problems associated with probability
- solve simple theoretical problems associated with probability
- derive the basic properties of probability, starting from the axioms
**Contents:**
The course is an introduction to Probability. After review of high school curriculum material, the axiomatic approach to Probability is introduced. The most important concepts are the probability space, conditional probability, independence, a random variable as well as its distribution and expected value.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
32 h lectures, 16 h exercises
**Target group:**
Major students
**Prerequisites and co-requisites:**
802151P Introduction to mathematical deduction
802154P Elementary functions
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Lasse Holmström
**Working life cooperation:**
-

## 802355A: Rings, Fields and Polynomials, 5 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Kari Myllylä

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800333A Algebra I 8.0 op

**ECTS Credits:**
5 ECTS credits
**Language of instruction:**
Finnish
**Timing:**
Second year, 1. period
**Learning outcomes:**
After completing the course, student is able to

- derive and proof main results in the course
- use and apply different proof techniques
- recognize algebraic structures and the concepts
- see connections and differences between different algebraic structures

**Contents:**
The course introduces algebraic structures, such as rings, polynomial rings, ideals, integral domains, fields, finite fields, field extensions and quotient field. The course gives an understanding of algebraic terms and concepts used in mathematics and physics.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
28h lectures, 14h exercises
**Target group:**
Major students
**Prerequisites and co-requisites:**
802354A Number theory and groups
**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exam or final exam
**Grading:**
1-5
**Person responsible:**
Kari Myllylä
**Working life cooperation:**
-

## 801323A: Seminar, 6 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

800331A Proseminar 10.0 op

**ECTS Credits:**
6 cr

**Language of instruction:**
Finnish (also English)
**Timing:**
2.-3. year of studies
**Learning outcomes:**
After completing the Bachelor's thesis, student
- is able to form a clear and logical
- is able to concentrate to important and essential details in the subject of thesis
- gain experience presenting mathematical concept and research studies.

**Contents:**
Proseminar (Bachelor's thesis) is a small mathematical study based on literature. Student is familiarized to write mathematical texts and obtain information using literature. Thesis includes a oral presentation from the subject of the thesis.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Seminars and own work
**Target group:**
Major students
**Prerequisites and co-requisites:**
Compulsory basic and intermediate studies.
**Recommended optional programme components:**
Maturity test is written from the topic of Bachelor's thesis.
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Opinnäytetyö
**Grading:**
Pass/Fail
**Person responsible:**
Maarit Järvenpää
**Working life cooperation:**
-

## 802353A: Series and Integrals, 6 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Peter Hästö

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 800318A | Analysis 3 | 5.0 op |
| 802164P | Series and Integral | 5.0 op |

**ECTS Credits:**
6 ECTS credits
**Language of instruction:**
Finnish (possible also in English)
**Timing:**
First year, 4. period
**Learning outcomes:**
After completing the course, student is able to
- operate with real series
- separate the concept of continuity and uniform continuity
- define and calculate Riemann integrals
- derive and operate function sequences and function series
- calculate derivate and integrate function series

**Contents:**
The course is a continuum for the courses Limits and continuity and Derivative. Basic topological methods (presented in Euclidean Topology) are heavily used in proofs and methods involving continuous functions. The goal is the same as in the prerequisite courses, that is, to develop mathematical thinking and extend the knowledge of mathematical analysis.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
30h exercises, 14h exercises
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
802154P Elementary functions
802155P Limit and continuity
802156P Derivative
802352A Euclidean topology

**Recommended optional programme components:**
-
**Recommended or required reading:**
Lecture notes
**Assessment methods and criteria:**
Midterm exams or final exam
**Grading:**
1-5
**Person responsible:**
Peter Hästö
**Working life cooperation:**
-

## 806112P: Basic Methods of Data Analysis, 10 op

**Opiskelumuoto:** Basic Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jari Päkkilä

**Opintokohteen oppimateriaali:**

**Armitage, P.** , , 2002

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805305A | Introduction to Regression and Analysis of Variance | 5.0 op |

**ECTS Credits:**
10 cr
**Language of instruction:**
Finnish
**Timing:**
2. year, periods 1-2
**Learning outcomes:**
On successful completion of this course, the student will be able to
- analyze continuous and categorial response in the most common experimental and observational studies
- critically evaluate chosen model
- use some statistical software
**Contents:**
Skills for performing statistical analyses and inferences on the basis of data obtained in common experimental and observational studies are expanded and deepened. Topics included are e.g. (1) principles of collection, description, and modelling of, and inference on statistical data; (2) basic methods of analysing continuous outcome variables, like comparison of groups, analysis of variance, regression analysis, residuals and model diagnostics, nonparametric

methods, treatment of correlated and lifetime (censored) observations; (3) and basic methods of analysing binary, categorical and count data.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
56h lectures, 42h exercises
**Target group:**
Major and minor students.
**Prerequisites and co-requisites:**
Todennäköisyyslaskennan peruskurssi
806113P Introduction to statistics
802118P Linear algebra I
802154P Elementary functions
802155P Limits and continuity
802156P Derivative

**Recommended optional programme components:**
To be completed before 805310A Statistical inference I, 806359A Regression modelling and other studies in statistics.
**Recommended or required reading:**
Lecture notes,
Armitage P. & Berry, G. & Matthews, J.N.S.: Statistical Methods in Medical Research, 4th Edition, Blackwells, Oxford, 2001.
**Assessment methods and criteria:**
MId-term exam or final exam. Mid-term exam requires active participation into the course exercises.
**Grading:**
1-5
**Person responsible:**
Esa Läärä
**Working life cooperation:**
-

## 801396A: Introduction to Probability Theory II, 5 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Tuominen, P.**, , 1993
**Opintokohteen kielet:** Finnish

**ECTS Credits:**
4 cr
**Language of instruction:**
Finnish
**Timing:**
2. year, Fall semester
**Learning outcomes:**
On successful completion of this course, the student will be able to
- understand probability theory deeper than before
- apply various stocastic models
- derive the basic results associated with the new concepts introduced
**Contents:**
The course is a direct continuation for the course Probability Theory I. The new concepts include for instance the moments of a distribution, the probability generating function, the Law of Large Numbers, the Central Limit Theorem as well as two-dimensional distibutions.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
24h lectures, 12h exercises

**Target group:**
Major- and minor students. Recommended for students aiming to Master's degree with major in statistics or major in mathematics and computer sciences.
**Prerequisites and co-requisites:**
801195P Introduction to propability I
802352A Euclidean topology
802353A Series and integrals
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Lasse Holmström

## 806359A: Regression modelling, 10 op

**Voimassaolo:** 01.08.2012 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805351A | Linear Regression | 5.0 op |
| 805352A | Generalized Linear Models | 5.0 op |

**ECTS Credits:**
10 cr
**Language of instruction:**
Finnish
**Timing:**
2. year, periods 2-3
**Learning outcomes:**
After successful completion of the course the student is able to describe the basic concepts and assumptions of generalized linear models, as well as main principles of regression modelling, and is also able to apply these methods in the analysis of experimental or observational data.
**Contents:**
Generalized linear regression models for continuous, binary and count responses; model formulation, selection of variables and interpretation of parameters; fitting of models, estimation of parameters and prediction by the method of maximum likelihood; model criticism and diagnostics; use of R environment and SAS software in modelling.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Lectures (56 h), calculation and computation practicals (28 h), independent work.
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
Compulsory basic and intermediate studies in mathemtics (core studies), 801396A Introduction to propability II, 806112P Basic methods of data-analysis, and 805310A Statistical inference I
**Assessment methods and criteria:**
Final exam
**Grading:**
1-5
**Person responsible:**
Esa Läärä
**Working life cooperation:**
-

## 805310A: Statistical Inference I, 10 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Pawitan, Yudi** , , 2001
**Sprott, D. A.** , , 2000
**Kalbfleisch, J. G.** , , 1985

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805349A | Likelihood Inference | 5.0 op |
| 805350A | Estimation and Test Theory | 5.0 op |

**ECTS Credits:**
10 cr
**Language of instruction:**
Finnish
**Timing:**
2. or 3. year spring semester (periods 3-4).
**Learning outcomes:**
After successful completion of the course the student is able to describe the main principles of frequentist statistical inference, derive likelihood functions and from these compute point and interval estimates, test statistics and P-values for models with few parameters, as well as to interpret results such obtained.

**Contents:**
Statistical model and observed data; likelihood function, log-likelihood, score and information; construction and properties of point and interval estimates; likelihood ratio, score and Wald statistics and their asymptotic sampling distributions; jackknife and bootstrap methods; elements of Bayesian inference; Use of R environment in inferential tasks.

**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
Lectures (56 h), calculation and computation practicals (28 h), and independent work.
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
Introduction to propability I
Basic methods of data-analysis
**Recommended optional programme components:**
Requirement for further studies in statistics.
**Assessment methods and criteria:**
Mid-term exams or final exam
**Grading:**
1-5
**Person responsible:**
Hyon-Jung Kim-Ollila
**Working life cooperation:**
-

## 805340A: Statistical Software, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

805353A Statistical Software 5.0 op

**ECTS Credits:**
4 cr
**Language of instruction:**
English
**Timing:**
3. year studies. Fall semester. Timing varies.
**Learning outcomes:**
After successful completion of the course the student can use independently major statistical software needed in data analysis.
**Contents:**
The course covers R, SAS and SPSS, and their most important tools for data management, statistical computation, graphics and programming will be introduced and proficiency for their fluent use is acquired.
**Mode of delivery:**
Face-to-face teaching
**Learning activities and teaching methods:**
34 h lectures and computer class exercises.
**Target group:**
Major and minor students
**Prerequisites and co-requisites:**
Basic methods of data-analysis
**Recommended optional programme components:**
-
**Recommended or required reading:**
-
**Assessment methods and criteria:**
Home work
**Grading:**
1-5
**Person responsible:**
Hyon-Jung Kim-Ollila
**Working life cooperation:**
-

## H326635: Optional intermediate studies in statistics, 0 - 180 op

**Voimassaolo:** 01.08.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Study module

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

*Electives*

### 805324A: Time series analysis, 5 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Harvey, Andrew C.** , , 1993
**Lütkepohl, Helmut** , , 1991
**Hamilton, James D.** , , 1994

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

5 cr

**Learning outcomes:**

After finishing the course, a student can apply linear, nonlinear and nonparametric modeling of time series. A student learns how to choose between alternative time series models and can apply computer programs to fit time series models. Furthermore, a student learns to read scientific articles about time series.

**Contents:**

The course covers basic concepts of time series analysis: stationarity, autocorrelation, spectral distribution and periodogram. Linear time series analysis includes explanation, prediction, parameter estimation and model diagnostics in ARMA models. Nonlinear time series analysis includes threshold models and heteroskedastic time series models (ARCH and GARCH). Furthermore, nonlinear nonparametric smoothing is covered (time space smoothing and state space smoothing) and nonparametric estimation of spectral densities. Nonparametric function estimation includes kernel estimation, local polynomial regression and additive modeling.

**Recommended or required reading:**

Fan, J. ja Yao, Q. (2005). Nonlinear Time Series, Springer.

**Person responsible:**

Jussi Klemelä

### 806351A: Introduction to Independent Component Analysis, 4 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805334A: Analysis of categorical data, 9 op

**Voimassaolo:** - 28.02.2011

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opintokohteen oppimateriaali:**
**Agresti, Alan** , , 1990
**Christensen, Ronald** , , 1990
**McCullagh, Peter** , , 1989
**McCulloch, Charles E.** , , 2001

**Opintokohteen kielet:** Finnish

**ECTS Credits:**

9 cr

**Learning outcomes:**

A student who has succesfully completed the course is supposed to
- be familiar with generalized linear models and to be able to use them when studying discrete data
- be able to model the behaviour of ordinal dependent variables
- be able to make use of so-called mixed models while studying discrete or ordinal data

**Contents:**

The course deals with the analysis of contingency tables and with models for qualitative and ordinal dependent variables. Models for truncated dependent variables are also briefly touched. A majority of these models can be interpreted as generalised linear models (GLIM). This is why the essentials of the GLIM-theory and the corresponding phraseology is presented. So-called generalised mixed linear models (including random effects) and the estimation of their parameters by the GEE and the ML methods are also discussed. The course can be taken either as a graduate course or as an undergraduate course. It consists of 52 hours of lectures and 36 hours of excercises in the computer lab.

**Person responsible:**

Markku Rahiala

### 805328A: Multivariate analysis, 9 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805333A: Robust methods, 6 op

**Voimassaolo:** - 31.07.2007
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805398A: An introduction to stochastic modelling, 8 op

**Voimassaolo:** - 01.09.2012
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen oppimateriaali:**
**Severini, Thomas A.** , , 2005
**Mood, Alexander M.** , , 1974
**Giri, Narayan C.** , , 1975
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805380A: Clinical biostatistics, 6 op

**Voimassaolo:** - 01.09.2012
**Opiskelumuoto:** Basic Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa

**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806330A: Analysis of Market Risk, 5 op

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

806630S Market Risk Analysis 5.0 op

**ECTS Credits:**

5 cr

**Language of instruction:**

Finnish

**Timing:**

3. year of studies or later. Timing varies.

**Learning outcomes:**

The student knows how to estimate the unconditionalvalue-at-risk using empirical quantiles, parametric modeling, semiparametricmodeling, and extreme value theory.The student knows also how to estimate the conditionalvalue-at-risk using GARCH models.The student can read scientific articles about risk management.

**Contents:**

The course is an introduction to the quantitative risk management of aportfolio of stocks. The course introduces various risk measures,extreme value theory, and modeling of financial time series. The course covers:

- conditional and unconditional loss distribution,
- Value-at-Risk and other risk measures,-standard methods of estimating
- Value-at-Risk: multivariate normalmodeling, historical simulation/empirical quantiles, and the MonteCarlo method,
- modeling of distributions: multivariate distributions, normal mixturedistributions, spherical and elliptical distributions, and dimensionreduction,
- modeling of financial time series: ARMA models, GARCH models, andvolatility models,-copulas and measures of dependence,
- extreme value theory: block maxima and threshold exceedance methods.

**Mode of delivery:**

Face-to-face teaching

**Learning activities and teaching methods:**

Besides lectures, there are voluntary exercises.

**Target group:**

students of mathematical sciences, students of financeand economics

**Prerequisites and co-requisites:**

806113P Introduction to Statistics

**Recommended optional programme components:**

-

**Recommended or required reading:**

McNeil, A. J., Frey, R., and Embrechts, P. (2005).Quantitative Risk Management: Concepts, Techniques and Tools,Princeton Series in Finance, 608 pp.

**Assessment methods and criteria:**

Final exam

**Grading:**

1-5

**Person responsible:**

Jussi Klemelä

**Working life cooperation:**

-

**Other information:**

Home page of the course is http://cc.oulu.fi/~jklemela/marketrisk/

### 805309A: Statistical methods in epidemiology, 9 op

**Voimassaolo:** 01.06.2009 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Läärä Esa

**Opintokohteen oppimateriaali:**

**Santos Silva, Isabel dos** , , 1999
**Clayton, David** , , 1993
**Rothman, Kenneth J.** , , 1998

**Opintokohteen kielet:** Finnish

### 805339A: The Statistical Foundation of Econometrics, 5 - 6 op

**Voimassaolo:** 01.06.2010 -

**Opiskelumuoto:** Intermediate Studies

**Laji:** Course

**Vastuuyksikkö:** Department of Mathematical Sciences

**Arvostelu:** 1 - 5, pass, fail

**Opettajat:** Jussi Klemelä

**Opintokohteen oppimateriaali:**

**Hayashi, Fumio** , , 2000
**Gourieroux, Christian** , , 1995
**Gourieroux, Christian** , , 1995
**Harvey, Andrew C.** , , 1990

**Opintokohteen kielet:** Finnish

**Leikkaavuudet:**

| | | |
|---|---|---|
| 805683S | The statistical foundations ofeconometrics | 5.0 op |

**ECTS Credits:**

5/6 cr

**Learning outcomes:**

The course familiarizes students with applications of statistical models when inferences are made on economic phenomena. The principles of statistical inference on economic phenomena are the same as those of general statistical inference but there are some special issues that make the inference different in economics than in other application areas of statistics. After finishing the course, a student can apply both linear regression and nonlinear regression and a student is able to apply the generalized method of moments as well as the method of instrumental variables. A student can diagnose the validity of the assumptions of the linear regression model and tune his inferences accordingly.

**Contents:**

The course starts with the study of the linear regression model, and covers asymptotic inference related to the linear regression model, tests of the parameter restrictions and tests of a structural change. Besides linear regression, also nonlinear regression and the generalized method of moments is covered, as well as inference based on instrumental variables and problems stemming from measurement errors.
Inference under heteroscedasticity and autocorrelated disturbances is included. The basic theory of time series analysis (cointegration and autoregressive conditional heteroscedasticity) and the basic theory of panel data is included.

**Recommended or required reading:**

William H. Greene: Econometric Analysis (Prentice Hall)

**Person responsible:**

Jussi Klemelä

### 805332A: Design of experiments, 9 op

**Voimassaolo:** - 31.07.2007
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 805308A: Analysis of longitudinal data, 5 op

**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

### 806357A: Statistical finance, 5 op

**Voimassaolo:** 01.08.2010 -
**Opiskelumuoto:** Intermediate Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Jussi Klemelä
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## Tutkintorakenteisiin kuulumattomien opintokokonaisuuksien ja -jaksojen kuvaukset

### 806623S: An introduction to stochastic modelling, 8 op

**Opiskelumuoto:** Advanced Studies

**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Läärä Esa
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 806627S: Linear mixed models in the analysis of panel data, 6 op

**Voimassaolo:** 01.08.2009 -
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 806625S: Multivariate analysis, 6 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 806617S: Nonparametric and robust methods, 8 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 806604S: Principles of bayesian inference, 10 op

**Voimassaolo:** - 01.09.2012
**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opettajat:** Hyon-Jung Kim-Ollila
**Opintokohteen oppimateriaali:**
**Andrew Gelman et al.**, , 2004
**Lee, Peter M.** , , 1997
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.

## 806603S: Robust methods, 6 op

**Opiskelumuoto:** Advanced Studies
**Laji:** Course
**Vastuuyksikkö:** Department of Mathematical Sciences
**Arvostelu:** 1 - 5, pass, fail
**Opintokohteen kielet:** Finnish

Ei opintojaksokuvauksia.