Programme-specific Section of the Curriculum for the MSc Programme in Actuarial Mathematics at the Faculty of Science, University of Copenhagen 2010 (Rev. 2015)

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1 Title, affiliation and language
A shared section that applies to all BSc and MSc Programmes at the Faculty of Science is linked to this programme-specific curriculum.

1.1 Title
The MSc Programme in Actuarial Mathematics leads to a Master of Science (MSc) in Actuarial Mathematics with the Danish title: Cand.scient. (candidatus/candidata scientiarum) i forsikringsmatematik.

1.2 Affiliation
The programme is affiliated with the Study Board for Mathematics and Computer Science, and the students can both elect, and be elected, to this study board.

1.3 Corps of external examiners
The following corps of external examiners is used for the central parts of the MSc Programme:
- Corps of External Examiners for Mathematics (matematik).

1.4 Language
The language of this MSc Programme is English.

2 Academic profile
2.1 Purpose
The MSc programme in Actuarial Mathematics is a research-based programme, the objective of which is to provide the student with the mathematical knowledge and insights required to work independently and in a professionally sound manner within the insurance profession and contribute to the further development of this theoretical field.

2.2 General programme profile
The programme provides a general introduction to both life and non-life insurance mathematics. The student can subsequently specialise in one of these disciplines or in fields such as stochastic processes, risk management, financial theory and statistical analysis.

Actuarial mathematics, probability theory, finance, statistics and computer science are the key subject areas of the programme.

2.3 General structure of the programme
The MSc Programme is set at 120 ECTS credits.

There are no defined specialisations in this programme.

2.4 Career opportunities
The MSc Programme in Actuarial Mathematics qualifies students for a PhD programme, and depending on the academic specialisation it may also be targeted at business functions and/or areas such as:
- Actuarial functions in insurance companies.
- Regulative authorities.
- Specialized software development.
3 Description of competence profiles
Students following the MSc Programme acquire the knowledge, skills and competences listed below. Students will also acquire other qualifications through elective subject elements and other study activities.

3.1 Competence profile
On completion of the programme, an MSc in Actuarial Mathematics has acquired the following:

Knowledge about:
- General theory for stochastic processes, including various special classes of processes: Martingales, Counting Processes, Renewal Processes, Stochastic Integrals and more.
- Stochastic differential equations with applications to finance.
- Risk measures and extreme value theory.
- Ruin theory, in particular the Cramér-Lundberg model.
- Credit modelling and operational risk modelling.
- Claim reservation.
- Term structure theory and market reserves.
- Parametric and non-parametric statistical models for insurance applications.
- Selected research-active fields with life and non-life insurance mathematics.

Skills to:
- Read and understand actuarial mathematical and statistical original literature.
- Communicate actuarial mathematical issues on a scientific basis.
- Account orally and in writing for inquiries into open actuarial mathematical issues.
- Derive and solve differential equations describing actuarial problems.
- Determine arbitrage free prices for financial claims.
- Compute ruin probabilities and value-at-risk.
- Analyse statistical models for insurance applications.

Competences to:
- Structure an inquiry into open actuarial mathematical issues, regarding both life and non-life insurance mathematics and divide it into smaller easily accessible challenges.
- Further develop and adapt probabilistic and statistical models for real-life challenges.
- Conduct independent, stringent argumentation.
- Independently take responsibility for his or her own professional development and specialisation.
- Reflect on methodologies for analysing and solving actuarial mathematical issues at a scientific level.

4 Admission requirements
Students are admitted to the MSc Programme in Actuarial Mathematics once a year, with studies starting on 1 September.

Applicants with a Bachelor’s degree in Actuarial Mathematics from the University of Copenhagen who complete their Bachelor’s degree in block 1 or 2 may additionally be admitted to the MSc Programme in Actuarial Mathematics with studies starting on 1 February of the academic year in question.
4.1 Applicants with a Bachelor’s degree in Actuarial Mathematics
Applicants with a Bachelor’s degree in Actuarial Mathematics from the University of Copenhagen, other Danish or Nordic universities are directly academically qualified for admission to the MSc Programme.

4.2 Applicants with a closely related Bachelor’s degree
Applicants with a Bachelor’s degree in Mathematics-Economics or Mathematics from the University of Copenhagen or other Danish or international universities may also be admitted if their programme includes the following:
- Subject elements in life insurance mathematics (at least 7.5 ECTS).
- Subject elements in non-life insurance mathematics (at least 7.5 ECTS).
- Subject elements in statistics on a measure-theoretical basis (at least 15 ECTS).

4.3 Applicants with a related Bachelor’s degree
Applicants with a Bachelor’s degree in Computer Science, Physics or Chemistry from the University of Copenhagen or other Danish or international universities may also be admitted if their programme includes the following elements:
- Subject elements in mathematical analysis, including measure theory at least 22.5 ECTS credits.
- Subject elements in linear algebra at least 7.5 ECTS credits.
- Subject elements in life insurance mathematics at least 7.5 ECTS credits.
- Subject elements in non-life insurance mathematics at least 7.5 ECTS credits.
- Subject elements in statistics on a measure-theoretical basis at least 15 ECTS credits.

4.4 Other applicants
The Faculty may also admit applicants who, after a thorough academic assessment, are deemed to possess a Bachelor’s degree with educational qualifications equivalent to those required in Subclauses 4.1-3.

4.5 Language requirements
4.5.1 Applicants from Nordic universities
Applicants with a Bachelor's degree from Nordic universities must as a minimum document English language qualifications comparable to a Danish upper secondary school English B level.

4.5.2 Non-Nordic applicants
Applicants with a non-Nordic Bachelor’s degree must be able to document English proficiency corresponding to an IELTS test score of minimum 6.5 or a TOEFL test score of minimum 213 (computer-based), 560 (paper-based) or 83 (Internet-based).

5 Prioritisation of applicants
If the number of qualified applicants to the programme exceeds the number of places available, applicants will be prioritised as follows:

1) Applicants with a Bachelor’s degree in Actuarial Mathematics from the University of Copenhagen seeking admission by way of direct extension of their completed BSc programme.
2) Other applicants with a Bachelor’s degree in Actuarial Mathematics.
3) Other applicants with a Bachelor’s degree in Mathematics or Mathematics-Economics from the University of Copenhagen.
4) Other applicants.

Applicants are then prioritised according to their total numbers of ECTS credits within the academic fields and the grades obtained.
6 Structure of the programme

The compulsory subject elements, restricted elective subject elements and the thesis constitute the central parts of the programme (Section 21 of the Ministerial Order on Bachelor and Master’s Programmes (Candidatus) at Universities).

All of the compulsory subject elements (including thesis) defined below must be followed at the exact time planned according to the table in Appendix 1. Restricted elective and elective subject elements may be freely placed in the remaining blocks.

6.1 Programme components

The programme is set at 120 ECTS credits and consists of the following:

- Compulsory subject elements, 60 ECTS credits.
- Restricted elective subject elements, 15 ECTS credits.
- Elective subject elements, 15 ECTS credits.
- Thesis, 30 ECTS credits.

6.1.1 Compulsory subject elements

All of the following subject elements are to be covered (60 ECTS credits):

- NMAK11003U Advanced Probability Theory 1 (VidSand1 Block 1 7.5 ECTS credits)
- NMAA05115U Stochastic Processes in Life Insurance (LivStok Block 1 7.5 ECTS credits)
- NMAK11011U Advanced Probability Theory 2 (VidSand2 Block 2 7.5 ECTS credits)
- NMAA05113U Continuous Time Finance (FinKont Block 2 7.5 ECTS credits)
- NMAA06068U Topics in Life Insurance (Liv2 Block 3 7.5 ECTS credits)
- NMAA06068U Topics in Non-Life Insurance (Skade2 Block 3 7.5 ECTS credits)
- NMAA05117U Stochastic Processes in Non-Life Insurance (SkadeStok Block 1 7.5 ECTS credits)
- NMAK10020U Quantitative Risk Management (QRM Block 2 7.5 ECTS credits)

6.1.2 Restricted elective subject elements

15 ECTS credits are to be covered as subject elements from the following list:

- NMAK15011U Control Theory in Finance (Block 1 7.5 ECTS credits)
- NMAK15019U Phase-type distributions: Theory and applications (Block 1 7.5 ECTS credits)
- NMAK13005U Introduction to Extreme Value Theory (IntroExtremValue) (Block 2 7.5 ECTS credits)
- NMAK15024U Topics in Financial Risk Management (Block 2 7.5 ECTS credits)
- NMAK14013U Modelling dependence in discrete time (Block 3 7.5 ECTS credits)
- NMAK15018U Modelling Dependence in Non-Life Insurance (Block 4 7.5 ECTS credits)
- NMAK14022U Statistics for non-linear time series models (Block 4 7.5 ECTS credits)

6.1.3 Elective subject elements

15 ECTS credits are to be covered as elective subject elements.

BSc subject elements corresponding to 15 ECTS credits may be included in the MSc Programme without the approval of the study board.

Projects outside the course scope may be included in the elective section of the programme with up to 15 ECTS credits. The regulations are described in Appendix 5 to the shared section of the curriculum.

Projects in practice may be included in the elective section of the programme with up to 15 ECTS credits. The regulations are described in Appendix 4 to the shared section of the curriculum.
6.1.4 Thesis
The MSc Programme in Actuarial Mathematics includes a thesis corresponding to 30 ECTS credits, as described in Appendix 2 to the shared curriculum. The topic of the thesis must be within the academic scope of the programme.

There are programme specific rules which define parts of the shared curriculum in more detail. The following specific rules apply to this programme:

- The thesis must be written full time.

6.1.5 Academic Mobility
The academic mobility in the MSc Programme in Actuarial Mathematics is placed in block 1+2 of the 2nd year. This means that the curriculum makes it possible to follow subject elements or conduct projects outside the Faculty of Science. In addition the student has the possibility to arrange similar academic mobility in other parts of the programme. Both options require that the student follows the rules and regulations regarding pre-approvals and credit.

6.2 Compliance of the requirements for external examiners and assessment
The MSc Programme automatically fulfils the requirement that one-third of the programme's ECTS credits must be subject to external examination and two-thirds of the ECTS credits must be assessed by grades, cf. the Shared Section of the BSc and MSc Curricula for Study Programmes.

ECTS credits transferred are excluded from the calculation of the requirement for external examination and assessment by grades.

7 Exemptions
In exceptional circumstances, the university may grant exemptions from the rules in the curriculum specified solely by the university.

8 Commencement etc.
8.1 Validity
This subject specific section of the curriculum applies to all students enrolled in the programme – see however Appendix 2.

8.2 Transfer
Students enrolled on previous curricula may be transferred to the new one as per the applicable transfer regulations or according to an individual credit transfer by the study board.

8.3 Amendments
The curriculum may be amended once a year so that any changes enter into force on the start of the academic year. Amendments must be proposed by the study board and approved by the Dean.

Notification about amendments that tighten the admission requirements for the programme will be published online at www.science.ku.dk one year before they come into effect.

If amendments are made to this curriculum, an interim arrangement may be added if necessary to allow students to complete their MSc Programme according to the amended curriculum.
Appendix 1 Tables

Tables for students admitted to the programme in September (summer):

Table – MSc Programme in Actuarial Mathematics

<table>
<thead>
<tr>
<th></th>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>Advanced Probability Theory 1</td>
<td>Advanced Probability Theory 2</td>
<td>Topics in non-life insurance</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>Stochastic processes in life</td>
<td>Continuous Time Finance</td>
<td>Topics in Life Insurance</td>
<td>Restricted elective</td>
</tr>
<tr>
<td></td>
<td>insurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2nd year</td>
<td>Stochastic processes in non-life</td>
<td>Quantitative risk management</td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td></td>
<td>insurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*This table is only relevant for students who begin the MSc Programme in February (block 3).

Table for students admitted to the programme in February (winter):

Table – MSc Programme in Actuarial Mathematics*

<table>
<thead>
<tr>
<th></th>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year</td>
<td>Elective</td>
<td>Elective</td>
<td>Advanced Probability Theory 1</td>
<td>Advanced Probability Theory 2</td>
</tr>
<tr>
<td></td>
<td>Topics in non-life insurance</td>
<td>Restricted elective</td>
<td>Stochastic Processes in Life</td>
<td>Continuous Time Finance 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insurance</td>
<td></td>
</tr>
<tr>
<td>2nd year</td>
<td>Topics in life insurance</td>
<td>Restricted elective</td>
<td>Stochastic Processes in Non-Life</td>
<td>Quantitative risk management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Insurance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Thesis</td>
</tr>
</tbody>
</table>

*This table is only relevant for students who begin the MSc Programme in February (block 3).
Appendix 2 Interim arrangements

The Shared Section of the BSc and MSc Curricula for Study Programmes 2014 (rev. 2015) applies to all students admitted at the beginning of the academic year 2015/16 or earlier.

1 General changes valid for students admitted in the academic year 2014/2015 or earlier

Restricted elective subject elements
For students enrolled in 2014/2015 or earlier 15 ECTS credits are to be covered by restricted elective subject elements from the following list:

- Subject elements that have the abbreviation “AAM” (advanced actuarial mathematics)
- Projects outside the course scope with the principal supervisor from the Department of Mathematical Sciences.

At least one “AAM”-course will be provided in every block. The same course can only be taken once.

Thesis
The thesis may either be carried out as a full-time project at the end of the study programme or concurrently with other subject elements. However, the thesis must conclude the programme.

Competence profile
On completion of the programme, an MSc in Actuarial Mathematics enrolled in 2014/2015 or earlier has acquired the following:

Knowledge about:
- Selected research-active fields within life and non-life insurance mathematics.

Skills to:
- Read and understand actuarial mathematical and statistical original literature.
- Communicate actuarial mathematical issues on a scientific basis.
- Account orally and in writing for inquiries into open actuarial mathematical issues.

Competences to:
- Structure an inquiry into open actuarial mathematical issues, regarding both life and non-life insurance mathematics and divide it into smaller easily accessible challenges. Further develop and adapt probabilistic and statistical models for real-life challenges.
- Conduct independent, stringent argumentation.
- Independently take responsibility for his or her own professional development and specialisation.
- Reflect on methodologies for analysing and solving actuarial mathematical issues at a scientific level.

2 Course specific changes valid for students admitted in the academic year 2011 or earlier

<table>
<thead>
<tr>
<th>Discontinued course</th>
<th>Interim arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Probability Theory 2 (Sand2), 7.5 ECTS credits.</td>
<td>The course was offered for the last time in 2009 and a third examination attempt has been held in 2011/12.</td>
</tr>
<tr>
<td>Probability Theory 3 (Sand3), 7.5 ECTS credits.</td>
<td>If you have completed neither Probability Theory 3 (Sand3) nor Probability Theory 4 (Sand4): Take both Advanced Probability Theory 1</td>
</tr>
</tbody>
</table>
If you have completed either Sand3 OR Sand4: Take Advanced Probability Theory 2 (VidSand2).

If you have completed either Sand3 OR Sand4: Take Advanced Probability Theory 2 (VidSand2).

Probability Theory 4 (Sand4), 7.5 ECTS credits. The course was offered for the last time in 2009 and a third examination attempt has been held in 2011/12.

If you have completed neither Probability Theory 3 (Sand3) nor Probability Theory 4 (Sand4): Take both Advanced Probability Theory 1 (VidSand1) and Advanced Probability Theory 2 (VidSand2).

If you have completed either Probability Theory (Sand3) OR Probability Theory 4 (Sand4): Take Advanced Probability Theory 2 (VidSand2).

Advanced Probability Theory 1 (Vidsand1), (NMAK11003U) 7.5 ECTS credits. The course was offered for the last time in 2014/15 and a third examination attempt will be offered in the academic year 2015/16.

Probability Theory 2 (Sand2) and Probability Theory 3 (Sand3) can replace Advanced Probability Theory 1 (VidSand1).

Advanced Probability Theory 2 (Vidsand2), (NMAK11011U), 7.5 ECTS credits. The course was offered for the last time in 2014/2015 and a third examination attempt has been held.

Probability Theory 3 (Sand3) + Probability Theory 4 (Sand4) can replace Advanced Probability Theory 2 (VidSand2).

### 3 Course specific changes valid for students admitted in the academic year 2014 or earlier

<table>
<thead>
<tr>
<th>AAM courses</th>
</tr>
</thead>
</table>
| For students enrolled in 2014/2015 or earlier the restricted elective subject elements are designated by the abbreviation ’AAM’ (Advanced Actuarial Mathematics). These restricted elective subject elements have previously been designated by the following parenthesis after the course title: ‘(Topics in insurance mathematics)’.

Below is a list of the previous and present AAM-subject elements:

- NMAA09033U A300: Emner I large divinations
- NMAA09013U AS200: Ekstremværditeori
- NMAK10029U Statistiske metoder i forsikringsmatematik
- NMAA06013U Monte Carlo Methods in Insurance Finance
- NMAA07010U Levy processer i finansiering
- NMAK11018U Forbruges- og protefølgevalgsproblemer i finans og forsikring
- NMAK11023U Statistiske metoder i skadeforsikring
- NMAK11026U Mathematical Demograph
- NMAA09010U Asset-liabilitymanagement for pensionskasser
- NMAK10032U Stokastisk analyse med anvendelser i forsikring og/eller i finans
- NMAK13021U Topics in Life Insurance Mathematics
- NMAK13012U Levy Processes in Finance
- NMAK12015U Bayes metoder og kreditibilitet i skadesforsikring
- NMAK14010U Consumption-Investment-Insurance Problems
- NMAK14022U Statistics for non-linear time series models
- NMAK14017U Optimal investment
- NMAK14014U Monte Carlo Methods in Insurance and Finance
- NMAK14013U Modeling dependence in discrete time
- NMAK13005U Introduction to Extreme Value Theory
Appendix 3 Description of objectives for the thesis

After completing the thesis, the student should have:

Knowledge about:
- Scientific problems within the study programme’s subject areas.
- A suitable combination of methodologies/theories based on international research for use in his/her work with the problem formulation.
- Theories/models on the basis of an organised value system and with a high degree of independence.

Skills to:
- Apply and critically evaluate theories/methodologies, including their applicability and limitations.
- Assess the extent to which the production and interpretation of findings/material depend on the theory/methodology chosen and the delimitation chosen.
- Discuss academic issues arising from the thesis.
- Draw conclusions in a clear and academic manner in relation to the problem formulation and, more generally, considering the topic and the subject area.
- Discuss and communicate the academic and social significance, if any, of the thesis based on ethical principles.

Competences to:
- Initiate and perform academic work in a research context.
- Solve complex problems and carry out development assignments in a work context.