Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Semester 1

	Lecture (UE)	Exercise (UE)	ECTS
Specialisation - Mathematics 1			30
Computational Science 2 (Optional)	28	28	4
Commutative Algebra (Optional)	30	30	8
Riemannian Geometry (Optional)	30	30	8
Partial Differential Equations I (Optional)	30	30	8
Algorithmic Number Theory (Optional)	30		4
Basics of Discrete Mathematics (Optional)	30		4
Probabilistic Models in Finance (Optional)	45		6
Student Project (Optional)	0		4
Numerical Analysis (Optional)		45	6
Probability (Stochastic Analysis) (Optional)	30	15	6
Discrete-time stochastic processes (Optional)	30	15	6
Complements to Graph Theory (Optional)	1		1
Introduction to Graph Theory (Optional)	30		3
Didactics - Mathematics 1 : In each of the 4 semesters of the Master in Secondary Education – Mathematics, the students are requested to choose 1 course in Didactics Professional Knowledge: research field school, educational system and policy, teaching and learning in the social context. Over the 4 semesters, all 3 fields must be covered. The students will be individually advised by the course director, who must validate their choice.			5
Applied Didactics I	30		2
Applied Didactics II	30		3
Internship in a secondary school I			0

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

	Lecture (UE)	Exercise (UE)	ECTS
General Competences I - Forschungsfeld Schule			5
Digitale Schule (1. Semester)	26		4
Einführung in die Schulpädagogik	28		0
Workshop zur Vorbereitung des Schulpraktikums für Studierende im 1. Semester. (Optional)	10		0

Semester 2

	Lecture (UE)	Exercise (UE)	ECTS
Module Specialisation - Mathematics 2			0
Algebraic Topology (Optional)	45		8
Riemann Surfaces (Optional)	30	30	8
Advanced Stochastic Models and Financial Applications (Optional)	30		5
Numerical Methods for Variational Problems (Optional)		30	5
Numerical solution of partial differential equations and applications (Optional)		45	6
Student seminar (Optional)	30		2
Algebraic Number Theory (Optional)	45		6
Partial Differential Equations II (Optional)	30	30	8
Advanced Graph Theory (Optional)	45		6
Continuous Time Models in Mathematical Finance (Optional)	30	30	8
Module Didactics - Mathématics 2			5
Learning and teaching mathematics I	30		2
Module Didactics - Mathématics 2			5
Hands-on experiences with mathematical didactics I	30		3

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

	Lecture (UE)	Exercise (UE)	ECTS
Module 4 : General Professional Competence II			5
Mehrsprachigkeit im Sprach- und Fachunterricht (MATH)	28		3
Workshop zur Vor- und Nachbereitung des Schulpraktikums	30		2

Semester 3

	Lecture (UE)	Exercise (UE)	ECTS
Specialisation - Mathematics 3			30
Student Group Project (Optional)	0		2
Arithmetic Geometry (Optional)	45		6
Advanced Discretization Methods (Optional)	30		5
Advanced Stochastic Modelling (Optional)	30		5
Data Science (Optional)	30		5
Numerical solution of partial differential equations and applications (Optional)		30	5
Continuous-Time Stochastic Calculus and Interest Rate Models (Optional)	30		5
Lie Algebras and Lie Groups (Optional)	45		6
Gaussian processes and applications (Optional)	30		5
Combinatorial Geometry (Optional)	30	15	6
Didactics - Mathematics 3			5
Applied Didactics III	30		2
Applied Didactics IV	30		3
Internship in secondary school II	0		0

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

	Lecture (UE)	Exercise (UE)	ECTS
General Competences III - Lehren und Lernen im sozialen Kontext			5
Teaching Children with Special Educational Needs (Optional)	28		0
Einführung in die Pädagogische Psychologie (Optional)	28		0
Digitale Schule (3. Semester) (Optional)	30		0
Workshop zur Vor- und Nachbereitung des vertiefenden Schulpraktikums (Optional)	15		0

Semester 4

	Lecture (UE)	Exercise (UE)	ECTS
Module Didactics - Mathematics 4			5
Learning and teaching mathematics II	30		2
Hands-on experiences with mathematical didactics II	30		3
Module Specialisation - Mathematics 4			20
Master Thesis	1		20
Module 4.3 : General Professionnal Competence IV - FHSE			3
Workshop Professionell Auftreten	28		1
Workshop: Nachbereitung des vertiefenden Schulpraktikums	10		2

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Semester 1

Computational Science 2

Module:	Specialisation - Mathematics 1 (Semester 1)
ECTS:	4
Objective:	Computational Science is a field of applied computer science, that is, the application of computer science to solve problems across a range of disciplines. It combines computer simulation, scientific visualization, mathematical modeling, computer programming and data structures, networking, database design, symbolic computation, and high performance computing with various disciplines. This area offers exposure to many valuable ideas and techniques, including precision of numerical representation, error analysis, numerical techniques, parallel architectures and algorithms, modeling and simulation, information visualization, software engineering, and optimization.
Description:	1. Minimisation 1.1. interior extremum +Newton 1.1.1. Understand the principle of and be able to minimise a function with the NR method 1.2. Conjugate gradient 1.2.1. Understand the principle of and be able to minimise a function using nonlinear CG 1.3. Genetic minimisation 1.3.1. Understand the principle of and be able to minimise a function with GO 1.4. Trust region 1.4.1. Understand the principle of and be able to minimise a function with the trust region method 2. Numerical differentiation 2.1. finite difference 2.1.1. Understand the principle of and be able to find the derivatives of a function with finite differences 2.2. adjoint methods 2.2.1. Understand the principle of and be able to find the derivatives of a function with adjoint methods 3. Constrained minimisation 3.1. Substitution 3.1.1. Understand the principle of and be able to deal with constraints using substitution 3.2. Penalty method 3.2.1. Understand the principle of and be able to deal with constraints using penalties 3.3. Lagrange multipliers 3.3.1. Understand the principle of and be able to deal with constraints using Lagrange multipliers 3.4. Augmented Lagrangian 3.4.1. Understand the principle of and be able to deal with constraints using augm. Lagrangian method 3.5. equality vs inequality constraint 3.5.1. Understand the difference between equality and inequality constraints and be able to deal with both
Language:	Anglais

Mandatory: Non

Evaluation: During the course (weeks 5 and 8), the student will receive two short exams, strongly based on the exercises in the lectures notes. The grades of these short exams will each be weighted with 20% for the final grade. At the end of the course (in the exam period), a final exam will take place, which will be weighted for 60%. The final grade is thus composed by 0.2 times the grade of the first short exam, by 0.2 times the grade of the second short exam, and by 0.6 times the grade of the final exam.
Redoing sudents:
Will receive two new short exams and a final exam during the summer semester (short exams in weeks 5 and 8, final exam in the exam period of the summer semester).
The weight factors of these exams are the same as described above.
(No lectures are provided during summer semester).

Remark: Notes and exercises will be provided. These notes and exercises are amongst others based on "Nocedal, J & Wright, S.J., Numerical optimisation. Springer Series in Operational Research and Financial Engineering, 2nd Edition, Springer Science+Business Media, LLC, New York, USA (2006). ISBN-10: 0-387-30303-0, ISBN-13: 978-0387-30303-1

Professor: BEEX Lars

Commutative Algebra

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 8

Objective: Learn the concepts of commutative algebra in relation to applications in algebraic number theory, algebraic geometry and other fields of mathematics.

Course learning outcomes: The successful students possesses deepened and extended knowledge of the topics treated in Commutative Algebra.

Description: In number theory one is naturally led to study more general numbers than just the classical integers and, thus, to introduce the concept of integral elements in number fields. The rings of integers in number fields have certain very beautiful properties (such as the unique factorisation of ideals) which characterise them as Dedekind rings. Parallely, in geometry one studies affine varieties through their coordinate rings. It turns out that the coordinate ring of a curve is a Dedekind ring if and only if the curve is non-singular (e.g. has no self intersection).
With this in mind, we shall work towards the concept and the characterisation of Dedekind rings. Along the way, we shall introduce and demonstrate through examples basic concepts of algebraic geometry and algebraic number theory. Moreover, we shall be naturally led to treat many concepts from commutative algebra.
Depending on the previous knowledge of the audience, the lecture will cover all or parts of the following topics:
- General concepts in the theory of commutative rings
  + rings, ideals and modules
  + Noetherian rings
  + tensor products
  + localisation
  + completion

+ dimension
- Number rings
  + integral extensions
  + ideals and discriminants
  + Noether's normalisation theorem
  + Dedekind rings
  + unique ideal factorisation
- Plane Curves
  + affine space
  + coordinate rings and Zariski topology
  + Hilbert's Nullstellensatz
  + resultant and intersection of curves
  + morphisms of curves
  + singular points

Teaching modality: Lecture course and problem sessions

Language: Anglais

Mandatory: Non

Evaluation: Mode: Continuous or Combined

For Master in Mathematics
The final mark is the arithmetic mean of a mark from continuous assessment (homework, supervised exercises, presentations) and a mark for the final exam.

For Master in Secondary Education - Mathematics
The final mark is the arithmetic mean of a mark from continuous assessment (homework, supervised exercises, presentations) and a mark for a didactical paper.

Remark: **Lecture notes, exercise sheets**(available on Moodle)
Literature
There are many books on commutative algebra, for example:
- E. Kunz, Introduction to Commutative Algebra and Algebraic Geometry.
- Dino Lorenzini. An Invitation to Arithmetic Geometry, Graduate Studies in Mathematics, Volume 9, American Mathematical Society.
- M. F. Atiyah, I. G. Macdonald. Introduction to Commutative Algebra, Addison-Wesley Publishing Company.

Professor: WIESE Gabor, LA ROSA Alfio Fabio, KIEFER Ann

Riemannian Geometry

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 8

Objective: The objective is to allow the student to familiarize himself with a very active field of mathematics, with broad applications throughout science. Beyond this goal, special emphasizes will be put on the Mathematical Method, i.e., the optimal technique to learn and apply mathematics, in particular in order to solve real life problems using mathematical tools. This method is the most important of the objectives of any study program in mathematics.

Course learning outcomes:
On successful completion of the course, the student should be able to:
- Explain the main definitions and results of Differential and Riemannian Geometries
- Comment on new concepts, like the category of smooth manifolds, smooth scalar observables, their derivatives, vector bundles, tensor fields, Lie derivatives, covariant derivatives, Christoffel symbols, curvature, torsion, Riemannian manifolds, Levi-Civita connection, parallel transport, geodesics, as well as various types of curvature on Riemannian manifolds
- Apply the new techniques and solve related problems
- Structure the acquired abilities and summarize essential aspects adopting a higher standpoint
- Give a talk for peers or students on a related topic and write scientific texts or lecture notes, observing modern standards in scientific writing, in Didactics and in Pedagogy
- Provide evidence for the mastery of the Mathematical Method

Description:
Differential and Riemannian Geometries have applications in numerous fields of science, including Einstein's general theory of relativity, string theory, black holes and galaxy clusters, probability, engineering, economics, modeling and design, wireless communication and image processing, biology, chemistry, geology…
The main concept in Differential Geometry are differential manifolds - roughly, higher dimensional analogs of curves and surfaces. To be able to use efficiently these new spaces, a generalization of fundamental mathematical notions, such as derivatives and integrals, is required.
As for Riemannian manifolds, they are differential manifolds that come equipped with a metric, which then allows for concepts like length, area and volume on the manifold considered.
This metric is also an essential ingredient of the definition of the curvature of a Riemannian or pseudo-Riemannian manifold. Curvature is the most important aspect of (pseudo-) Riemannian manifolds: they are curved spaces like, for instance, the Universe. To understand the fundamental concept of curvature, a prior excursion in the world of connections (a kind of derivatives) on vector bundles (manifolds with additional structure) is indispensable.

Teaching modality: Interactive lectures and exercise sessions

Language: Anglais

Mandatory: Non

Evaluation: Oral or written exam

Remark: **BIBLIOGRAPHY**
1. M. P. do Carmo, Riemannian Geometry, Birkhäuser (1992)
2. W. Klingenberg, Riemannian Geometry, de Gruyter (1995)
3. John M. Lee, Riemannian Manifolds, Springer (1997)
4. P. Petersen, Riemannian Geometry, Springer (2006)

Professor: PONCIN Norbert, PISTALO Damjan

Partial Differential Equations I

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 8

Objective: The goal of the course it to get acquainted with Partial differential equations (PDE) as a powerful tool for modeling problems in science, providing functional analytic techniques in order to deal with PDE.

Course learning outcomes: On successful completion of the course the student should be able to:

- Apply methods of Fourier Analysis to the discussion of constant coefficient differential equations
- Work freely with the classical formulas in dealing with boundary value problems for the Laplace equation
- Prove acquaintance with the basic properties of harmonic functions (maximum principle, mean value property) and solutions of the wave equation (Huygens property)
- Solve Cauchy problems for the heat and the wave equations
- Give a pedagogic talk for peers on a related topic

Description: Fourier transform, the classical equations, spectral theory of unbounded operators, distributions, fundamental solutions.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark:
1. Rudin: Functional analysis
2. Jost: Postmodern analysis
3. Folland: Introduction to partial differential equations.
4. Reed-Simon: Methods of mathematical physics I-IV

Professor: OLBRICH Martin, GROTTO Francesco, EL EMAM Christian

Algorithmic Number Theory

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 4

Course learning outcomes: On successful completion of the course, the student should be able to:

- Explain the main algorithms for primality testing, factorizing large integers, solving the discrete logarithm problem, both in the multiplicative group of finite fields, as well as in the context of elliptic curves defined over finite fields
- Read and understand some scientific articles published in the domain, and ask relevant questions
- Give a talk for peers on related topics
- Organize his approach to general problems in an algorithmic way

Language: Anglais

Mandatory: Non

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Professor: LEPREVOST Franck

Basics of Discrete Mathematics

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 4

Course learning outcomes: More important than the actual content of the course (given below), is the development of the student's mathematical maturity. Upon completing this course a student should be able to:

1. recall basic concepts and tools which should be present in any science curriculum, not only in mathematics and computer science, but also in engineering and other applied sciences,
2. formulate and solve mathematically several logical and combinatorial problems arising in science as well as in quotidian life, and
3. recognize the genuine pleasure in tackling problems and the blissful joy by attaining their solution.

Description: The content includes but is not limited to:

1. Discrete calculus: sums and recurrences; manipulation of sums; multiple sums; general methods; finite calculus; summation by parts.
2. Binomial coefficients: basic identities; binomial theorem; multinomial coefficients; Vandermonde's convolution; Newton series.
3. Generating functions: basic maneuvers; solving recurrences; exponential generating functions.
4. Special numbers: Stirling numbers; Eulerian numbers; Harmonic numbers; Harmonic summations; Bernoulli numbers; Fibonacci numbers.
5. Asymptotics: O Notation, Euler's summation formula.

Teaching modality: Lecture course
Course slides

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark: **Littérature / Literatur / Literature**(recommended but not mandatory):

- R. L. Graham, D. E. Knuth, and O. Patashnik, Concrete Mathematics, Addison-Wesley, 2nd edition, 2003.
- W. G. Kelley and A. C. Peterson, Difference Equations. An Introduction with Applications, Academic Press, 2nd edition, 2001.
- C. Mariconda and A. Tonolo, Discrete Calculus. Methods for Counting, Springer, 2016.
- D. E. Knuth, The Art of Computer Programming, Volume 1: Fundamental Algorithms, 3rd edition, Addison Wesley, 1997.

Professor: MARICHAL Jean-Luc

Probabilistic Models in Finance

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 6

Objective: Introductory course to basic concepts of Mathematical Finance, also suitable for students who are not going to choose their specialization in Finance. The goal is to deepen the knowledge of modern probability theory by studying applications of general interest in an actual field of applied mathematics.

Course learning outcomes: On successful completion of the course, the student should be able to:

- Derive and apply formulas for option pricing and hedging strategies
  Carry out calculations based on arbitrage arguments
- Calculate the price of European call and put options using the Cox, Ross and Rubinstein model
- Apply the techniques of Snell envelopes to evaluate American options
- Derive the classical Black-Scholes formulas as limiting case of a sequence of CRR markets

Description: Discrete financial markets, the notion of arbitrage, discrete martingale theory, martingale transforms, complete markets, the fundamental theorem of asset pricing, European and American options, hedging strategies, optimal stopping, Snell envelopes, the model of Cox, Ross and Rubinstein.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark: **Literature**

- D. Lamberton, B. Lapeyre: Introduction au calcul stochastique appliqué à la finance. Ellipses, 1997
- S. E. Shreve: Stochastic calculus for finance. I: The binomial asset pricing model. Springer Finance, 2004
- H. Föllmer, A. Schied: Stochastic finance. An introduction in discrete time. 2nd ed., de Gruyter, 2004
- F. Delbaen, W. Schachermayer: The mathematics of arbitrage. Springer Finance, 2006

Professor: AMORINO Chiara

Student Project

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 4

Description: The student project consists of project work that is carried out under the supervision of a professor or a postdoc. The work is either individual or group work. Group work needs the explicit approval of the Study Director.

At the beginning of the project, supervisor and student(s) define tasks to be carried out by the student(s), corresponding to the volume of 100 working hours (4 ECTS). The student(s) need to notify the Study Director of the project and the tasks at the latest on 15 October.
The project outcome is a pdf document written by the student.
Additional outcomes (such as computer code, images, videos) can be asked for.
The required outcome has to be handed in to the Study Director(s) and the supervisor at the latest on 31 December.
The student project can be done in the framework of the Experimental Mathematics Lab https://math.uni.lu/em

Language: Anglais

Mandatory: Non

Professor: WIESE Gabor

Numerical Analysis

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 6

Objective: At the end of the course, a student will be able

- to understand the main methods, the rigorous mathematical analysis and algorithms developed in numerical analysis
- to master their concrete coding starting from a pseudo-code to a Matlab implementation (that will be used as an example of programming language)
- to formulate some basic physics or engineering applications in view of their treatment by a numerical method and its computer solution.

Description: The objective of the course is to provide the main tools in numerical analysis to manage rigorously the computer solution of practical problems (physics, engineering).

The main results about the theory of numerical methods will be explained. During the course, the student will code some algorithms in Matlab to propose some concrete, robust and efficient scientific computing solutions to some concrete problems. The course content is the following:

1. Programming with Matlab
2. Polynomial interpolation and approximation
3. Numerical derivation and integration
4. Numerical solution of Ordinary Differential Equations
5. Numerical solution of nonlinear systems of equations
6. Numerical optimization
7. Linear algebra (linear system solution, eigenvalue problems)

Language: Anglais

Mandatory:	Non
Evaluation:	The evaluation will be based on a writing exam.
Remark:	Xavier ANTOINE, Numerical Analysis, course document. Xavier ANTOINE, A Course in Matlab, course document.
Professor:	ANTOINE Xavier

Probability (Stochastic Analysis)

Module:	Specialisation - Mathematics 1 (Semester 1)
ECTS:	6
Objective:	Introduction to basic concepts of Stochastic Analysis.
Description:	Continuous martingales, stochastic integration, quadratic variation, Itô calculus, theorem of Girsanov, stochastic differential equations, Markov property of solutions, connection of stochastic differential equations and partial differential equations, martingale representation theorems, chaotic expansions, Feynman-Kac formula.
Teaching modality:	Lecture course
Language:	Anglais
Mandatory:	Non
Evaluation:	Written exam
Remark:	I. Karatzas, S. Shreve: Brownian motion and stochastic calculus. 2nd edition. Springer, 1991 B. Oksendal: Stochastic differential equations. Springer, 2003 D. Revuz, M. Yor: Continuous Martingales and Brownian Motion. Springer Grundl., 1999
Professor:	PECCATI Giovanni, PERRUCHAUD Pierre

Discrete-time stochastic processes

Module:	Specialisation - Mathematics 1 (Semester 1)
ECTS:	6
Objective:	Introduction to basic concepts of modern probability theory
Course learning outcomes:	On successful completion of the course, the student should be able to: • Understand and use concepts of modern probability theory (e.g., filtrations, martingales, stopping times) • Apply the notion of martingale to model random evolutions • Know and apply classical martingale convergence theorems • Describe and manipulate basic properties of Brownian motion

Description: Filtrations, conditional expectations, martingales, stopping times, optional stopping, Doob inequalities, martingale convergence theorems, canonical processes, Markov semigroups and processes, Brownian motion.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark: H. Bauer, Wahrscheinlichkeitstheorie
D. Williams, Probability with Martingales

Professor: PILIPAUSKAITE Vytauté

Complements to Graph Theory

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 1

Description: Compared to the course Introduction to Graph Theory, the student will have an additional workload that will allow him/her to get a better understanding of a selection of the course topics.

Language: Anglais

Mandatory: Non

Evaluation: Continuous evaluation

Professor: TEHEUX Bruno

Introduction to Graph Theory

Module: Specialisation - Mathematics 1 (Semester 1)

ECTS: 3

Objective: On successful completion of the course the students should be able to

- understand the relevance of the topics covered in the course for their applications,
- master the proofs of the main results of the course,
- solve problems using the toolkit developed in the course
- be autonomous in learning in the field of Graph Theory.

Description: Through a presentation of selected topics, the course aims to be an introduction to graph theory, its applications and its algorithmic aspects. It is designed as a self-contained course and focused on problems pertaining to Data Science.

Possible topics for the course include, but are not limited to

- Graphs and digraphs, degree and the degree sequence algorithm

- Connectedness, distance, shortest paths and connected components algorithms
- Graph matching problems and algorithms
- Elements of algebraic graph theory and PageRank algorithm
- Graph traversal algorithms
- Trees and applications
- Minimum spanning tree algorithms
- Network flow, min cut – max flow theorem and Ford–Fulkerson algorithm
- Centrality and betweness measures
- Cluster analysis
- Random Graphs

Language: Anglais

Mandatory: Non

Evaluation: **First session**

Oral or written exam
The final grade is the maximum between the exam grade and the weighted arithmetic mean of the exam grade (weight 0.75) and the grade of the homework (weight 0.25).

Remark:

- R. Diestel, Graph Theory, Springer, 2017
- D. Jungnickel, Graphs, Networks and algorithms, Springer 2017

Professor: TEHEUX Bruno

Applied Didactics I

Module: Didactics - Mathematics 1 (Semester 1)

ECTS: 2

Objective:

- Comment lire et interpréter les différents programmes de mathématiques ?
- Quelle est la progression didactique à travers les 7 années de l'enseignement secondaires ?
- Quelles sont les similarités et les différences entre les attentes dans les différents ordres d'enseignement/sections ?
- Quelles sont les attentes finales et les questions d'examen qui les précisent ?
- Comment rendre opérationnel les notions de compétences procédurales ?

Course learning outcomes: Working through the program from a higher standpoint
secondary school analysis and geometry

Description: Le programme cadre pour l'enseignement des mathématiques dans l'enseignement secondaire classique et général :

- les domaines de l'analyse et de la géométrie
- les compétences à développer

Explicitation des finalités de l'enseignement des mathématiques à l'aide de questions d'examen

Préparation au concours de recrutement

Concepts-clé pour l'enseignement des mathématiques

- activités mathématiques de base
- apprentissage autonome
- situations d'apprentissage ouvertes et complexes
- résolution de problèmes

Language: Anglais

Mandatory: Oui

Professor: HAUSTGEN Marc Paul, COLLETTE-CLERBAUT Frédérique

Applied Didactics II

Module: Didactics - Mathematics 1 (Semester 1)

ECTS: 3

Objective:

- Comment puis-je planifier les leçons du point de vue de l'élève ?
- Comment puis-je formuler le sujet, le sujet et l'objectif d'apprentissage ciblé ?
- Comment vais-je analyser et préciser le sujet d'une leçon, prendre des décisions de réduction significatives et planifier en fonction des objectifs ?
- Comment vais-je structurer les leçons de manière à ce que les élèves soient capables de suivre la leçon et d'agir de diverses manières ?
- Comment puis-je préparer les tests et les examens en classe ?
- Comment corriger et évaluer les tests et examens de mathématiques en classe ?
- Comment puis-je utiliser les résultats des épreuves de manière diagnostique et remédiative ?

Description:

- Méthodes de planification de leçons avec choix de méthodes et de formes sociales appropriées
- Méthodes de communication et d'aide à la compréhension
- Gestion de l'erreur dans le processus d'apprentissage
- Observation, description et évaluation de processus d'apprentissage
- Conception d'épreuves d'évaluation
- Travail avec des grilles de compétences/indicateurs

Mandatory: Oui

Professor: BINDELS Gene

Internship in a secondary school I

Module: Didactics - Mathematics 1 (Semester 1)

ECTS: 0

Language: Français

Mandatory: Oui

Evaluation: Validated in S2

Digitale Schule (1. Semester)

Module: Modul: Forschungsfeld Schule (Semester 1)

ECTS: 4

Course learning outcomes:

- Erweiterung der eigenen digitalen Kompetenzen im Hinblick auf didaktische Einbindung von digitalen Technologien im Schulunterricht
- Schaffung eines medienkritischen Bewusstseins mit spezifischem Blick auf Situationen des Lehrens und des Lernens (u.a. Schülerinnen und Schülern einen selbstständigen Umgang mit digitalen Medien zu vermitteln).
- Planung eigener Lehr-Lern-Arrangements.

Description: Thema des Kurses ist der Umgang mit digitalen Technologien für den Einsatz im Schulunterricht. Dabei werden einerseits die didaktischen Potenziale derselben an Fallbeispielen erprobt, diskutiert und auch kritisch hinterfragt. Im Wechsel zwischen Praxis und Theorie werden andererseits verschiedene digitale Tools vorgestellt und durch gezielte Aufgabenstellungen vermittelt. Begleitet werden diese praxisbezogenen Studien von theoretischen Auseinandersetzungen, ebenso sind kulturelle und gesellschaftliche Aspekte der digitalen Medien Kursinhalt.

Language: Allemand

Mandatory: Oui

Evaluation: Praktische Prüfung in Form einer Lehr-Lern-Einheit.

Remark: **Bibliografie**

Wird in der Veranstaltung bekanntgegeben und über Moodle zur Verfügung gestellt.

Professor: HARION Dominic

Einführung in die Schulpädagogik

Module: Modul: Forschungsfeld Schule (Semester 1)

ECTS: 3

Course learning outcomes: Die Studierenden haben gelernt…

- Sinn, Absicht und Realität von Schule unter einem historischen, pädagogischen und soziologischen Blickwinkel zu analysieren
- den Lehrerberuf als Profession zu verstehen
- den Zusammenhang von Bildung, Bildungszielen und Bildungsplänen zu erkennen
- Lernen als sozialen Prozess zu beschreiben.
- Verschiedene Ideen davon, was „guten Unterricht" ausmacht zu diskutieren

Die Studierenden sind in der Lage …

- professionelle Standards von Lehrerhandeln umzusetzen

- die Bedingungen des luxemburgischen Schulsystems zu analysieren und verschiedene Theorien zur Unterrichtsqualität und Diagnostik anzuwenden

Description: Die Vorlesung „Einführung in die Schulpädagogik" analysiert die (luxemburgische) Schule als eine historisch gewachsene Institution, die ganz unterschiedlichen Zwecken dient bzw. dienen soll. Dabei stehen pädagogische, soziologische und historische Erklärungsansätze im Mittelpunkt der Beschreibung schulischer Wirklichkeiten. Zudem werden der Lehrerberuf sowie die Schulentwicklung (Curricula, Bildungsziele etc.) auf ihre professionellen Begründungen hin vorgestellt und hinterfragt. Die Vorlesung führt ebenfalls in die wichtigsten Ideen zum Thema „Lernen" und zur Unterrichtsqualität ein.

Language: Allemand, Anglais

Mandatory: Oui

Evaluation: Klausur

Remark: **Bibliografie**

- Ludwig Haag, Sibylle Rahm, Hans Jürgen Apel, Werner Sacher (Hrsg.): Studienbuch Schulpädagogik. Verlag Julius Klinkhardt 2013.
- Hanna Kiper, Hilbert Meyer, Wilhelm Topsch (Hrsg.): Einführung in die Schulpädagogik. Cornelsen Verlag 2011.
- Ilona Esslinger-Hinz, Anne Sliwka (Hrsg.): Schulpädagogik. Beltz Verlag 2011.

Professor: LENZ Thomas

Workshop zur Vorbereitung des Schulpraktikums für Studierende im 1. Semester.

Module: General Competences I - Forschungsfeld Schule (Semester 1)

ECTS: 0

Course learning outcomes: Lernziele: Die Studierenden…

… sind vertraut mit den theoretischen Grundlagen allgemeiner Didaktik und können diese in unterrichtspraktische Anwendungsfelder übertragen.

… haben ein Basiswissen pädagogischer Diagnostik erworben und können dieses handlungsleitend in Unterrichtshospitation und Unterrichtsplanung umsetzen.

… haben ihren eigenen Wissensstand und ihre Kompetenzen in Theorie und Unterrichtspraxis reflektiert und auf dieser Basis persönliche Entwicklungsziele und Forschungsinteressen für ihr Studium identifiziert.

Description: Der Workshop dient einerseits der Einführung in die Allgemeine Didaktik und fokussiert sowohl auf theoretische Grundlagen und praxisorientierte Umsetzung diagnostischer Verfahren zu Vorbereitung der Unterrichtshospitation wie auch auf Gestaltungsmöglichkeiten von Unterricht zur Vorbereitung der eigenen Unterrichtspraxis im Rahmen des orientierenden Praktikums.

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Andererseits werden eigene Wissens- und Erfahrungsstände der Studierenden gemeinsam mit den das Praktikum begleitenden Lehrpersonen reflektiert, um individuelle Entwicklungsziele und Forschungsinteressen für das Masterstudium zu identifizieren.

Die Workshopinhalte und Lernziele sind ebenso wie die zu Grunde gelegte Literatur mit den Didaktiken der jeweiligen Fächer abgestimmt und bilden den allgemeinen bildungswissenschaftlichen Rahmen derselben.

Language: Allemand, Français

Mandatory: Non

Remark: **Bibliographie**

Ein Reader mit Grundlagentexten wird zu Beginn des Semesters über Moodle zur Verfügung gestellt. Dieser ist vor Beginn der Workshops zu bearbeiten.

Professor: HARION Dominic

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Semester 2

Algebraic Topology

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 8

Objective: On successful completion of the course, the student should be able to:

- Explain the main definitions and results of Algebraic Topology;
- Comment on new concepts;
- Apply the new techniques and solve problems;
- Structure the acquired abilities and summarize essential aspects adopting a higher standpoint;
- Give a talk for peers or students on a related topic and write scientific texts or lecture notes, observing modern standards in scientific writing, in Didactics and in Pedagogy;
- Provide evidence for the mastery of the Mathematical Method.

Description: Topologyis a field of mathematics that deals with the fundamental properties of spaces. In the topological world, two spaces are considered identical if they can be continuously transformed into one another or more generally, if they are related by what topologists call homotopy equivalence. For example, a sphere and a pyramid are identical, as are a donut and a coffee cup… A main goal is therefore to classify spaces up to homotopy equivalence.

Algebraic topologyuses algebraic methods to solve this and other topological problems. An important method is the search for algebraic homotopy invariants. In particular, we try to assign an algebraic object such as a group to each topological space and to prove that this group is invariant if we replace the space with a homotopy equivalent space. One of the proofs of the fundamental theorem of algebra uses an algebraic invariant.

Algebraic topology is closely related to homological algebra(a toolset for extracting information from a widely used type of sequence of arrows and nodes), which in turn has evolved in parallel with category theory(a language or framework that focuses on the basic components of a given structure).

We will study the basics of category theory and homological algebra in parallel with algebraic topology. The main homotopy invariants we discuss are the 'singular homology functor' and the 'homotopy functor'. An amazing result called the Hurewicz isomorphism, shows that the first singular homology group and the (abelianized) first homotopy group of a space are two variants of the same information. Van Kampen's theorem allows us to practice our understanding of category theory and to compute homotopy groups of larger spaces from those of smaller spaces from which they are constructed. The final chapter will highlight the relationship between the coverings of a space and subgroups of its first homotopy group.

The objective is to allow the student to familiarize himself with a very active field of mathematics, with broad applications throughout science. Beyond this goal, special emphasizes will be put on the Mathematical Method, i.e., the optimal technique to learn and apply mathematics, in particular in order to solve real life problems using mathematical tools. This method is the most important of the objectives of any study program in mathematics.

Basics of category theory
Categories, 2-categories, functors, natural transformations, groupoids, products and coproducts, limits and colimits, examples and applications.

Fundamental concepts of homological algebra
Chain complexes, chain maps, chain homotopies, homology functor, connecting homomorphism, Künneth isomorphism, simplicial and singular homology, homotopy invariance, examples and application.

Homotopy groups
Algebra and topology (revision), first homotopy group, Hurewicz isomorphism, homotopy functor, homotopy invariance, typical examples and applications.

Van Kampen theorem
Free product with amalgamation, Van Kampen-Seifert theorem (basic, general and groupoid version), examples and applications (in particular: first homotopy group of a product and of a coproduct.

Covering space theory
Coverings of spaces, lifting property, coverings of groupoids, orbit categories, classifications and constructions of coverings, connections with the preceding chapters, examples and application.

Language: Anglais

Mandatory: Non

Evaluation: Students choose between an oral and written exam, and an evaluation based on a dossier.

Remark: **Literature**

- Allen Hatcher, Algebraic Topology, Cambridge University Press, 2002 - Mathematics - 544 pages, ISBN-13: 978-0521795401
- Peter May, A concise course in Algebraic Topology, University of Chicago Press, 1999 - Mathematics - 243 pages, ISBN-13: 978-0226511832
- Charles Weibel, An introduction to homological algebra, Cambridge studies in advanced mathematics 38, 1997, ISBN: 0-521-55987-1
- Saunders Mac Lane, Categories for the Working Mathematician, Graduate Texts in Mathematics, 5(2), Springer, 1978, ISBN: 978-0-387-98403-2

Professor: PONCIN Norbert

Riemann Surfaces

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 8

Objective: At the end of the course the students should have a basic understanding of what Riemann surfaces are and how they can be studied from different points of view, especially the complex and topological one. They should be able to understand and solve simple problems involving the material from the course.

Description: A primary goal of various kinds of geometric theories is to describe shapes of arbitrary dimensions from a mathematical point of view. One way to do so is to build such shapes out of pieces of a euclidean space R^n, obtaining smooth manifolds. In some cases, smooth manifolds can be covered instead with pieces of a complex affine space C^n: when the complex dimension is 1, such a manifold is a Riemann surface (its real dimension will be 2).
From a topological point of view, we will be looking simply at a sphere, a doughnut, or a surface with more "holes"; however, the mere existence of a complex structure provides the foundations for an extremely rich theory. Riemann surfaces lie at the crossroads of many fields of research of modern mathematics: topology, complex and algebraic geometry, number theory and harmonic analysis, among others.
The course will cover the basic notions of the theory, starting from the definition of a complex manifold, and move on to the classification of Riemann surfaces via the study of their divisors. This will allow the students to acquire familiarity with some ubiquitous tools from complex geometry, such as the Riemann-Roch theorem.
We will put some focus on examples along the way. If time allows, we will see how some constructions from the complex analytic theory can be reinterpreted in the language of modern algebraic geometry, bridging the gap between the two worlds, and we will touch some more advanced topics that could inspire the students' further work.

Language: Anglais

Mandatory: Non

Evaluation: Weekly exercise will be provided and the students will be asked to present some of them orally. This will provide for continuous evaluation that will make up for 1/3 of the grade. The remaining 2/3 will be given by the result of a final oral exam.

Remark: Literature

- Rick Miranda, Algebraic Curves and Riemann Surfaces.
- Martin Schlichenmaier, An Introduction to Riemann Surfaces, Algebraic Curves and Moduli Spaces.
- Oleksandr Iena, Riemann surfaces. Lecture Notes. Winter Semester 2015/2016.

The above texts are available on a-z.lu. More references will be provided during the course.

Professor: CONTI Andrea

Advanced Stochastic Models and Financial Applications

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 5

Language: Anglais

Mandatory: Non

Professor: PECCATI Giovanni

Numerical Methods for Variational Problems

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 5

Objective: Theory (lectures):

- From first principles derive some simple elliptic PDEs.
- Understand mathematical conditions related to uniqueness, existence, convergence, stability and regularity of (numerical) solutions to these PDEs.
- Construct local finite element spaces and understand how they can be 'glued' into global spaces with appropriate continuity.
- Understand the difficulties associated with discretizing mixed problems, e.g. the PDEs describing fluid flow.

Implementation (practicals):

- Starting from a skeleton Python code, implement a basic finite element code for solving the Poisson problem in one and two dimensions.
  - Fundamental data structures for representing meshes and data on meshes.
  - Numerical tabulation of finite element basis functions.
  - Numerical integration using Gauss-Legendre quadrature.
  - The finite element assembly algorithm.
  - Choosing and using appropriate algorithms for solving sparse linear systems.
- Perform basic verification via the process of unit testing.
- See how a state-of-the-art finite element solver such as the FEniCS Project (https://fenicsproject.org) can be used to solve more advanced problems.

Description: In this course you will learn the basic theory and practical implementation of the finite element method. The finite element method is the most widely used approach for solving partial differential equations on complicated domains. The finite element method encompasses many interesting topics, including computer algorithms, numerical linear algebra, functional analysis and mechanics. Its development is one of the major algorithmic achievements of the late 20th and 21st centuries, with important contributions made by the mathematics, engineering, and computer science communities.
The materials for this course were prepared in collaboration with Dr. David Ham and Prof. Colin Cotter at Imperial College London.

Language: Anglais

Mandatory: Non

Evaluation: The theory part will be assessed by an examination counting for 50% of the course.
The implementation part will be assessed by submission of working finite element code counting for the remaining 50% of the mark for the course.

Remark: Note / Literature / Bibliography
Provided by the supervisor

Professor: HALE Jack

Numerical solution of partial differential equations and applications

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 6

Objective: The objectives of the course are to provide to students a global overview of the finite element and finite difference methods for PDEs. Not only the mathematical foundations will be developed but also the concrete implementation of finite element/difference approximation techniques in view of their application to engineering problems. Some problems will be fully solved by using some computer programs written by the students (by using the PDE toolbox of Matlab or some bricks written by students).
On successful completion of the course, the student should be able to:

- Explain the mathematical foundations of the finite element/difference methods
- Master their concrete implementations for nontrivial engineering boundary-value problems
- Adapt, if necessary, the finite element/difference methods to the problem under consideration

Description:

1. Complements on Sobolev spaces; trace theorems; Green's formulae
2. The Lax-Milgram theory; variational formulations
3. The Finite Element Method for stationary elliptic Partial Differential Equations (PDEs): theoretical aspects
4. The Finite Element Method for stationary elliptic Partial Differential Equations (PDEs): implementation and computational aspects
5. Introduction to the Finite Difference Method for PDEs (time and space discretizations)

Language: Anglais

Mandatory: Non

Evaluation: The students will have to provide a report that will be evaluated. In addition, a final written examination will be organized.

Remark: Support / Arbeitsunterlagen / Support:
Lecture notes (french), exercise sheets (english)

Littérature / Literatur / Literature:

1. X. Antoine, Numerical solution of PDEs, lecture notes
2. X. Antoine, Numerical Analysis, course at the University of Luxembourg
3. G. Allaire, Analyse Numérique et Optimisation, Presses de l'Ecole Polytechnique
4. P.A. Raviart et J.M. Thomas, Introduction à l'Analyse Numérique des Equations aux Dérivées Partielles, Dunod.

Professor: ANTOINE Xavier

Student seminar

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 2

Objective: On successful completion of the seminar, the students should be able to:

- Fully benefit from seminar talks
- Acquire good insight into a field by means of individual work
- Give themselves lectures on specific topics
- Share their knowledge with others

Description: Every participant chooses a supervisor among the academic staff of the Department of Mathematics and, jointly with the supervisor, a topic for a talk.
The audience of the talk consists at least of the participants of the seminar, the supervisor and one other academic staff member of the Department of Mathematics (e.g. the supervisor of another talk). The duration of the talk is 75 minutes (time for questions not included).
A typewritten version of this (these) lecture(s) is requested.

Language: Anglais

Mandatory: Non

Evaluation: Continuous evaluation. The mark is based on the talk and the written text.

Remark: Literature

Provided by the supervisor

Professor: WIESE Gabor, MAKSOUD Alexandre

Algebraic Number Theory

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 6

Objective: Introduce the students to Algebraic Number Theory.
On successful completion of the course, the students should be able to:

- appreciate the role played by abstract algebraic number theory for the solution of concrete Diophantine equations,
- define number fields and enumerate their fundamental properties seen in class,
- outline the proofs of the fundamental results of the lecture,
- calculate class numbers and rings of integers in simple cases.

Description:

- Explicit Diophantine equations
- Number fields
- Cyclotomic fields
- Geometry of numbers
- Introduction to further topics in number theory

Language: Anglais

Mandatory: Non

Evaluation: Oral exam (presentation), and homeworks

Remark: Literature

to be announced in the lecture

Professor: PERUCCA Antonella

Partial Differential Equations II

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 8

Objective: Learning tools in order to deal with PDE, understanding the interplay between local and global problems and techniques.

Description: Distributions as generalized functions continued, Sobolev spaces, elliptic regularity, elliptic operators on compact manifolds, some non-linear equations.

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark: Literatur

- Jost: Postmodern analysis
- Folland: Introduction to partial differential equations
- Reed-Simon: Methods of mathematical physics I-IV
- Aubin: Nonlinear analysis on manifolds

Professor: OLBRICH Martin

Advanced Graph Theory

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 6

Objective: On successful completion of the course, the student should be able to:

- Illustrate the main results and concepts with well-chosen examples
- Master the proofs and techniques of the theory
- Solve exercises related to the topics covered in class
- Give an overview of the course content, focusing on his/her own taste and favorite topics
- Communicate his/her own pleasure in solving mathematical problem

Description: Graphs are structures that are ubiquitous in Mathematics and its applications. Through a presentation of selected topics, the course aims to be an introduction to certain modern aspects of graph theory. Some basic knowledge of the concept of graphs is a prerequisite for this course.

According to time and taste, topics covered will be chosen among (and are not limited to) the following ones:

- Matching, covering and packing problems
- Edge and vertex colorings
- Edge and vertex connectivity
- Ramsey theory for graphs
- Expander graphs and applications
- Graph minors and reconstruction problems
- Infinite Graph Theory

Language: Anglais

Mandatory: Non

Evaluation: Oral exam or written exam according to number of participants.

Remark: Literature

Reinhard Diestel. Graph Theory, 5th edition. Graduate texts in mathematics 173, Springer, 2017

Professor: TEHEUX Bruno

Continuous Time Models in Mathematical Finance

Module: Module Specialisation - Mathematics 2 (Semester 2)

ECTS: 8

Objective: Introduction to continuous time models in mathematical finance (Black-Scholes model).

Description: Arbitrage, risk-neutral measures, option pricing, hedging, Black-Scholes-Merton equation, call-put parity, connections with partial differential equations, forwards and futures, american options, exotic options, change of numéraire, Garman-Kohlhagen formula, term-structure models, Vasicek model, Heath-Jarrow-Morton model, forward LIBOR model.

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark: Literature

- M. Baxter, A. Rennie: Financial calculus. An introduction to derivative pricing. CUP, 1996
- F. E. Benth: Option Theory with Stochastic Analysis. Springer, 2004
- R. J. Elliot, P. E. Kopp: Mathematics of Financial Markets. 2nd ed., Springer Finance, 2004
- J. C. Hull: Options, futures, and other derivatives. 6th ed., Prentice-Hall, 2005
- S. E. Shreve: Stochastic calculus for finance. II: Continuous-time models. Springer, 2004
- J. Michael Steele: Stochastic Calculus and Financial Mathematics. Springer, 2001

Professor: PECCATI Giovanni

Learning and teaching mathematics I

Module:	Module Didactics - Mathématics 2 (Semester 2)
ECTS:	2
Language:	Anglais
Mandatory:	Oui
Professor:	COLLETTE-CLERBAUT Frédérique

Hands-on experiences with mathematical didactics I

Module:	Module Didactics - Mathématics 2 (Semester 2)
ECTS:	3
Objective:	Semester 2 students are expected to give a short talk on a didactical topic. Reading research articles and books about didactics will be an occasion for the students to expand their knowledge of this discipline and preparing the presentation is a valuable communication exercise.
Description:	Students from Semester 4 create small workshops, students from Semester 2 give short talks. In the remaining sessions the teacher and externals will make further activities. Various didactical topics will be covered.
Language:	Anglais, Français, Allemand
Mandatory:	Oui
Evaluation:	One presentation in the form of a short talk. The presentation and the related material will be evaluated.
Remark:	Literature / Note There are multiple themes presented by various people. References will be directly provided.
Professor:	PERUCCA Antonella

Mehrsprachigkeit im Sprach- und Fachunterricht (MATH)

Module:	Modul: Mehrsprachigkeit und Heterogenität (Semester 2)
ECTS:	3
Language:	Allemand
Mandatory:	Oui
Professor:	KIEFER Ann

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Workshop zur Vor- und Nachbereitung des Schulpraktikums

Module:	Modul: Mehrsprachigkeit und Heterogenität (Semester 2)
ECTS:	6
Language:	Français, Allemand
Mandatory:	Oui
Professor:	HARION Dominic

Semester 3

Student Group Project

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 2

Objective: On successful completion of the project the student should be able to:

- cooperate effectively in a team,
- analyse complex tasks
- propose solution strategies,
- break up a longer project into subsequent steps,
- apply a variety of methods in one project,
- present a task and its solution in a scientific way.

Description: The student group project consists of project work that is carried out by a group of (usually two or three) students under the supervision of a professor or a postdoc.
At the beginning of the project, supervisor and students define tasks to be carried out by the students, corresponding to the volume of 50 working hours (2 ECTS). The student(s) need to notify the Study Director of the project and the tasks at the latest on 15 October.
The project outcome is a pdf document written by the student. Additional outcomes (such as computer code, images, videos) can be asked for. The required outcome has to be handed in to the Study Director(s) and the supervisor at the latest on 31 December.
The student project can be done in the framework of the Experimental Mathematics Lab https://math.uni.lu/eml

Language: Anglais

Mandatory: Non

Evaluation: Project work

Professor: WIESE Gabor

Arithmetic Geometry

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 6

Objective:

- Know examples of and be able to explain the continuity of mathematics from classical problems (as taught in school) to modern research questions.
- Understand the relevance of knowing modern mathematics for being able to teach an integral picture of mathematics at secondary schools.
- Be able to work with mathematical notions going beyond secondary school and Bachelor level.

- Master the basics of local fields and be able to compute with p-adic numbers, as generalisation of the real numbers.
- Master the fundamentals of the theory of quadratic forms, be able to explain its origin in the study of conics, know and be able to apply important theorems, be able to handle examples.
- Master the basics of elliptic curves, know about their classical origin, know about their application in cryptography, understand their relevance for current number theory research, know and be able to apply important theorems, be able to handle examples.

Description: This course leads from classical mathematics (real numbers, conics, "classical" geometry, plane curves) to some topics in modern number theory and geometry and underlines the continuity from classical geometry (as taught in school) and classical number theory to the modern points of view.

It covers p-adic numbers and more generally local fields as analogues of the real numbers, quadratic forms (arising from the study of conic sections) and elliptic curves (arising from the study of certain integrals), as well as some of their relevance for modern mathematics.

Having their origin in the study of conics, the theory of quadratic forms is a modern theory situated in both geometry and number theory with plenty of applications. It turns out that for a full classification of quadratic forms, one needs to introduce analogues for the real numbers: the so-called p-adic numbers, or, more generally, local fields. In the first part of the lecture, the theory of quadratic forms is introduced, number theory applications are treated, p-adic numbers are dealt with, and the classification theorem is fully proved.

The second part of the course is concerned with elliptic curves. These are curves arising from the study of certain integrals. They are relevant in everyday life for their fundamental role in Elliptic Curves Cryptography (e.g. used in ID cards, passports). In the language of modern geometry, they are curves of genus one with a rational point. For number theory, they appear in many of the most important questions of current research, e.g. the Birch-and-Swinnerton-Dyer conjecture, which is one of the 7 Millenium Problems. In the course, elliptic curves are introduced in modern geometric language, thus introducing this language, and several important number theoretic and geometric properties are proved, such as the addition law (making them into a group, a complicated generalisation of the integers), and statements on their rational points (number theoretic "Diophantine" question).

The course will be a classical lecture, complemented by integrated exercises and contributions by the students via short talks.

Students from the Master in Secondary Education will be asked to focus in their contributions on how to link the topics of their lectures with High School mathematics.

Language: Anglais

Mandatory: Non

Evaluation: Students will be rated for their contributions via short talks. The number and the lengths of the short talks will depend on the number of participants and will be fixed in the beginning of the course.

Remark:

- Serre: A course in arithmetic, Springer
- Silverman: The arithmetic of elliptic curves, Springer
- Anni, Deo, Wiese: Lecture notes for Topics in Number Theory and Geometry, distributed during the lecture

Professor: WIESE Gabor

Advanced Discretization Methods

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Objective: The objectives of the course are to introduce some advanced discretization techniques for the numerical solution of partial differential equations arising in engineering and applied sciences. The schemes will be explained in details as well as their mathematical properties (e.g. order of accuracy, stability). In addition, these methods will be implemented by using Matlab and tested on concrete problems.

Course learning outcomes: On successful completion of the course the student should be able to:

- Explain the mathematical foundation of advanced discretization techniques for PDEs
- Master their concrete implementation on nontrivial engineering boundary-value problems
- Adapt them according to the problem under consideration

Description:

1. Complements the Finite Element Method
2. Finite difference schemes in space
3. Finite difference schemes fort he discretization of time-dependent PDEs
4. Introduction to integral equations

Teaching modality: Lecture course, exercises of applications

Language: Anglais

Mandatory: Non

Evaluation: The students will have to provide some reports that will be evaluated. In addition, a final written examination will be organized.

Remark: Support / Arbeitsunterlagen / Support: Lecture notes (french), exercise sheets (english)

Littérature / Literatur / Literature

1. X. Antoine, Numerical solution of PDEs, lecture notes
2. X. Antoine, Numerical Analysis, course at the University of Luxembourg
3. G. Allaire, Analyse Numérique et Optimisation, Presses de l'Ecole Polytechnique
4. P.A. Raviart et J.M. Thomas, Introduction à l'Analyse Numérique des Equations aux Dérivées Partielles, Dunod

Professor: BORDAS Stéphane

Advanced Stochastic Modelling

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Objective: Objective : The course will contain an account of the following topics:

*stable convergence and limit theorems
*high frequency observations
*estimation of financial volatility and related statistics.

Course learning outcomes: Learning outcomes : Relevant to the course subject matter the student should at the end of the course be able to:
*reproduce key results on stable convergence, strong/weak limit theorems for Ito semimartingales, and applications to volatility estimation
*apply the basic techniques of stable convergence and limit theorems for semimartingales to concrete examples
*study a prescribed topic on their own and solve selected exercises with pertinent written notes.

Description: Description : In this course we will introduce the concept of stable convergence and investigate various types of limit theorems for semimartingales applied to estimation of financial volatility. The notion of stable convergence was shown to be a very useful tool in statistical inference for stochastic processes. The first part of the lecture is concentrating around the properties of stable convergence. In the second part of the lecture we will discuss limit theorems for high frequency observations of semimartingales, which are considered as models of asset prices. We will show the relevant asymptotic results in details and present some statistical applications, which are important in mathematical finance.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Evaluation mode : 2 hours written exam

Remark: T. Björk (2009). Arbitrage Theory in Continuous Time. Oxford.

P. Malliavin and A. Thalmaier (2005). Stochastic Calculus of Variations in Mathematical Finance. Springer-Verlag.

M. Musiela and M. Rutkowski (1997). Martingale Methods in Financial Modeling. Springer Verlag.

Professor: PODOLSKIJ Mark

Data Science

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Objective: The successful candidate understands the fundamental theoretical concepts of selected aspects of Data Science. (S)he will be able to work on appropriate solutions to data-centric problems. A continuation with concerned aspects, for example through a Master Thesis, will be motivated and supported.

Course learning outcomes: On successful completion of the course the student should be able to:
- Explain and apply the fundamental theoretical concepts of selected aspects of Data Science
- Elaborate appropriate solutions to data-centric problems

- Deepen her/his competence in the field through a Master Thesis or self-learning

Description: The course is split into a lecture (Week 1 – 8; 13 - 14) and a seminar phase (Week 9 – 12). We concern selected aspects of

- Data Mining and Machine Learning
- Data Modeling and SQL
- Database Systems
- Data Quality and Preprocessing
- Data Privacy and Security
- Data and Information Visualization
- Information Retrieval

Teaching modality: CM (67%), SEM (33%)

Language: Anglais

Mandatory: Non

Evaluation: 50% Seminar, 50% Oral examination

Remark: Support:

- Elmasri, Navathe: Fundamentals of Database Systems. Pearson Addison Wesley. 2006.
- Han, Kamber: Data Mining – Concepts and Techniques. Morgan Kaufmann. 2011.
- Manning, Raghavan, Schütze: Introduction to Information Retrieval. Cambridge University Press.
- Ware: Information Visualization. Morgan Kaufmann. 2012.
- Witten, Kamber: Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann.
- Aggarwal, Yu: Privacy-Preserving Data Mining – Models and Algorithms. Springer. 2008.
- Marz: Big Data: Principles and best practices of scalable realtime data systems. Manning. 2015.

as well as different articles, reports, and journals contributions.

Professor: SCHOMMER Christoph

Numerical solution of partial differential equations and applications

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Objective: The objectives of the course are to provide to students a global overview of the finite element method. Not only the mathematical foundations will be developed but also the concrete implementation of finite element approximation techniques in view of their application to engineering problems. Some problems will be fully solved by using some computer programs written by the students (by using the PDE toolbox of Matlab or some bricks written by students).

Course learning outcomes: On successful completion of the course, the student should be able to:
- Explain the mathematical foundations of the finite element method
- Master its concrete implementation for nontrivial engineering boundary-value problems
- Adapt, if necessary, the finite element method to the problem under consideration

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Description:

1. Complements on Sobolev spaces; trace theorems; Green's formulae
2. The Lax-Milgram theory ; variational formulations
3. The Finite Element Method for stationary elliptic Partial Differential Equations (PDEs): theoretical aspects
4. The Finite Element Method for stationary elliptic Partial Differential Equations (PDEs): implementation and computational aspects

Teaching modality: Lecture course, exercises of applications

Language: Anglais

Mandatory: Non

Evaluation: The students will have to provide some reports that will be evaluated. In addition, a final written examination will be organized.

Remark: Support / Arbeitsunterlagen / Support:

Lecture notes (french), exercise sheets (english)

Littérature / Literatur / Literature:

1) X. Antoine, Numerical solution of PDEs, lecture notes

2) X. Antoine, Numerical Analysis, course at the University of Luxembourg

3) G. Allaire, Analyse Numérique et Optimisation, Presses de l'Ecole Polytechnique

4) P.A. Raviart et J.M. Thomas, Introduction à l'Analyse Numérique des Equations aux Dérivées Partielles, Dunod.

Professor: ANTOINE Xavier

Continuous-Time Stochastic Calculus and Interest Rate Models

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Course learning outcomes: On successful completion of the course, the student should be able to:

- Calculate probabilities and expectations related to the semi-martingale models presented in the lectures
- Carry out calculations based on change of numéraire and no-arbitrage pricing
- Compute the prices of interest rate derivatives
- Apply stochastic volatility models to deal with implied volatility surfaces

Description: Basic Notions of Fixed Income Markets; Semimartingale Modeling; Stochastic Differential Equations; No-Arbitrage Pricing; Change of Numéraire; Short Rate Models; Heath-Jarrow-Morton Framework; Market Models; Stochastic Volatility.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Written exam

Remark:

- D. Brigo and F. Mercurio (2006) Interest Rate Models : Theory and Practice. Springer Verlag
- M. Musiela and M. Rutko wski (1997) Martingale Methods in Financial Modeling. Springer Verlag

Professor: PECCATI Giovanni

Lie Algebras and Lie Groups

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 6

Objective: The purpose of this course is to give an introduction into the theory of finite dimensional Lie groups and Lie algebras, assuming some basic knowledge of differentiable manifolds.

Course learning outcomes: On successful completion of the course, the student should be able to:

- Expound the mathematical foundation behind symmetries of solid bodies, dynamics of mechanical systems, and geometric structures in nature.
- Explain the deep interrelations between Lie groups and Lie algebras, as well as the technical tools behinds these interrelations.
- Simplify mathematical problems admitting symmetry Lie groups actions to problems admitting symmetry actions of their Lie algebras.
- Master applications to the theory of manifolds and representation theory, which in turn have applications in physics, engineering and mechanics.

Description: The Lie algebra of a Lie group, the exponential map, , the adjoint representation, actions of Lie groups and Lie algebras on manifolds, the un iversal enveloping algebra, basics of the representation theory.

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Written examination

Remark: **Littérature / Literatur / Literature**

1) "Lie groups and Lie algebras" by Eckhard Meinrenken, 83 pages (free to download)

2) "Prerequisites from Differential Geometry" by Sergei Merkulov (free to download)

Professor: MERKOULOV (MERKULOV) Serguei

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Gaussian processes and applications

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 5

Course learning outcomes: On successful completion of the course, the student should be able to:

- Explain the language, basic concepts and techniques associated with Gaussian variables, vectors, and processes
- Identify, analyse, and prove relevant properties of models based on a Gaussian structure
- Solve exercises involving a Gaussian structure

Language: Anglais

Mandatory: Non

Professor: NOURDIN Ivan

Combinatorial Geometry

Module: Specialisation - Mathematics 3 (Semester 3)

ECTS: 6

Course learning outcomes: The course requires minimal prerequisites (some linear algebra, Euclidean geometry and basic topology) but aims to explore results that are at the limit of current known understanding. In particular, we'll discuss some open problems and try to illustrate the process of modern research. The subjects are chosen so that they can be treated with a hands-on approach, and this approach and experience are as important for this course as the actual content.

Description: The course will cover a selection of themes from combinatorial aspects of geometry.

Themes include general theorems about convex sets in n dimensional real space (and Helly type theorems), Minkovski's first theorem for lattices, and Ramsey theory (graph coloring problems).

Teaching modality: Lecture course

Language: Anglais

Mandatory: Non

Evaluation: Oral exam and classwork

Professor: PARLIER Hugo, PANDA Pallavi

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Applied Didactics III

Module:	Didactics - Mathematics 3 (Semester 3)
ECTS:	2
Language:	Français
Mandatory:	Oui
Professor:	HAUSTGEN Marc Paul, COLLETTE-CLERBAUT Frédérique

Applied Didactics IV

Module:	Didactics - Mathematics 3 (Semester 3)
ECTS:	3
Language:	Français
Mandatory:	Oui
Professor:	BINDELS Gene

Internship in secondary school II

Module:	Didactics - Mathematics 3 (Semester 3)
ECTS:	0
Language:	Français
Mandatory:	Oui
Evaluation:	validated in S4

Teaching Children with Special Educational Needs

Module:	Modul: Lehren und Lernen im sozialen Kontext (Semester 3)
ECTS:	3
Course learning outcomes:	This course (lecture) is aimed to deepen students' knowledge on the latest research about the leaning processes of children with specific learning difficulties like dyslexia, specific language impairment, dyscalculia and ADHD. This course will also try to equip these future teachers with strategies aimed to more efficiently teach children with special education needs.

Description: Over the year's research has informed the scientific and the educational community about how children's learning processes can be affected by neurologically-based difficulties. These specific learning difficulties can interfere with the learning of basic skills like reading, writing, maths or language learning. They can also interfere with higher level skills such as organization, time planning, abstract reasoning, long or short term memory and attention. As teachers, it is essential to understand the impact specific learning difficulties have on children's learning trajectories and how we can best ameliorate these difficulties.

Language: Anglais

Mandatory: Oui

Evaluation: Exam

Remark: **Bibliography**

- Beck I., Mackeown M. & Kucan L. (2013). Bringing Words to Life: Robust Vocabulary Instruction. New York: Guilford.
- Carroll, J.M., Bowyer-Crane, C., Duff, F., Hulme, C., & Snowling, MJ. (2011). Effective intervention for language and literacy in the early years. Oxford: Wiley-Blackwell.
- Hulme C. & Snowling M. (2009). Developmental Disorders of Language Learning and Cognition. Oxford UK: Wiley Blackwell. Chapter 2 & 3
- Purpura, D. J., & Ganley, C. (2014). Working memory and language: Skill-specific or domain-general relations to mathematics? Journal of Experimental Child Psychology, 122, 104-121.
- Purpura, D. J., Napoli, A. R., Wehrspann, E. A., & Gold, Z. S. (in press). Causal connections between mathematical language and mathematical knowledge: A dialogic reading intervention. Journal of Research on Educational Effectiveness.
- Purpura, D. J., & Reid, E. E. (2016). Mathematics and language: Individual and group differences in mathematical language skills in young children. Early Childhood Research Quarterly, 26, 259-268.
- Purpura, D. J., Schmitt, S. A., & Ganley, C. M. (2017). Foundations of mathematics and literacy: The role of executive functioning components. Journal of Experimental Child Psychology, 153, 15-34.
- Sims, D. M., Purpura, D. J., & Lonigan, C. J. (2012). The relation between inattentive and hyperactive/impulsive behaviors and early mathematics skills. Journal of Attention Disorders. doi:10.1177/1087054712464390.
- Snowling, M. J., & Hulme, C. (2011). Evidence-based interventions for reading and language difficulties: Creating a virtuous circle. British Journal of Educational Psychology, 81(1), 1-23.

Professor: ENGEL DE ABREU Pascale

Einführung in die Pädagogische Psychologie

Module: Modul: Lehren und Lernen im sozialen Kontext (Semester 3)

ECTS: 3

Objective:

- Ein (Pädagogisch-) Psychologisches Fundament für angehende Lehrerinnen und Lehrer zur Verfügung stellen
- Unterricht aus einer psychologischen Perspektive analysieren

- Prozesse wissenschaftlichen Erkenntnisgewinns und seiner Bedeutung für die Berufspraxis nachvollziehbar machen
- Zum eigenständigen Denken und professionellem Handeln anregen
- Typische Mythen und Fehlkonzepte in Bezug auf Lernen und Unterricht aus psychologischer Sicht hinterfragen und ggf. korrigieren

Description: Die Vorlesung führt ein in Gegenstand und Methode der (Pädagogischen) Psychologie als empirische Wissenschaft und ihrer Bedeutung für angehende LehrerInnen. Insbesondere die Pädagogische Psychologie, aber auch die Allgemeine, Differentielle, Entwicklungs- und Sozialpsychologie tragen bei zum Verständnis menschlichem Erleben und Verhalten in Kontexten der Erziehung, der Bildung und des (formalen) Lernens (bzw. Unterrichtens). Vorgestellt und diskutiert werden zunächst allgemeine Inhalte und Methoden der Psychologie als empirischer Wissenschaft, allgemeine Lernvoraussetzungen (z.B. Informations-verarbeitung, Lernmotivation), Aspekte der Unterrichtsgestaltung (z.B. Klassenführung), Aspekte der sozialen Interaktion (z.B. Freundschaft, Bullying), psychologische Besonderheiten des Lehrerberufs (z.B. Lehrerpersönlichkeit, Burnout) sowie verschiedene Aspekte pädagogisch-psychologischer Diagnostik (z.B. ausgewählte Lernstörungen wie ADHS). Dabei werden sowohl empirische Originalstudien als auch empirisch fundierte Interventionsansätze zur Illustration vertiefend besprochen. Zudem werden Fallbeispiele und Übungen besprochen und durchgeführt.

Die Vorlesung ist (vorläufig) geplant als Hybrid-Format, mit regelmäßigen Live-Remote-Vorlesungen und Präsenz-Nachbesprechung einzelner Themen in Kleingruppen. Zu jeder Sitzung lädt der Dozent die Studierenden per Webex ein.

Language: Allemand, Anglais

Mandatory: Oui

Remark: **Bibliografie**

Grundlagenliteratur (d.h. online verfügbar und prüfungsrelevant, spez. Kap.)

- Fritz, A., Hussy, W. & Tobinski, D. (2018). Pädagogische Psychologie. München: Reinhardt/ UTB.
- Fromm, M. (2017). Lernen und Lehren: Psychologische Grundlagen für Lehramtsstudierende. Münster: Waxmann.
- Götz, T. (2017, Hrsg.). Emotion, Motivation und selbstreguliertes Lernen. Paderborn: Schöningh/UTB.
- Imhoff, M. (2013). Psychologie für Lehramtsstudierende. Berlin: Springer.
- Kunter, M. & Trautwein, U. (2013). Psychologie des Unterrichts. Paderborn: Schöningh/UTB.
- Wild, E. & Möller, J. (2015, Hrsg.). Pädagogische Psychologie. Berlin: Springer.
- Wisniewski, B. (2019). Psychologie für die Lehrerbildung. Bad Heilbrunn: Klinkhardt/UTB.

Professor: GRUND Axel

Digitale Schule (3. Semester)

Module: Modul: Lehren und Lernen im sozialen Kontext (Semester 3)

ECTS: 5

Objective:

- Erweiterung der eigenen digitalen Kompetenzen im Hinblick auf didaktische Einbindung von digitalen Technologien im Schulunterricht
- Schaffung eines medienkritischen Bewusstseins mit spezifischem Blick auf Situationen des Lehrens und des Lernens (u.a. Schülerinnen und Schülern einen selbstständigen Umgang mit digitalen Medien zu vermitteln).
- Planung eigener Lehr-Lern-Arrangements.

Description: Thema des Kurses ist der Umgang mit digitalen Technologien für den Einsatz im Schulunterricht. Dabei werden einerseits die didaktischen Potenziale derselben an Fallbeispielen erprobt, diskutiert und auch kritisch hinterfragt. Im Wechsel zwischen Praxis und Theorie werden andererseits verschiedene digitale Tools vorgestellt und durch gezielte Aufgabenstellungen vermittelt. Begleitet werden diese praxisbezogenen Studien von theoretischen Auseinandersetzungen, ebenso sind kulturelle und gesellschaftliche Aspekte der digitalen Medien Kursinhalt.

Language: Allemand

Mandatory: Oui

Evaluation: Praktische Prüfung in Form einer Lehr-Lern-Einheit.

Remark: **Bibliografie**

Wird in der Veranstaltung bekanntgegeben und über Moodle zur Verfügung gestellt.

Professor: BAUMANN Isabell Eva

Workshop zur Vor- und Nachbereitung des vertiefenden Schulpraktikums

Module: Modul: Lehren und Lernen im sozialen Kontext (Semester 3)

ECTS: 3

Course learning outcomes: Die Studierenden …

… haben erweiterte Kenntnisse zu Schwerpunktbereichen der allgemeinen Didaktik und Pädagogik erworben.

… verfügen über ein anwendungsbezogenes Konzeptrepertoire aus den Bereichen Instruktion, Differenzierung und Classroom Management.

… haben den eigenen Wissensstand und ihre Kompetenzen in Theorie und Unterrichtspraxis adaptiert und auf Basis ihrer individuellen Entwicklungsziele und Forschungsinteressen für ihr Studium weiterentwickelt.

Description: Der Workshop dient der Vertiefung pädagogischer Rahmenbedingungen und didaktischer Konzepte im Enseignement Secondaire und damit der Erweiterung und Adaptation von Gestaltungsmöglichkeiten der Unterrichtspraxis im Rahmen des vertiefenden Praktikums. Ein besonderer Schwerpunkt liegt dabei auf den individuellen Entwicklungszielen und Forschungsinteressen der Studierenden, die aus der Reflexion des orientierenden Praktikums abgeleitet wurden.

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Language: Allemand, Français

Mandatory: Oui

Evaluation: Aktive Teilnahme an Workshop / Schulpraktikum / Praktikumsportfolio.

Remark: **Bibliografie**

Ein Reader mit Grundlagentexten wird zu Beginn des Semesters über Moodle zur Verfügung gestellt. Dieser ist vor Beginn der Workshops zu bearbeiten.

Professor: HARION Dominic

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Semester 4

Learning and teaching mathematics II

Module: Module Didactics - Mathematics 4 (Semester 4)

ECTS: 2

Course learning outcomes: L'étudiant sera capable de

- décrire les aspects principaux liés à la différenciation pédagogique à savoir les contenus, les structures, les processus et les productions attendus des élèves

- mettre en œuvre différentes formes de différenciation par flexibilité, adaptation et modification.

- faire le lien entre différenciation pédagogique et évaluation

- élaborer des documents pédagogiques permettant une différenciation en cours de mathématiques

Description: · Différenciation pédagogique

o Aspects théoriques

o Elaboration de situations d'apprentissage en vue d'une différenciation interne

o Mise en œuvre pratique dans une classe d'un lycée

· Elaboration de tâches mathématiques différenciantes

Language: Français

Mandatory: Oui

Evaluation: Portfolio de documentation des activités élaborées et mises en œuvre suivis d'un entretien

Remark: Cours distribués lors de chaque séance

Professor: COLLETTE-CLERBAUT Frédérique

Hands-on experiences with mathematical didactics II

Module: Module Didactics - Mathematics 4 (Semester 4)

ECTS: 3

Objective: Semester 4 students are expected to work on projects and produce something original that can be presented to their peers in a small workshop. Facing a didactical challenge will contribute to the independence and critical thinking.

Description: Students from Semester 4 create small workshops, students from Semester 2 give short talks. In the remaining sessions the teacher and externals will make further activities. Various didactical topics will be covered.

Language: Anglais, Français, Allemand

Mandatory: Oui

Evaluation: One presentation in the form of a small workshop. The presentation and the related material will be evaluated.

Remark: Literature / Note

There are multiple themes presented by various people. References will be directly provided.

Professor: PERUCCA Antonella

Master Thesis

Module: Module Specialisation - Mathematics 4 (Semester 4)

ECTS: 20

Course learning outcomes: On successful completion of the Master Thesis, the students should be able to:

- Organize a comprehensive literature review
- Discuss and communicate scientific ideas
- Approach mathematical problems efficiently and identify appropriate theories or conceptual techniques
- Discover original mathematics
- Verify results and apply them
- Write mathematical texts that are consistent with the tradition

Description: The Master Thesis in mathematics consists of the definition of a research project, the detailed explanation of research articles and/or monographs aimed at a mathematics audience, as well as of potential further developments of these. The project, which should contain parts of original mathematics, will be designed to suit the individual objectives of the students, to deepen their competence in a selected field of mathematics, and to open a door towards mathematical research.

Language: Anglais, Français, Allemand

Mandatory: Oui

Evaluation: Supervisor, director of studies

Master en Enseignement Secondaire - Master en Enseignement Secondaire, Filière Mathématiques

Remark:	Admission to the Master Thesis will be granted only to students who acquired at least 75 ECTS credit points during the first three semesters of the Master's program (in a well-founded case, an exception to this rule might be decided by the study director).
Professor:	WIESE Gabor, PODOLSKIJ Mark

Workshop Professionell Auftreten

Module:	Modul: Forschungsfeld Schule (Semester 4)
ECTS:	1
Language:	Français, Allemand
Mandatory:	Oui
Professor:	ULLMANN Barbara

Workshop: Nachbereitung des vertiefenden Schulpraktikums

Module:	Modul: Forschungsfeld Schule (Semester 4)
ECTS:	2
Language:	Allemand
Mandatory:	Oui
Professor:	HARION Dominic