Programme-specific Section of the Curriculum for the MSc Programme in Mathematics at the Faculty of Science, University of Copenhagen 2009 (Rev. 2020)

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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 Mathematics with a general profile in mathematics leads to a Master of Science (MSc) in Mathematics with the Danish title: Cand.scient. (candidatus/candidata scientiarum) i matematik.

1.2 Affiliation
The programme is affiliated with the Study Board of 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 Mathematics is a research-based programme, the objective of which is to provide the student with the mathematical knowledge of and insights into the main fields and methodologies of mathematics required to work independently within this field. The compulsory study programme can form the basis of working also with applied mathematics as well as teaching mathematics.

2.2 General programme profile
The study programme allows in-depth study of various aspects of the mathematical core fields of algebra, analysis and geometry, but also more specialised mathematical disciplines, metadisciplines such as the history and didactics of mathematics as well as important applications within the natural and social sciences.

Mathematics is the key subject area of the programme.

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

There are no defined specialisations in this programme.

2.4 Career opportunities
The MSc Programme in Mathematics qualifies students to become professionals within business functions and/or areas such as:
  • A PhD programme
  • The financial sector.
  • Software development.
  • Teaching at upper secondary schools.
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 Generic competence profile
On completion of the programme, an MSc in Mathematics has acquired the following:

Knowledge about:
- Advanced vector space theory.
- Selected research-active fields within mathematics.

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

Competences in/to:
- Structure an inquiry into open mathematical issues and divide it into smaller easily accessible challenges.
- Conduct independent, stringent argumentation.
- Independently take responsibility for his or her own professional development and specialisation.
- Reflect on methodologies for analysing and solving mathematical issues at a scientific level.

4 Admission requirements
With a Bachelor’s degree in Mathematics from the University of Copenhagen the student is granted reserved access and guaranteed a place on the MSc Programme in Mathematics if the student applies in time to begin the MSc Programme within three years of the completion of the Bachelor's degree.

4.1 Applicants with a Bachelor’s degree in Mathematics
Applicants with a Bachelor's degree in Mathematics from the University of Copenhagen or a Bachelor’s degree in Mathematics with the BSc elective subject course package (studieretning) in Mathematics from Aarhus University are directly academically qualified for admission to the MSc Programme in Mathematics.

4.2 Applicants with a Bachelor’s degree in Science and IT
Applicants with a Bachelor’s degree in Natural Science and IT from the University of Copenhagen may be admitted if the programme includes:
- A specialisation in Mathematics as well as the MSc admission course package in Mathematics.

4.3 Applicants with a closely related Bachelor’s degree
Applicants with a Bachelor’s degree in Actuarial Mathematics, Mathematics-Economics or Statistics from the University of Copenhagen may also be admitted if their programme includes the following:
- Subject elements in algebra (at least 15 ECTS).
- Subject elements in geometry and topology (at least 15 ECTS).

4.4 Applicants with a related Bachelor’s degree
Applicants with a Bachelor’s degree in the following:
- Computer Science, Physics or Chemistry from the University of Copenhagen or other Danish or international universities.
- Actuarial Mathematics, Mathematics or Mathematics-Economics from other Danish or international universities may also be admitted if their programme includes the following:
  - Subject elements in mathematical analysis at least 30 ECTS
  - Subject elements in linear algebra and algebra at least 22.5 ECTS
  - Subject elements in geometry and topology at least 15 ECTS

4.5 Other applicants
The Faculty may also admit applicants who, after an individual academic assessment, are deemed to possess educational qualifications equivalent to those required in subclauses 4.1-4.

4.6 Language requirements
Applicants must as a minimum document English language qualifications comparable to a Danish upper secondary school English B level or English proficiency corresponding to the tests and scores required. Accepted tests and required minimum scores are published online at www.science.ku.dk.

4.7 Supplementary subject elements
The qualifications of an applicant to the MSc programme are assessed exclusively on the basis of the qualifying bachelor’s degree. Supplementary subject elements passed between the completion of the bachelor’s program and the admission to the MSc programme cannot be included in the overall assessment.

However, subject elements passed before the completion of the bachelor’s programme may be included in the overall assessment. This includes subject elements completed as continuing education as well as subject elements completed as part of a former higher education program. A maximum of 30 ECTS supplementary subject elements can be included in the overall assessment.

Subject elements passed before completing the BSc programme which are to form part of the MSc programme to which the student has a legal right of admission (§9-courses) cannot be included in the overall assessment.

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 Mathematics from the University of Copenhagen with reserved access to the programme.
2) Applicants with a Bachelor’s degree in Mathematics
3) Applicants with a Bachelor’s degree in Actuarial Mathematics, Natural Science and IT or Mathematics-Economics from the University of Copenhagen.
4) Other applicants.

If the number of qualified applicants exceeds the number of places available, applicants are prioritised according to the following criteria (listed below in prioritised order):
- Total numbers of ECTS within mathematics.
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).

6.1 Programme components
The programme is set at 120 ECTS and consists of the following:
- Compulsory subject elements, 7.5 ECTS.
- Restricted elective subject elements, 52.5 ECTS.
- Elective subject elements, 30 ECTS.
- Thesis, 30 ECTS.

6.1.1 Compulsory subject elements
All of the following subject elements are to be covered (7.5 ECTS):
- NMAK15005U Advanced Vector Spaces AdVec Block 1 7.5 ECTS

6.1.2 Restricted elective subject elements
52.5 ECTS are to be covered as restricted subject elements from the following two lists:

1) 22.5 ECTS are to be covered as restricted subject elements from the following list:

<table>
<thead>
<tr>
<th>Subject Element</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAA05014U</td>
<td>Algebra 3</td>
<td>Alg3</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NMAA05038U</td>
<td>Algebraic Topology</td>
<td>AlgTop Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK11003U</td>
<td>Advanced Probability Theory 1</td>
<td>VidSand1 Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK11011U</td>
<td>Advanced Probability Theory 2</td>
<td>VidSand2 Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAA05100U</td>
<td>Homological Algebra</td>
<td>HomAlg Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK10008U</td>
<td>Functional Analysis</td>
<td>FunkAn Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAA06062U</td>
<td>Geometry 2</td>
<td>Geom2 Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NFKA09006U</td>
<td>Advanced Didactics of Mathematics</td>
<td>DidMatV Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK15016U</td>
<td>History of Mathematics 2</td>
<td>Hist2 Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK10019U</td>
<td>Differential Operators and Function Spaces</td>
<td>DifFun Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
</tbody>
</table>

2) 30 ECTS are to be covered as further restricted subject elements from the list above and by restricted subject elements from the following list:

<table>
<thead>
<tr>
<th>Subject Element</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAA06020U</td>
<td>Categories and Topology</td>
<td>CatTop Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16022U</td>
<td>Partial Differential Equations</td>
<td>PDE Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16013U</td>
<td>Introduction to Modern Cryptography</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK18001U</td>
<td>Analysis of Manifolds</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK20005U</td>
<td>Groups, Operator Algebras and Dynamics</td>
<td>GOADyn Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16000U</td>
<td>Algebraic Geometry 2</td>
<td>AlgGeo2 Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK19009U</td>
<td>Solving Polynomical Equations</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK20006U</td>
<td>Riemannian Geometry</td>
<td>Block 1</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16001U</td>
<td>Analytic Number Theory</td>
<td>AnNum Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16008U</td>
<td>Experimental Mathematics</td>
<td>XM Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK18009U</td>
<td>Topics in Mathematical Logic</td>
<td>Block 2</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK14020U</td>
<td>Quantum Information Theory</td>
<td>QIT Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK16007U</td>
<td>Elliptic Curves</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK18005U</td>
<td>Introduction to Representation Theory</td>
<td>Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAA07012U</td>
<td>Introduction to Operator Algebras</td>
<td>IntroOpAlg Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
<tr>
<td>NMAK14009U</td>
<td>Commutative Algebra</td>
<td>KomAlg Block 3</td>
<td>7.5 ECTS</td>
<td></td>
</tr>
</tbody>
</table>
6.1.3 Elective subject elements
30 ECTS are to be covered as elective subject elements. All subject elements at MSc level may be included as elective subject elements in the MSc Programme.

BSc subject elements corresponding to 15 ECTS may be included in the MSc Programme.

Projects outside the course scope may be included in the elective section of the programme with up to 15 ECTS. 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. The regulations are described in Appendix 4 to the shared section of the curriculum.

Thesis preparation projects may not be included in the elective section of the programme. The regulations are described in Appendix 6 to the shared section of the curriculum.

6.1.4 Thesis
The MSc Programme in Mathematics with a General Profile in Mathematics includes a thesis corresponding to 30 ECTS, as described in Appendix 2 to the shared curriculum. The thesis must be written within the academic scope of the programme.

6.1.5 Academic mobility
The curriculum makes it possible to follow subject elements outside the Faculty of Science.

For students admitted in September the academic mobility for the MSc Programme in Mathematics is placed in block 1+2 of the 2nd year.

For students admitted in February the academic mobility for the MSc Programme in Mathematics is placed in block 3+4 of the 2nd year.

Academic mobility requires that the student follows the rules and regulations regarding pre-approval and credit transfer.

In addition the student has the possibility to arrange similar academic mobility in other parts of the programme.

7 Exemptions
In exceptional circumstances, the study board may grant exemptions from the rules in the curriculum specified solely by the Faculty of Science.
8 Commencement etc.

8.1 Validity
This subject specific section of the curriculum applies to all students enrolled on 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 come into effect at the beginning 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 – General profile in 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><strong>1st year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced Vector Spaces</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td><strong>2nd year</strong></td>
<td></td>
<td></td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table illustrates the recommended academic progression. The student is allowed to plan an alternative progression within the applicable rules.

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

Table – General profile in 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><strong>1st year</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Advanced Vector Spaces</td>
<td>Restricted elective</td>
<td></td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td></td>
</tr>
<tr>
<td><strong>2nd year</strong></td>
<td></td>
<td></td>
<td></td>
<td>Thesis</td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elective</td>
<td>Elective</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table illustrates the recommended academic progression. The student is allowed to plan an alternative progression within the applicable rules.

*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 applies to all students.

The interim arrangements below only consist of parts where the current curriculum differs from the rules and regulations that were previously valid. Therefore, if information about relevant rules and regulations are missing, it can be found in the curriculum above.

1 General changes valid for students admitted in the academic year 2019/20
Students admitted to the MSc Programme in the academic year 2019/20 must finish the programme as listed in the curriculum above with the following exceptions.

1.1 General profile in Mathematics
Restricted elective subject elements
30 ECTS are to be covered as restricted elective subject elements from the following lists:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAK13030U</td>
<td>Approximation Properties for Operator Algebras</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK15003U</td>
<td>Advanced Mathematical Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK19008U</td>
<td>Dynamical Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK19007U</td>
<td>Riemannian Geometry and General Relativity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*See course specific changes below

2 General changes valid for students admitted in the academic year 2018/19
Students admitted to the MSc Programme in the academic year 2018/19 must finish the programme as listed in the curriculum above with the following exceptions.

2.1 General profile in Mathematics
Restricted elective subject elements
30 ECTS are to be covered as restricted elective subject elements from the following lists:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAK17004U</td>
<td>Introduction to Descriptive Set Theory</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK13013U</td>
<td>Lie Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK13030U</td>
<td>Approximation Properties for Operator Algebras</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and Groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK15003U</td>
<td>Advanced Mathematical Physics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK19008U</td>
<td>Dynamical Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NMAK19007U</td>
<td>Riemannian Geometry and General Relativity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*See course specific changes below

**The course is not offered in 2020/21
### 2.1 Specialisations

Effective from the academic year 2018/2019, the following restricted elective courses within the specialisations “General profile in Mathematics” and “Nordic Double Degree in Didactics of Mathematics (1st year at UCPH)” are offered in blocks different from the previous years.

- NMAK17002U Complex Analysis 2 is offered in block 4, instead of 3.
- NMAK17011U Algebraic Number Theory is offered in block 2 instead of 4.
- NMAK14005U Algebraic Geometry is offered in block 4 instead of 1
- NMAK16000U Algebraic Geometry 2 is offered in block 1 instead of 2
- NMAK13030U Approximation properties for Operator Algebras and Groups is offered in block 1 instead of 2

#### 2.1.1 General profile in Mathematics

**Restricted elective subject elements**

52.5 ECTS are to be covered as restricted subject elements from the following lists:

1) 22.5 ECTS are to be covered as restricted subject elements from the following list:

- Restricted elective subject elements offered as part of the specialisation General Profile in Mathematics (in list 1) in this curriculum (see above)

2) 30 ECTS are to be covered as further restricted subject elements from the list above and by restricted subject elements from the following list:

- Restricted elective subject elements offered as part of the specialisation General Profile in Mathematics (in list 2) in this curriculum (see above)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAK15023U</td>
<td>Topics in Algebraic Typology</td>
<td>TopTopics</td>
<td>7.5</td>
</tr>
<tr>
<td>NMAK17009U</td>
<td>Topics in Algebra and Number Theory</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NMAK17004U</td>
<td>Introducion to Descriptive Set Theory</td>
<td>DesSet</td>
<td>7.5</td>
</tr>
<tr>
<td>NMAK13013U</td>
<td>Lie Groups</td>
<td>GeomLie</td>
<td>Block 4</td>
</tr>
<tr>
<td>NMAK13030U</td>
<td>Approximation Properties for Operator Algebras and Groups</td>
<td>Approx</td>
<td>Discontinued*</td>
</tr>
<tr>
<td>NMAK15003U</td>
<td>Advanced Mathematical Physics</td>
<td>AdvMathPh</td>
<td>7.5</td>
</tr>
<tr>
<td>NMAK19008U</td>
<td>Dynamical Systems</td>
<td>Discontinued*</td>
<td>7.5</td>
</tr>
</tbody>
</table>

*See course specific changes below

**The course is not offered in 2020/21

### 3 Course specific changes

<table>
<thead>
<tr>
<th>Discontinued courses</th>
<th>Interim agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximation Proprties for Operator Algebras and Groups (NMAK13030U), 7.5 ECTS</td>
<td>The course was a restricted elective course in the academic year 2019/20 or earlier. Offered the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21.</td>
</tr>
<tr>
<td>Dynamical Systems (NMAK19008U), 7.5 ECTS</td>
<td>The course was a restricted elective course in the academic year 2019/20 or earlier. Offered the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21.</td>
</tr>
<tr>
<td>Riemannian Geometry and General Relativity</td>
<td>The course was a restricted elective course in the academic year 2019/20 or earlier. Offered the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21.</td>
</tr>
</tbody>
</table>
| (NMAK19007U), 7.5 ECTS | Offered the last time: 2019/20  
Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21. |
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 in/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 in/to:
- Initiate and perform academic work in a research context.
- Solve complex problems and carry out development assignments in a work context.