Programme-specific Section of the Curriculum for the MSc Programme in Computer Science with a minor subject at the Faculty of Science, University of Copenhagen 2010 (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 Computer Science with a minor subject leads to a Master of Science (MSc) in Computer Science and minor in [the minor subject] with the Danish title: *Cand.scient. (candidatus/candidata scientiarum) i datalogi med sidefag i [the minor subject]*.

It will appear from the diploma that the study programme has been completed as an MSc in two subjects and, provided that the requirements pertaining to the Upper Secondary School course packages (*gymnasiefagpakkerne*) have been met, that academic qualifications (*faglig competence*) for teaching at the Danish Upper Secondary School in the subjects have been achieved.

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 Computer Science (*datalogi*).

1.4 Language
The language of this MSc Programme is English.

2 Academic profile

2.1 Purpose
Computer science (Danish: *datalogi*) is concerned with the systematic processing of information, particularly for automatic processing by computers. The concept corresponds to Informatik (German) and informatique (French). Students learn how to identify and analyse complex issues within computation and information processing on a scientific basis and at a high level of abstraction, and, through the application of relevant results and methodologies, to solve computer science problems, both of a theoretical and a practical nature, including, in particular, to design and implement correct, efficient and useful software.

2.2 General programme profile
The MSc programme in Computer Science with a minor subject is a research-based programme admission to which requires a BSc in Computer Science and a minimum of the subject elements from the minor subject. The minor subject must be within the fields taught in the Danish Upper Secondary School.

The programme includes a common compulsory part covering a broad range of core CS topics at a graduate level; a restricted elective part allowing deeper immersion in a chosen topic area, and a minor-subject part containing selected further courses from the minor subject.

Computer science is the key subject area of the programme. The programme also includes a large number of subject elements from the minor subject area.
2.3 General structure of the programme

The MSc Programme is set at 120 or 150 ECTS depending on whether the minor subject is within the field of sciences or not.

Exercise and Sport Sciences is in this regard considered as being outside the field of science.

The MSc Programme in Computer Science with a minor subject consists of the following elements:

- Basic study program, 120 ECTS including the thesis.
- Extension of the minor subject, 30 ECTS, if the minor subject is outside the field of science.

There are no defined specialisations in this MSc Programme

2.4 Career opportunities

The MSc Programme in Computer Science with a minor subject qualifies students to become professionals within business functions and/or areas such as:

- A PhD programme
- Research, development, and consulting within the Information and Communication Technology sector.
- IT development and support within other sectors, such as the financial or biomedical industry, or in public administration.
- Upper secondary school teacher in Computer Science and the minor subject.

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 Computer Science with a minor subject has acquired the following:

Knowledge about:

- State-of-the-art principles for program and system development, including appropriate use of structuring methodologies and programming paradigms.
- The relevant mathematical, statistical, and logical foundations for constructing effective and efficient solutions to a variety of computational problems.
- Academic literature, terminology, traditions and research methods within computer science in general, and their area of specialisation in particular.
- Relevant real-world applications of computer science and information technology, e.g. in business, cultural, health, environmental, and other societal contexts.

Skills in/to:

- Identify opportunities for principled application of theoretical or foundational computer-science results or methods within practical or applied contexts.
- Design, implement, and maintain large and/or complex programs or systems, subject to external quality and performance constraints.
• Adapt and apply general mathematical models for analysis and classification of data.

• Combine relevant computer-science and other knowledge in order to analyse a problem with a significant computational or information-processing component, as well as assess previous attempts at solving the same problem and related problems.

• Select, combine, and where appropriate develop or refine theories and methods, and use these to make a significant contribution to solving computer-science problems or to promoting a scientific understanding of the problems.

• Evaluate a proposed solution to a problem objectively and systematically, and – where appropriate involving experiments – analyse the areas in which the solution is successful and unsuccessful, and identify its weaknesses, strengths and consequences.

• Document their own research results and discoveries in a manner that meets the requirements for academic publications.

• Apply and disseminate knowledge about information technology and participate in general debates on the subject.

Competences in/to:

• Acquiring a comprehensive overview of complex scientific or organisational contexts, identifying and analysing the computational or information-processing problems arising in such contexts, and decomposing or transforming the problems into a form amenable to solution by relevant computer-science methodology.

• Employing general theoretical results and methods to an extent and level of formality appropriate to the complexity and criticality of the concrete task at hand.

• Formulating, structuring, and running research-based projects, computer-science development work and other advanced assignments within information technology.

• Participating in larger program- or system-development teams, properly applying the relevant principles for modular software construction, and understanding how the correctness and performance of the full product follows from those properties of the individual components.

• Taking professional responsibility for the quality of a completed analysis, design, implementation, or evaluation task, based on a sound understanding and application of the relevant assessment methodologies.

• Acquiring new knowledge in an efficient and systematic manner, and familiarising themselves with evolving computer-science subject areas at a high scientific level.

4 Admission requirements

With a Bachelor’s degree in Computer Science or a Bachelor’s degree in Computer Science and Economy, or a Bachelor’s degree in Machine Learning and Data Science from the University of Copenhagen the student is granted reserved access and guaranteed a place on the MSc Programme in Computer Science if the student applies in time to begin the MSc Programme within three years of the completion of the Bachelor's degree.
The admission requirements for the MSc Programme in Computer Science with a minor subject is the same as the admission requirements listed in paragraph 4 in “Programme-specific Section of the Curriculum for the MSc Programme in Computer Science” supplemented with the following:

- At least 105 ECTS from the Upper Secondary School course package (gymnasiefagpakken) are included in the BSc programme.
- At least 60 ECTS from the minor subject is included in the BSc programme.
  - If the minor subject is within the field of sciences (with the exception of Exercise and Sport Sciences) the 60 ECTS must be contained in the minor subject Upper Secondary School course package (den reducerede gymnasiefagpakke).

5 Prioritisation of applicants
If the number of qualified applicants to the programme exceeds the number of places available the applicants will be prioritised according to paragraph 5 in “Programme-specific Section of the Curriculum for the MSc Programme in Computer Science”.

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 120/150 ECTS and consists of the following elements:
- Compulsory subject elements, 30 ECTS.
- Restricted elective subject elements, 15 ECTS
- The minor subject
  - 45 ECTS (minor subject within the field of science)
  - 75 ECTS (minor subject outside the field of science)
- Thesis, 30 ECTS

6.1.1 Compulsory subject elements
All of the following subject elements are to be covered (30 ECTS):

<table>
<thead>
<tr>
<th>Subject ID</th>
<th>Subject Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAA09013U</td>
<td>Advanced Programming</td>
<td>AP</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAA09023U</td>
<td>Advanced Algorithms and Data Structures</td>
<td>AADS</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK15006U</td>
<td>Advanced Computer Systems</td>
<td>ACS</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAK15007U</td>
<td>Machine Learning</td>
<td>ML</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>

6.1.2 Restricted elective subject elements within the major subject
15 ECTS are to be covered as subject elements from one or both of the following lists:

1) Up to 15 ECTS in BSc subject elements from the following list must be followed, if they were not passed as part of the BSc programme:

<table>
<thead>
<tr>
<th>Subject ID</th>
<th>Subject Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMAA09014U</td>
<td>Sandsynlighedsregning og statistik</td>
<td>SS</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDAB15003U</td>
<td>Interaktionsdesign</td>
<td>Inter</td>
<td>7.5 ECTS</td>
</tr>
<tr>
<td>NDIA10001U</td>
<td>Grundkursus i de naturvidenskabelige fags didaktik</td>
<td>DidG</td>
<td>7.5 ECTS</td>
</tr>
</tbody>
</table>
2) The remaining credits (up to 15 ECTS) are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Subject Element</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK14008U</td>
<td>Programming Massively Parallel Hardware PMPH</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10006U</td>
<td>IT Innovation and Change ITIaC</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16000U</td>
<td>Algorithm Engineering AE</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10005U</td>
<td>Medical Image Analysis MIA</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK17000U</td>
<td>Collaborative Computing CollComp</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16009U</td>
<td>Visualization Vis</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15012U</td>
<td>Advanced Topics in Human-Centered Computing ATHCC</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16007U</td>
<td>Software Engineering SE</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09007U</td>
<td>Computability and Complexity CoCo</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10009U</td>
<td>Computational Geometry CG</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA08006U</td>
<td>Semantics and Types SaT</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09027U</td>
<td>Signal and Image Processing SIP</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09009U</td>
<td>Numerical Optimization NO</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK20002U</td>
<td>Neural Information Retrieval NIR</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15018U</td>
<td>Large-Scale Data Analysis LSDA</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16004U</td>
<td>Mobile Computing MC</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16005U</td>
<td>Program Analysis and Transformation PAT</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16008U</td>
<td>User Interface Technology UIT</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK14005U</td>
<td>Randomized Algorithms RA</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK12006U</td>
<td>Computational Methods in Simulation CMIS</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16001U</td>
<td>Approximation Algorithms APX</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09013U</td>
<td>Proactive Computer Security PCS</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NFKK14001U</td>
<td>Project outside the course scope</td>
<td>Block 1-5</td>
<td>7.5</td>
</tr>
<tr>
<td>NFKK14005U</td>
<td>Project outside the course scope</td>
<td>Block 1-5</td>
<td>15</td>
</tr>
</tbody>
</table>

6.1.3 Restricted elective subject elements within the minor subject

45 ECTS are to be covered as subject elements from the minor subject if the minor subject is within the field of science.

75 ECTS are to be covered as subject elements from the minor subject if the minor subject is outside the field of science.

If the student lacks less than 45 or 75 ECTS of the minor subject when entering the MSc Programme begins the difference must be covered as elective subjects.

6.1.4 Elective subject elements

The elective subjects are generally covered by the subject elements which the student follows on the minor subject.

It is, however, possible to release elective subjects if the academic minimum requirements for the minor subjects have been met – this will, e.g., be the case if one or both of the following two conditions are present:

- A subject element form part of both the major and minor Upper Secondary School course packages (gymnasiefagpakker). The subject elements should only be passed once, and the student has full freedom of choice in terms of the remaining ECTS.
- If less than 45 or 75 ECTS within the minor subject are missing when entering the MSc Programme.
BSc subject elements corresponding to 15 ECTS may be included in the MSc Programme as elective subject elements.

Projects outside the course scope may be included in the elective section of the programme with up to 15 ECTS. Note that Projects outside the course scope may not exceed 15 ECTS in total on the restricted elective and elective section of the programme. 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.

6.1.5 Thesis
The MSc Programme in Computer Science with a minor subject 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.

6.1.6 Academic mobility
The academic mobility is generally covered by the subject elements which the student follows on the minor subject.

The student has the possibility to arrange academic mobility in parts of the programme. This requires that the student follows the rules and regulations regarding pre-approvals and credit.

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 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 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

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

**Table – MSc Programme in Computer Science with a minor subject within SCIENCE**

<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>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td></td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>2nd year</td>
<td>Advanced Programming</td>
<td>Advanced Computer Systems</td>
<td>Thesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Advanced Algorithms and Data Structures</td>
<td>Machine Learning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|           | Compulsory | Restricted elective | Minor subject |

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

**Table – MSc Programme in Computer Science with a minor subject outside SCIENCE**

<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>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td></td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td>2nd year</td>
<td>Advanced Programming</td>
<td>Advanced Computer Systems</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td></td>
<td>Advanced Algorithms and Data Structures</td>
<td>Machine Learning</td>
<td>Restricted elective</td>
<td>Restricted elective</td>
</tr>
<tr>
<td>3rd year</td>
<td>Thesis</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|           | Compulsory | Restricted elective | Minor subject |

The table illustrates the recommended academic progression. The student is allowed to plan an alternative progression within the applicable rules. Note that minor subjects outside SCIENCE may have a fixed progression.
Table for students admitted to the programme in February (winter):

Table – MSc Programme in Computer Science with a minor subject within SCIENCE*

<table>
<thead>
<tr>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year Minor subject</td>
<td>Minor subject</td>
<td>Advanced Programming</td>
<td>Advanced Computer Systems</td>
</tr>
<tr>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Advanced Algorithms and Data Structures</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>2nd year Minor subject</td>
<td>Minor subject</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Thesis</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)

Table – MSc Programme in Computer Science with a minor subject outside SCIENCE*

<table>
<thead>
<tr>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 1</th>
<th>Block 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
<td>Minor subject</td>
</tr>
<tr>
<td>2nd year Minor subject</td>
<td>Minor subject</td>
<td>Advanced Programming</td>
<td>Advanced Computer Systems</td>
</tr>
<tr>
<td>Restricted elective</td>
<td>Restricted elective</td>
<td>Advanced Algorithms and Data Structures</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>3rd year Thesis</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. Note that minor subjects outside SCIENCE may have a fixed progression. *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 for students admitted in the academic year 2019/20

Students admitted to the MSc Programme in the academic year 2018/19 and 2019/20 must finish the programme as listed in the curriculum above with the following exceptions:

* Restricted elective subject elements within the major subject

15 ECTS are to be covered as subject elements from one or both of the following lists:

- Restricted elective subject elements offered as part of the list 2) in this curriculum (see above)
- NDAK15005U Information Retrieval IR Discontinued* 7.5 ECTS
- NDAK16006U Software Architecture SA Discontinued* 7.5 ECTS

* See course specific changes below.

2 Course specific changes

<table>
<thead>
<tr>
<th>Discontinued course (ECTS)</th>
<th>Interim arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Retrieval (NDAK15005U), 7.5 ECTS</td>
<td>The course was restricted elective in the academic year 2019-20. Offered for the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21 The course has changed title. In this curriculum Neural Information Retrieval (NDAK20002U), 7.5 ECTS replaces the course.</td>
</tr>
<tr>
<td>Software Architecture (NDAK16006U), 7.5 ECTS</td>
<td>The course was restricted elective in the curriculum in the academic year 2019-20. Offered for the last time: 2019/20 Last exam if applicable (cf. SCIENCE's Teaching and exam rules): 2020/21</td>
</tr>
</tbody>
</table>
Appendix 3 Description of objectives for the thesis

After completing the thesis, the student should have:

Knowledge about:
- The core subject area of the thesis, as well as - where applicable - any relevant auxiliary areas, both within and outside of computer science.
- General principles for scientific research work, including adaptive project planning, hypothesis generation and testing, and design and execution of experiments.
- General principles for scientific and technical writing, including an appropriate level of formality, and correct use of references and citations.

Skills in/to:
- Clearly formulate, delineate, motivate, and situate a scientific problem, containing a substantial computer-science component.
- Employ state-of-the-art methods and theories to analyse and decompose the problem, and to survey and evaluate previous attempts at solving the problem and/or related problems.
- Critically evaluate, select, and non-trivially combine or extend relevant results and techniques, to make significant contributions to the solution of the problem, or to the scientific understanding of the problem.
- Give a precise, operational description of all important aspects of the developed solution, with particular emphasis on own contributions.
- Objectively and systematically, and where appropriate involving experiments, assess to what extent the problem under study has been solved, and point out particular strengths, weaknesses, and consequences of the solution.
- Report the findings of the project in a well-structured, coherent, and comprehensive report, in accordance with academic standards for referencing and integrity, and including illustrations, tables, formulas, code, and other non-textual elements to an extent appropriate to the nature of the problem and its solution.
- Orally summarise and explain the main objectives, methods, results, and conclusions of the project; and interactively discuss and justify the chosen approach and resulting findings at a scientific level.
- Demonstrably meet the project-specific learning objectives stipulated in the thesis contract.

Competences in/to:
- Identifying and solving a non-trivial problem within computer science, or with a significant computational or IT content.
- Independently planning and executing, with limited supervision, a research project around the problem, and report its findings and conclusions to high standards of correctness and integrity.
- Assessing and discussing the significance and relevance of the obtained results to the scientific discipline of computer science, as well as any possible technological or societal implications.