Handbook of Modules for Master's Programme in Actuarial and Financial Mathematics at TU Kaiserslautern

Updated: SS 2020

This is a translation of the German version (Master Finanz- und Versicherungsmathematik) which can be found at http://www.mathematik.uni-kl.de/modulhandbuecher/

Translation errors cannot be excluded. In case of doubt only the German version applies.

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1. Actuarial and Financial Mathematics
1.1 Compulsory modules

Probability Concepts for Financial Markets

<table>
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<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-60-17-M-4</td>
<td>90 h</td>
<td>3 CP</td>
<td>1</td>
<td>every Semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

1 Courses
- Probability Concepts for Financial Markets

2 Result of study / competences:
Upon completion of this module, students will be able to formulate and develop the models of discrete-time financial markets using the concepts of measure-theoretic probability theory. They will have learnt and processed the theory of discrete-time stochastic processes from probability theory and will be able to apply it to problems of financial mathematics. They will have acquired the fundamentals of price theory in discrete time financial markets and will be able to apply these methods to various types of financial derivatives.

By participating in the integrated seminar, students will have acquired additional skills useful for presenting mathematical content.

3 Contents:
- Modelling of discrete-time financial markets,
- Review and extensions of concepts from probability: Conditional expectation, martingales, stopping times, change of measure,
- Binomial model,
- Pricing of financial products in discrete-time financial markets,
- European options,
- American options,
- Basics of portfolio optimization

4 Form of teaching:
Intensive course with integrated tutorials and seminar.

5 Prerequisites:
Module "Probability Theory" from the Bachelor's degree programme in Wirtschaftsmathematik.

6 Type of examination:
Presentations and written reports.

7 Requirements for the award of credits:
Seminarschein (course achievement) through successful participation in the intensive course. The type of work to be done will be announced by the course conductor before the beginning of the course; it would usually be a combination of presentation (duration 30-90 minutes) and written work.

8 Usability of this module:
Compulsory module for Master’s program in Actuarial and Financial Mathematics.

9 Significance towards the final grade:
The module will not be graded.

10 Reading to complement course material:
| N.H. Bingham, R. Kiesel: Risk-Neutral Valuation: Pricing and Hedging of Financial Derivatives,  
| J. Jacod, P. Protter: Probability Essentials,  
| R. Korn: Moderne Finanzmathematik – Theorie und praktische Anwendung, Band 1: Optionsbewertung und Portfolio-Optimierung,  
| S. Pliska: Introduction to Mathematical Finance,  

| **11** Authorised representatives of module:  
| Prof. Dr. R. Korn, Prof. Dr. J. Saß |

| **12** Additional Information:  
| The intensive course takes place during the first few weeks of the semester (before the lecture period). |
# Financial Mathematics (Finanzmathematik)

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-11-M-7</td>
<td>270 h</td>
<td>9 CP</td>
<td>1st or 2nd</td>
<td>every summer semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

## Courses
- **Financial Mathematics**
  - 4 SWS / 60 lecture hours
  - 2 SWS / 30 tutorial hours
  - 180 h
  - 20-40 Students
  - 15-25 Students

## Result of study / competences:
Students understand the basic structures and properties of stochastic integrals and stochastic differential equations and are familiar with the Itô formula and Girsanov’s theorem. They are exposed to various models of financial market, including the Black Scholes model, to understand the different methods for the pricing of financial derivatives. In addition, they gain insight in modelling and numerical treatment of SDEs.

By completing the exercises, students develop a skilled, precise and independent handling of the terms, propositions and methods taught in the course. They understand the proofs presented in the lecture and are able to reproduce and explain them. They can in particular outline the conditions and assumptions that are necessary for the validity of the statements.

## Contents:
- Basics of stochastic analysis (Brownian motion, Itô-integral, Itô-formula, martingale representation theorem, Girsanov theorem, linear stochastic differential equations, Feynman-Kac formula)
- Diffusion model for share prices and trading strategies
- Completeness of market
- Valuation of options with the duplication principle, Black-Scholes-formula
- Valuation of options and partial differential equations
- Exotic Options
- Arbitrage bounds (Put-Call-parity, parity of prices for European and American calls)

## Form of teaching:
Lectures and tutorials in small groups.

## Prerequisites:
Module “Probability Theory” from the Bachelor’s degree programme in Wirtschaftsmathematik.

## Type of examination:
Oral exam (individual examination, Duration 20-30 minutes).

## Requirements for the award of credits:
Participation in the end of semester examination.

## Usability of this module:
This course is a compulsory module under specialization for Master’s degree in Actuarial and Financial Mathematics.

Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International.
- Main focus of study is “Financial Mathematics” or “Statistics”;
- Areas of applied mathematics or general mathematics if the main focus of study is not chosen from the list above (considering the rules of the degree programme which might restrict the above).

## Significance towards the final grade:
One receives a final grade at the end of the oral examination. This comprises 9.7% of the final grade that one receives at the end of the Master’s Program.
### Reading to complement course material:

- N.H. Bingham, R. Kiesel: Risk-Neutral Valuation: Pricing and Hedging of Financial Derivatives,
- T. Björk: Arbitrage Theory in Continuous Time,
- I. Karatzas, S.E. Shreve: Brownian Motion and Stochastic Calculus,
- I. Karatzas, S.E. Shreve: Methods of Mathematical Finance,

### Authorised representatives of the module:

- Prof. Dr. R. Korn, Prof. Dr. J. Saß
Life Insurance Mathematics (Lebensversicherungsmathematik)

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-18-M-7</td>
<td>135 h</td>
<td>4,5 CP</td>
<td>1st or 2nd</td>
<td>every summer semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Courses</th>
<th>Effort</th>
<th>Self-Study</th>
<th>Intended size of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Insurance Mathematics or Practical Life Insurance Mathematics</td>
<td>2 SWS / 30 lecture hours</td>
<td>105 h</td>
<td>20-40 Students</td>
</tr>
</tbody>
</table>

1. **Result of study / competences:**
   Students understand the mathematical and practical foundations of classical life insurance mathematics. They can apply the acquired knowledge to evaluate and determine the cash flows and capital cover of various insurance benefits of life insurance products.
   They gain a precise and independent handling of the terms, propositions and methods of the lecture.
   It is possible that the pertaining Module is lectured by a mathematician from the insurance practice (actuary) under the title "Practical Life Insurance Mathematics". In this case, students gain additional insights into the practical work of an actuary in life insurance.

2. **Contents:**
   - Elementary financial mathematics (calculation of interest)
   - Mortality
   - Insurance benefits
   - Net premiums and net actuarial reserves
   - Inclusion of costs
   - Life related insurance
   - Various reject causes

3. **Form of teaching:**
   Lectures.

4. **Prerequisites:**
   Module "Stochastic Methods" from the Bachelor's degree programme in Wirtschaftsmathematik.

5. **Type of examination:**
   Written examination (Duration 60-120 minutes).

6. **Requirements for the award of credits:**
   Participation in the end of semester examination.

7. **Usability of this module:**
   This course is a compulsory module under specialization for Master’s degree in Actuarial and Financial Mathematics.
   Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International.
   - Main focus of study is "Financial Mathematics" or "Statistics";
   - Areas of applied mathematics or general mathematics if the main focus of study is not chosen from the list above (considering the rules of the degree programme which might restrict the above).

8. **Significance towards the final grade:**
   One receives a grade after writing the written examination. This comprises 4.8 % of the final grade that one receives at the end of Master’s Program.
| 10 | **Reading to complement course material:**  
|    | H.U. Gerber: Life Insurance Mathematics,  
|    | M. Koller: Stochastic Models in Life Insurance. |
| 11 | **Authorised representatives of the module:**  
|    | Prof. Dr. R. Korn, Prof. Dr. J. Säss |
### Non-Life Insurance Mathematics (Schadensversicherungsmathematik)

<table>
<thead>
<tr>
<th>Module Number</th>
<th>MAT-61-19-M-7</th>
<th>Effort</th>
<th>270 h</th>
<th>CP (Credits)</th>
<th>9 CP</th>
<th>Semester</th>
<th>1st or 2nd</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
<th>1 Semester</th>
</tr>
</thead>
</table>

**1 Courses**
- Non-Life Insurance Mathematics
  - 4 SWS / 60 lecture hours
  - 2 SWS / 30 tutorial hours
  - 180 h
  - 20-40 Students

**2 Result of study / competences:**

Students acquire a complete overview of the modelling of loss levels, time of damage and the reserve process under the generalized Cramer-Lundberg model. They understand the mathematical foundations of ruin theory and premium calculation (in particular, the experience rating and the terms of loss reserves and reinsurance) and are able to apply them.

By completing the exercises, students develop a skilled, precise and independent handling of the terms, propositions and methods taught in the course. They understand the proofs presented in the lecture and are able to reproduce and explain them. They can in particular outline the conditions and assumptions that are necessary for the validity of the statements.

**3 Contents:**
- Convolution and transforms
- Claim size distributions
- Individual risk model
- Collective risk models:
  - Claim number process
  - Poisson process
  - Renewal processes
  - Total claim size distribution
- Risk Process
- Ruin theory and ruin probabilities
- Premium calculation
- Experience rating:
  - Bayes estimation
  - Linear Bayes estimation (Bühlmann and Bühlmann-Straub model)
- Reserves
- Reinsurance and risk sharing

**4 Form of teaching:**
Lectures and tutorials in small groups.

**5 Prerequisites:**
Module "Probability Theory" from the Bachelor's degree programme in Wirtschaftsmathematik.

**6 Type of examination:**
Oral exam (individual examination, Duration 20-30 minutes).

**7 Requirements for the award of credits:**
Participation in the end of semester examination.
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
</table>
| 8 Usability of this module: | This course is a compulsory module under specialization for Master’s degree in Actuarial and Financial Mathematics. Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International.  
- Main focus of study is "Financial Mathematics" or "Statistics";  
- Areas of applied mathematics or general mathematics if the main focus of study is not chosen from the list above (considering the rules of the degree programme which might restrict the above). |
| 9 Significance towards the final grade: | One receives a grade at the end of the oral examination. This comprises 9.7% of the final grade that one receives at the end of the Master’s Program. |
| 10 Reading to complement course material: | H. Bühlmann: Mathematical Methods in Risk Theory,  
R. Kaas, M. Goovaerts, I. Dhaene, M. Denuit: Modern Actuarial Risk Theory,  
T. Mikosch: Non-Life Insurance: An Introduction with the Poisson Process,  
| 11 Authorised representatives of the module: | Prof. Dr. R. Korn, Prof. Dr. J. Saß |
1.2 Elective modules

### Seminar Actuarial and Financial Mathematics

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-SEM-M-7</td>
<td>90 h</td>
<td>3 CP</td>
<td>2nd or 3rd</td>
<td>every Semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

1. **Courses**

   Seminar <Topic of the seminar>

   2 SWSSeminar / 30 h

   Self-Study

   60 h

   Intended size of class

   10-20 Students

2. **Result of study / competences:**

   Students learn to use scientific methods in order to work on an advanced topic in the field of financial and actuarial mathematics autonomously. Moreover, they present this in the form of a lecture and thus acquire expertise in the presentation of mathematical content.

3. **Contents:**

   Few advanced topics from the field of financial and actuarial mathematics will be chosen depending on the topic of the seminar.

4. **Form of teaching:**

   Seminar

5. **Prerequisites:**

   Depending on the choice of the topic, different courses from the bachelor and the master degree programmes of mathematics will be required.

   Formal conditions: prior registration.

6. **Type of examination:**

   Presentation and seminar report.

7. **Requirements for the award of credits:**

   'Seminarschein' confirming successful participation in the seminar. The type of course work to be done will be announced by the course conductor before the beginning of the seminar; it would usually be a combination of an oral presentation (duration 30-90 minutes) and seminar report (seminar paper).

8. **Usability of this module:**

   Elective module for Master's program in Actuarial and Financial Mathematics.

   This could also be a part of the other Master’s degree programme under the department of mathematics.

9. **Significance towards the final grade:**

   The module will not be graded.

10. **Reading to complement course material:**

    The literature required will be announced during the course.

11. **Authorised representatives of the module:**

    Prof. Dr. R. Korn, Prof. Dr. J. Saß

12. **Additional Information:**

    The seminar registration and briefing usually takes place at the end of the lecture period of the preceding semester.
2. Statistics and Computational Methods

Under the section “Statistics and Computational Methods”, one has to obtain a total of 18-21 credits points from the elective modules. At least 9 CP have to be obtained from the following modules:

- “Mathematical Statistics”,
- “Monte Carlo Algorithms”,
- “Computational Finance”,
- “Financial Statistics”.

Any extra credit points required could be obtained from any of the following modules (from other Master’s degree programme under the department of mathematics)

- „Numerics of ODE”,
- „PDE: An Introduction”,
- „Numerical Methods for Elliptic and Parabolic PDE”,
- „Extreme Value Theory”,
- „Statistical Learning and Selected Applications”,
- „Machine Learning III- Mathematics of Machine Learning”,
- „Nonlinear Optimization”,
- „Functional Analysis”.

With the approval of the examination committee, other modules in the field of statistics and computational methods also are permitted.

### 2.1 Elective modules

<table>
<thead>
<tr>
<th>Mathematical Statistics (Mathematische Statistik)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module Number</strong></td>
</tr>
<tr>
<td>MAT-62-11-M-7</td>
</tr>
</tbody>
</table>

1. **Courses**
   - Mathematical Statistics
     - 4 SWS / 60 lecture hours
     - 2 SWS / 30 tutorial hours
     - Self-Study
     - 180 h
     - Intended size of class
     - 20-40 Students
     - 15-25 Students

2. **Result of study / competences:**

   Students know and understand classical and modern asymptotic approaches and techniques of proofs for mathematical statistics as well as their usability to solve practical relevant problems. They are able to apply methods of mathematical statistics by themselves.

   By completing the exercises, students develop a skilled, precise and independent handling of the terms, propositions and methods taught in the course. They understand the proofs presented in the lecture and are able to reproduce and explain them. They can in particular outline the conditions and assumptions that are necessary for the validity of the statements.
### Contents:
- Asymptotic analysis of M-estimators, especially of Maximum-Likelihood-estimators
- Bayes- and Minimax-estimators
- Likelihood-ratio-tests: asymptotic analysis and examples (t-test, $c^2$-goodness-of-fit-test)
- Glivenko-Cantelli-theorem, Kolmogorov-Smirnov-test
- Differentiable statistic functionals and examples of applications (derivation of asymptotic results, robustness)
- Resampling methods on the basis of Bootstraps

### Form of teaching:
Lectures and tutorials in small groups.

### Prerequisites:
Module "Stochastic Methods" from the Bachelor’s degree programme in Wirtschaftsmathematik.

### Type of examination:
Oral exam (individual examination, Duration 20-30 minutes).

### Requirements for the award of credits:
Participation in the end of semester examination.

### Usability of this module:
This course is an elective module for Master’s degree in Actuarial and Financial Mathematics.
Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International.
- Main focus of study is "Financial Mathematics" or "Statistics";
- Areas of applied mathematics or general mathematics if the main focus of study is not chosen from the list above (considering the rules of the degree programme which might restrict the above).

### Significance towards the final grade:
One receives the final grade at the end of the oral examination. This comprises 9.7% of the final grade that one receives at the end of the Master’s Program.

### Reading to complement course material:
- G. Casella, R. Berger: Statistical Inference,
- L. Breiman: Statistics,
- P. Bickel, K. Doksum: Mathematical Statistics,
- R. Serfling: Approximation Theorems of Mathematical Statistics,
- J. Shao: Mathematical Statistics.

### Authorised representatives of the module:
Prof. Dr. C. Redenbach
Monte Carlo Algorithms (Monte Carlo-Algorithmen)

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-60-14-M-6</td>
<td>270 h</td>
<td>9 CP</td>
<td>1st or 2nd</td>
<td>irregular (in SS)</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

1 Courses
Monte Carlo Algorithms
4 SWS / 60 lecture hours
2 SWS / 30 tutorial hours
180 h
15-25 Students

2 Result of study / competences:
Students develop a basic understanding of the construction, analysis and applications of Monte Carlo algorithms. They gain practical experience of using such algorithms and insights into different application fields.

By completing the exercises, students develop a skilled, precise and independent handling of the terms, propositions and methods taught in the course. They understand the proofs presented in the lecture and are able to reproduce and explain them.

3 Contents:
Monte Carlo algorithms are the algorithms which use randomness. The course gives an introduction to this important basic algorithmic technique in mathematics and computer science.

It discusses the topics
· Direct Simulation
· Simulation of distributions
· Variance reduction
· Markov Chain Monte Carlo algorithms
· High-dimensional integration
· What are random numbers?
and applications in physics as well as financial and insurance mathematics

4 Form of teaching:
Lectures and tutorials in small groups.

5 Prerequisites:
Module "Stochastische Methoden" from the Bachelor's degree programme in Wirtschaftsmathematik and basic knowledge in Numerics.

6 Type of examination:
Oral exam (individual examination, Duration 20-30 minutes).

7 Requirements for the award of credits:
Übungsschein (certifying successful participation in the tutorials), Participation in the end of semester examination.
Without a proof of successful participation in the exercises, only 6 credit points will be awarded for the module.

8 Usability of this module:
This course is an elective module for Master’s degree in Actuarial and Financial Mathematics.
Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International. This lecture can be put into the areas of applied mathematics or general mathematics if the main focus of study has not been chosen in the areas of Financial Mathematics or Statistics (considering the rules of the degree programme which might restrict the above).
<table>
<thead>
<tr>
<th></th>
<th>Significance towards the final grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One receives the final grade at the end of the oral examination. This comprises 9.7 % (6.5 % respectively) of the final grade that one receives at the end of Master's Program.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Reading to complement course material:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T. Müller-Gronbach, E. Novak, K. Ritter: Monte Carlo-Algorithmen,</td>
</tr>
<tr>
<td></td>
<td>S. Asmussen, P.W. Glynn: Stochastic Simulation,</td>
</tr>
<tr>
<td></td>
<td>E. Behrends: Introduction to Markov Chains,</td>
</tr>
<tr>
<td></td>
<td>P. Brémaud: Markov Chains,</td>
</tr>
<tr>
<td></td>
<td>P. Glasserman: Monte Carlo Methods in Financial Engineering,</td>
</tr>
<tr>
<td></td>
<td>C. Lemieux: Monte Carlo and Quasi-Monte Carlo Sampling,</td>
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<tr>
<td></td>
<td>R. Motwani, P. Raghavan: Randomized Algorithms,</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Authorised representatives of the module:</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Prof. Dr. K. Ritter</td>
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</tbody>
</table>
Computational Finance

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-14-M-7</td>
<td>135 h</td>
<td>4.5 CP</td>
<td>1st, 2nd or 3rd</td>
<td>irregular</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

1 Courses
- Computational Finance
- 2 SWS / 30 lecture hours
- Self-Study
- 105 h
- 15-25 Students

2 Result of study / competences:
Students are able to implement the knowledge they acquired in the introductory lectures on financial mathematics to price ratings of financial derivatives through different numerical methods.

3 Contents:
- Standard models: Black-Scholes, Heston and other SV models, local volatility
- Choice of model and calibration
- Options evaluation: analytical formula, PDE, Monte-Carlo simulation, trees
- Pricing of exotic options and certificates
- Selected topics on Monte-Carlo simulations: generation of random variables, numerical methods for SDE, variance reduction, stochastic Taylor expansion
- Convergence of Stochastic processes and Donsker’s Theorem.

4 Form of teaching:
Lectures

5 Prerequisites:
The course Probability Theory. Additional knowledge from "Financial Mathematics" is useful but not required.

6 Type of examination:
Oral exam (individual examination, Duration 20-30 minutes).

7 Requirements for the award of credits:
Participation in the end of semester examination.

8 Usability of this module:
This course is an elective module for Master’s degree in Actuarial and Financial Mathematics.

Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International.
- Main focus of study 'Financial Mathematics';
- Areas of applied mathematics or general mathematics if the main focus of study is not Financial Mathematics (considering the rules of the degree programme which might restrict the above).

9 Significance towards the final grade:
One receives the final grade at the end of the oral examination. This comprises 4.8 % of the final grade that one receives at the end of Master’s Program.

10 Reading to complement course material:
R. Korn, E. Korn, G. Kroisandt: Monte Carlo Methods and Models in Finance and Insurance,
Ö. Ugur: An Introduction to Computational Finance.

11 Authorised representatives of the module:
Prof. Dr. R. Korn, Prof. Dr. K. Ritter
## Financial Statistics

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-62-13-M-7</td>
<td>135 h</td>
<td>4,5 CP</td>
<td>1st, 2nd or 3rd</td>
<td>irregular</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

### 1 Courses
- **Financial Statistics**: 2 SWS / 30 lecture hours, 105 h
- **Intended size of class**: 15-25 Students

### 2 Result of study / competences:
Students know and understand advanced statistical methods to model and estimate risks, especially those concerning financial management and insurance business.

### 3 Contents:
- **Statistics of Financial Markets**:
  - Schemes and estimation procedures for financial time series (ARCH, GARCH and generalisations), Value-at-Risk
  - Copulas and its application for risk management based on multivariate data
- **Extreme Value Theory**:
  - Statistical methods to estimate the probability of extreme events or extreme quantiles.

### 4 Form of teaching:
Lectures.

### 5 Prerequisites:
The course "Regression and Time Series Analysis “from the Bachelor’s degree programme in Wirtschaftsmathematik.

### 6 Type of examination:
Oral exam (individual examination, Duration 20-30 minutes).

### 7 Requirements for the award of credits:
Participation in the end of semester examination.

### 8 Usability of this module:
This course is an elective module for Master’s degree in Actuarial and Financial Mathematics.
Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International:
- Main focus of study is "Financial Mathematics" or "Statistics";
- Areas of applied mathematics or general mathematics if the main focus of study is not chosen from the list above (considering the rules of the degree programme which might restrict the above).

### 9 Significance towards the final grade:
One receives the final grade at the end of the oral examination. This comprises 4.8 % of the final grade that one receives at the end of Master’s Program.

### 10 Reading to complement course material:
- J. Franke, W.K. Härdle, C.M. Hafner: Statistics of Financial Markets: An Introduction,

### 11 Authorised representatives of the module:
Prof. Dr. J. Franke, Dr. J.-P. Stockis
3. Financial Economics

The course details for the modules mentioned here can be found in the German version here or in the Handbook of Modules for Economics (Wirtschaftswissenschaften) here.

3.1 Compulsory modules

Insurance Economics.

3.2 Elective modules

Under elective modules in “Financial Economics” one has to obtain 9 credit points (CP) from the courses offered in Master’s in Economics under the title “Financial Economics” or “Finanz- und Bankmanagement” (link). In particular, one could choose modules from the following list:-

- “Bankmanagement II: Bankanalyse und –steuerung”
- “Choice under Uncertainty”,
- “Contract Theory”,
- “Dynamics of Financial Markets”,
- “Economics of Banking”,
- “Investitionsrechnung”,
- “Kapitalanlagemanagement”,
- “Risikomanagement”.

With the approval of the examination board, other modules from the field of Economics may also be permitted.
4. Specialization Actuarial and Financial Mathematics

4.1 In-depth module

<table>
<thead>
<tr>
<th>Specialization Actuarial and Financial Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module Number</strong></td>
</tr>
<tr>
<td>MAT-61-12A-M-7</td>
</tr>
</tbody>
</table>

1. Courses

- Interest Rate Theory
- Another in-depth course is to be chosen from:
  - "Continuous-Time Portfolio Optimization",
  - "Life, Health, and Pension Insurance Mathematics",
  - "Markov Switching Models and their Applications in Finance",
  - "Risk Measures with Applications to Finance and Insurance"
- Or another in depth (specialization) course from the field of actuarial and financial mathematics.

<table>
<thead>
<tr>
<th>Self-Study</th>
<th>Intended size of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>105 h</td>
<td>20-40 Students</td>
</tr>
<tr>
<td>105 h</td>
<td>15-30 Students</td>
</tr>
</tbody>
</table>

2. Result of study / competences:

Students understand the fundamentals of the theory of interest rate products and modelling of interest rate markets. They are able to understand the deep relations in the theory of interest rate modelling and analytical evaluation process of global rates.

In addition, they acquire in-depth knowledge of specific concepts and methods in other areas of financial and insurance mathematics, such as methods for solving stochastic control problems (stochastic control, duality approach), Markov switching models, the theory of risk measurements or advanced topics of personal insurance. They learn to apply these methods and are able to critically assess the implementation and application of the theoretical results.

They gain a precise and independent handling of terms, propositions and methods of the lecture. They understand proofs presented in the lecture and are able to reproduce and explain them. They can in particular outline the conditions and assumptions that are necessary for the validity of the statements and how these are to be interpreted in the context of actuarial and financial mathematics.

3. Contents:

**Interest Rate Theory:**

- Basics of interest modelling (Bonds and linear products, swaps, caps and floors, bond options, rate of interest options, interest rate term structure curve, interest rates (short rates and forward rates))
- Heath–Jarrow–Morton framework (simple example: Ho–Lee model, general HJM drift condition, one- and multidimensional modelling)
- Short rate models (general one factor-modelling, term structure equation, affine modelling of interest rate structure, Vasicek-, Cox-Ingersoll-Ross- and further models, option pricing model, model calibration )
- Defaultable bonds (Merton model)

**Other specialization modules:**

See the corresponding course description under Lehrveranstaltungsbeschreibung.

4. Form of teaching:

Lectures.
<table>
<thead>
<tr>
<th>5</th>
<th>Prerequisites:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module &quot;Financial Mathematics&quot;: Depending on the choice of the lecture, different courses from the bachelor and the master degree programme of mathematics will be required. Kindly refer to course description under Lehrveranstaltungsbeschreibung.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6</th>
<th>Type of examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral exam (individual examination, Duration 20-30 minutes).</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7</th>
<th>Requirements for the award of credits:</th>
</tr>
</thead>
<tbody>
<tr>
<td>The examinations of the selected courses.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8</th>
<th>Usability of this module:</th>
</tr>
</thead>
<tbody>
<tr>
<td>This course is a compulsory module under specialization for Master's degree in Actuarial and Financial Mathematics.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>9</th>
<th>Significance towards the final grade:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One receives the final grade at the end of the oral examination. This comprises 9.6 % of the final grade that one receives at the end of Master's Program.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>10</th>
<th>Reading to complement course material:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interest Rate Theory:</strong></td>
<td></td>
</tr>
<tr>
<td>T. Björk: Arbitrage Theory in Continuous Time,</td>
<td></td>
</tr>
<tr>
<td>D. Brigo, F. Mercurio: Interest Rate Models – Theory and Practice,</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other specialization modules:</th>
</tr>
</thead>
<tbody>
<tr>
<td>See the corresponding course description under Lehrveranstaltungsbeschreibung</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>11</th>
<th>Authorised representatives of the module:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. R. Korn, Prof. Dr. J. Saß</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12</th>
<th>Additional Information:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each winter semester at least one of the following courses will be offered: Continuous-Time Portfolio Optimization, Life, Health, and Pension Insurance Mathematics, Markov Switching Models and their Applications in Finance, Risk Measures with Applications to Finance and Insurance.</td>
<td></td>
</tr>
</tbody>
</table>

**Course catalogue for modules under specialization:**

As part of the specialization modules (in depth module) a specialization course amounting to 2 hours per week will be offered. This can be chosen from:

- Continuous-Time Portfolio Optimization
- Life, Health, and Pension Insurance Mathematics
- Markov Switching Models and their Applications in Finance
- Risk Measures with Applications to Finance and Insurance
With the approval of the examination committee, one is also allowed to choose other specialization courses from the field of financial and actuarial mathematics.
## Continuous-Time Portfolio Optimization (Zeitstetige Portfoliooptimierung)

<table>
<thead>
<tr>
<th>LV-Number</th>
<th>Effort</th>
<th>LP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-15-V-7</td>
<td>see Modul-beschreibung</td>
<td>see Modul-beschreibung</td>
<td>2nd or 3rd</td>
<td>irregular (in WS)</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

### 1 Courses
- Continuous-Time Portfolio Optimization

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Self-Study</th>
<th>Intended size of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 SWS / 30 lecture hours</td>
<td>105 h</td>
<td>15-30 Students</td>
<td></td>
</tr>
</tbody>
</table>

### 2 Result of study / competences:
Students know and understand the two main methods for solving stochastic control problems in financial and insurance mathematics, i.e. the stochastic control approach and the duality approach. They understand the proofs presented in the lecture and are able reconstruct and explain them. They can use the methods on various problems of portfolio optimization and critically assess the implementation and application of the theoretical results. They are able to assess the applicability of a method or alternative methods under various model extensions and restrictions to the strategies and understand the impact these have on the optimal solutions.

### 3 Contents:
- Introduction to Portfolio-Optimization (problem statement)
- Continuous-time portfolio problem: expected benefit approach
- Martingale method for complete markets
- Stochastic control approach (HJB equation, verification theorems)
- Portfolio-Optimization with restrictions (e.g. risk boundaries, transaction costs)
- Alternative methods

### 4 Form of teaching:
Lectures

### 5 Prerequisites:
Module "Financial Mathematics".

### 6 Reading to complement course material:
- I. Karatzas, S.E. Shreve: Methods of Mathematical Finance,
- R. Korn: Optimal Portfolios,
- R. Korn, E. Korn: Option Pricing and Portfolio Optimization - Modern Methods of Financial Mathematics,

---

## Life, Health, and Pension Insurance Mathematics (Personenversicherungsmathematik)

<table>
<thead>
<tr>
<th>LV-Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-31-M-7</td>
<td>see Modul-beschreibung</td>
<td>see Modul-beschreibung</td>
<td>2nd or 3rd</td>
<td>irregular (in WS)</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

### 1 Courses
- Life, Health, and Pension Insurance Mathematics

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Self-Study</th>
<th>Intended size of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 SWS / 30 lecture hours</td>
<td>105 h</td>
<td>15-30 Students</td>
<td></td>
</tr>
</tbody>
</table>
2 **Result of study / competences:**
Students understand the dynamic mathematical models in life insurance and life insurance products, which allow for investment in the financial market. In addition, they master the basic model requirements and methods of pension and health insurance.

They learn to combine techniques of financial mathematics with current issues of actuarial mathematics and critically assess the corresponding insurance products. Moreover, they are able to understand and apply the concepts learnt in the module "Life Insurance Mathematics" to the specific case of pension and health insurance mathematics.

3 **Contents:**
This lecture is based on the module "Life Insurance Mathematics". It deals with dynamic models in life insurance mathematics and with life insurance products which allow for investment in the financial market. In addition, mathematical models and specific problems of pension plans and health insurance are addressed. The following topics are covered:

*Life Insurance Mathematics:*
- Dynamic models (Markov chain, continuous time),
- Stochastic interest rates,
- Products with investment in the financial market and guarantee funds,
- Market consistent valuation.

*Actuarial Mathematics for Pension Plans:*
- State diagrams and benefits,
- Neuburger’s model,
- Estimation of decrement rates,
- Premiums and actuarial reserves.

*Health Insurance Mathematics:*
- Premium principles,
- Reserves for increasing age and contract changes,
- Profit participation and premium reductions,
- Risk assessment.

4 **Form of teaching:**
Lectures.

5 **Prerequisites:**
Module "Financial Mathematics" and "Life Insurance Mathematics".

6 **Reading to complement course material:**
M. Koller: Stochastic Models in Life Insurance,
# Markov Switching Models and their Applications in Finance

<table>
<thead>
<tr>
<th>LV-Number MAT-61-20-V-7</th>
<th>Effort see Modul-beschreibung</th>
<th>LP (Credits) see Modul-beschreibung</th>
<th>Semester 2nd or 3rd</th>
<th>Frequency of occurrence Irregular (in WS)</th>
<th>Duration 1 Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Courses</td>
<td>Markov Switching Models and their Applications in Finance</td>
<td>2 SWS / 30 lecture hours</td>
<td>Self-Study 105 h</td>
<td>Intended size of class 15-30 Students</td>
<td></td>
</tr>
</tbody>
</table>

## Result of study / competences:

Students know and understand properties of Markov switching models that are suitable for modelling financial time series and their application, both in discrete and continuous time. They can critically analyse different modelling approaches. They also understand the theoretical foundations of filter theory, the methods for parameter estimation and model selection and know how these can be implemented. With regard to the predictability of application and its comparison with econometric properties of financial time series, they are able to make a reasonable choice of models for various applications in financial mathematics and time series analysis. They understand the proofs presented in the lecture and are able to reproduce and explain them.

## Contents:

- Discrete-time and continuous-time Markov chains,
- Hidden Markov models in discrete time,
- Continuous time Markov switching models
- Parameter estimation and filtering
- Modelling financial asset prices
- Econometric properties of financial time series and model extensions,
- Applications to portfolio optimization

## Form of teaching:

Lectures

## Prerequisites:

Module "Mathematical Statistics" or "Probability Theory". Knowledge of modules "Time Series Analysis " or "Financial Mathematics" would be useful, but not necessarily required.

## Reading to complement course material:

A. Bain, D. Crisan: Fundamentals of Stochastic Filtering,
O. Cappé, E. Moulines, T. Rydén: Inferences in Hidden Mrkov Models,
R.J. Elliott, L. Aggoun, J.B. Moore: Hidden Markov Models – Estimation and Control,
S. Frühwirth-Schnatter: Finite Mixture and Markov Switching Models,
J.R. Norris: Markov Chains,
### Risk Measures with Applications to Finance and Insurance

<table>
<thead>
<tr>
<th>LV-Number</th>
<th>Effort</th>
<th>LP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-30-M-7</td>
<td>see Modul-beschreibung</td>
<td>see Modul-beschreibung</td>
<td>2nd or 3rd</td>
<td>Irregular (in WS)</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

1. **Courses**
   - Risk Measures with Applications to Finance and Insurance
   - 2 SWS / 30 lecture hours
   - Self-Study
   - 105 h
   - 15-30 Students

2. **Result of study / competences:**
   Students know and understand the basics of axiomatic theory of risk measures. They can classify different risk measures and assess the advantages and disadvantages of specific risk measures in various fields of finance and insurance mathematics. They understand the proofs and are able to reproduce and explain them. They can critically assess the different rating procedures and methods for the measurement of credit risk.

3. **Contents:**
   - Preferences and expected utility,
   - Axiomatic introduction of risk measures,
   - Robust representation of convex and coherent risk measures,
   - Examples: Value at Risk, Average Value at Risk, Short case, worst case,
   - Extensions: Semi Dynamic, dynamic, distribution-free risk measures,
   - Estimation of risk measures,
   - Rating systems:
     - Score-based ratings,
     - Utility based ratings of financial products,
     - Risk-classes for insurance products,
   - Credit risk: Structural models and reduced form models,
   - Applications:
     - Risk-based insurance premiums,
     - Portfolio optimization under risk constraints,
     - Credit derivatives.

4. **Form of teaching:**
   Lectures

5. **Prerequisites:**
   Module "Financial Mathematics".

6. **Reading to complement course material:**
   - H. Föllmer, A. Schied: Stochastic Finance: An Introduction in Discrete Time,
   - L. Rüschendorf: Mathematical Risk Analysis.
4.2 Reading Course

The department of mathematics offers various courses for guided independent academic work ("Reading Courses"), the topics for which change every semester and are often based on current research topics.

Towards the end of the lecture period each semester, the courses offered in various fields under "Reading Course" are presented by the working groups through an informative meeting.

In the master’s program "Financial and Actuarial Mathematics", one has to complete such a course amounting to 6CP.

<table>
<thead>
<tr>
<th>Reading Course: Advanced Topics in Actuarial and Financial Mathematics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module Number</strong></td>
</tr>
<tr>
<td>MAT-61-RC-M-7</td>
</tr>
<tr>
<td><strong>Courses</strong></td>
</tr>
<tr>
<td>Reading Course &lt;topic&gt;</td>
</tr>
<tr>
<td><strong>Result of study / competences:</strong></td>
</tr>
<tr>
<td>Using prescribed texts, students learn to work on an advanced topic in the field of financial and actuarial mathematics independently. They are prepared to work on their Master thesis in the chosen area of specialization.</td>
</tr>
<tr>
<td><strong>Contents:</strong></td>
</tr>
<tr>
<td>The topics are usually chosen from current areas of research (e.g. &quot;applications of BSDE in Financial and Actuarial Mathematics&quot;), research topics with practical relevance (e.g. &quot;The mathematics behind Solvency II&quot;) or classical areas that could not be covered in a lecture (e.g. reading research papers from the early stages of Financial Mathematics).</td>
</tr>
<tr>
<td><strong>Form of teaching:</strong></td>
</tr>
<tr>
<td>Reading Course</td>
</tr>
<tr>
<td><strong>Prerequisites:</strong></td>
</tr>
<tr>
<td>Depending on the choice of the topic, different courses from the bachelor and the master degree programmes of mathematics will be required.</td>
</tr>
<tr>
<td>Formal conditions: prior registration.</td>
</tr>
<tr>
<td><strong>Type of examination:</strong></td>
</tr>
<tr>
<td>Presentation, scientific discussion and/or report submission.</td>
</tr>
<tr>
<td><strong>Requirements for the award of credits:</strong></td>
</tr>
<tr>
<td>&quot;Schein&quot; certifying successful participation in the reading course.</td>
</tr>
<tr>
<td><strong>Usability of this module:</strong></td>
</tr>
<tr>
<td>Elective module for Master’s program in Actuarial and Financial Mathematics. (Specialization).</td>
</tr>
<tr>
<td>Elective module for Master’s degree in Mathematics, Technomathematics, Economathematics and Mathematics International. This can be considered as a module under specialization when the main focus of study is Financial Mathematics.</td>
</tr>
<tr>
<td>This module provides a basis for master’s thesis and other research in the field of financial mathematics.</td>
</tr>
<tr>
<td><strong>Significance towards the final grade:</strong></td>
</tr>
<tr>
<td>The module will not be graded.</td>
</tr>
<tr>
<td><strong>Reading to complement course material:</strong></td>
</tr>
<tr>
<td>Depends on the topic.</td>
</tr>
</tbody>
</table>
Authorised representatives of the module:
Prof. Dr. R. Korn, Prof. Dr. J. Saß
### 4.3 Internship or Project Work

**Projektseminar Advanced Modelling in Actuarial and Financial Mathematics**

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAT-61-PROJ-M-7</td>
<td>180 h</td>
<td>6 CP</td>
<td>3rd</td>
<td>Every semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

**1 Courses**

Projektseminar Advanced Modelling in Actuarial and Financial Mathematics

<table>
<thead>
<tr>
<th>Intended size of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 – 15 Students</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-Study</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 SWS / 30 h</td>
<td>150 h</td>
<td>3rd</td>
<td>Every semester</td>
<td>1 Semester</td>
</tr>
</tbody>
</table>

**2 Result of study / competences:**

Students are able to apply the acquired knowledge to practical problems of financial and actuarial industry. They can gather the knowledge required, develop and implement their solutions independently. Through the presentation, they display their understanding of the problem and the methods used to analyse the same.

**3 Contents:**

Working on a project from the field of finance and insurance sectors in a group (2-5 participants) under the guidance of a project supervisor:

- **Starting point** is a real life problem.
- **Handling the problem:** Problem solving; selection or development of an appropriate financial or actuarial model, gathering the required theoretical knowledge, formulating solutions, development of theoretical solutions or selection of suitable numerical methods, implementation of the method. During the regular meetings with the supervisor, a group member should present the current state of work and plan for further action.
- **Final presentation and / or final report:** Each member of the group would be responsible for a certain part of the project.

**4 Form of teaching:**

Project based seminar.

**5 Prerequisites:**

Depending on the choice of the topic, different courses from the bachelor and the master degree programmes of mathematics will be required.

Formal conditions: prior registration, eligibility to participate might depend on whether the student has passed certain specific modules from "Actuarial and Financial Mathematics". Participation criterion might also depend on the number of credit points the student has accumulated.

**6 Type of examination :**

Presentation and/or report submission.

**7 Requirements for the award of credits:**

"Praktikumsschein" certifying successful participation in the project based seminar.

With the approval of the examination board of the department of mathematics, this module can be replaced by an external (job-related) internship, provided it is ensured that the above-mentioned results of study / competences are achieved. The presentation or report submitted should be edited to ensure that enterprise-specific features are taken into account.

**8 Usability of this module:**

Elective module for Master’s program in Actuarial and Financial Mathematics. (Specialization).

**9 Significance towards the final grade:**

This module will not be graded.
<table>
<thead>
<tr>
<th></th>
<th>Reading to complement course material:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Authorised representatives of the module:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prof. Dr. R. Korn, Prof. Dr. J. Saß</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Additional Information:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Registration and briefing for the project seminar usually takes place at the end of the lecture period of the preceding semester.</td>
</tr>
</tbody>
</table>
## 5. Master's Thesis

### Master's Thesis

<table>
<thead>
<tr>
<th>Module Number</th>
<th>Effort</th>
<th>CP (Credits)</th>
<th>Semester</th>
<th>Frequency of occurrence</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>900 h</td>
<td>30 CP</td>
<td>4</td>
<td>every semester</td>
<td>6 Months</td>
</tr>
</tbody>
</table>

#### 1 Courses:
- Self-Study
  - 900 h
- One person, in exceptional cases, small groups (considering the rules of the degree programme and examination regulations).

#### 2 Result of study / competences:
- Students are able to:
  - Work on a mathematical problem autonomously within a given period of time. Hence use and apply the scientific methods and the technical and methodological competences acquired during their study,
  - Critically interpret scientific results and integrate them into the respective knowledge.
  - Present their results in writing according to the principles of good scientific practice.

#### 3 Contents:
- Advanced mathematical problem in the field of Actuarial and Financial Mathematics.

#### 4 Form of teaching:
- Thesis: under the guidance of a supervisor, the students have learned to work on an advanced mathematical topic on the basis of given literature, using scientific methods. They are able to write a scientific master's thesis in their chosen main focus of study.

#### 5 Prerequisites:
- **Recommended**: Modules offered under “Actuarial and Financial Mathematics” (incl. Specialization), seminars and Reading Courses; depending on the thesis, knowledge from other modules of the master’s program.
- **Formal**: One should have completed a minimum of 60 CP to start working on the master’s thesis.

#### 6 Type of examination:
- Final report has to be submitted, which would be graded.

#### 7 Requirements for the award of credits:
- Timely submission of the thesis report, final grade of 4.0 or better awarded by the examiners.

#### 8 Usability of this module:
- Compulsory module for Master's program in Actuarial and Financial Mathematics.

#### 9 Significance towards the final grade:
- The grade that one receives for the thesis report comprises 31.9% of the final grade that one receives at the end of Master's Program.

#### 10 Reading to complement course material:
- Ask the supervisor, also refer to 12 (Additional Information).

#### 11 Authorised representatives of the module:
- Faculty members of the department of mathematics.
12 **Additional Information:**

Information about the thesis is given in specific information sessions at the end of each lecture period. Students should contact the lecturers of the chosen specialization in time, at the latest at the beginning of the second year of their study, to collect information about the range of topics and the necessary content-related requirements.