Programme-specific Section of the Curriculum for the MSc Programme in Computer Science
at the Faculty of Science, University of Copenhagen
2009 (Rev. 2017)

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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 leads to a Master of Science (MSc) in Computer Science with the Danish title: Cand.scient. (candidatus/candidata scientiarum) i datalogi.

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 is a research-based two-year programme, building on top of a BSc programme in Computer Science or a closely related field. The programme includes a common compulsory part covering a broad range of core CS topics at a graduate level (first semester); an elective part containing both foundational courses within specific subareas (primarily second semester) and selected advanced and auxiliary topics (primarily third semester); and concluding with a MSc thesis (fourth semester).

Computer Science 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 Computer Science 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.

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 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 specialization 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:
• Acquire a comprehensive overview of complex scientific or organizational contexts, identify and analyse the computational or information-processing problems arising in such contexts, and decompose or transform the problems into a form amenable to solution by relevant computer-science methodology.
• Employ general theoretical results and methods to an extent and level of formality appropriate to the complexity and criticality of the concrete task at hand.
• Formulate, structure, and run research-based projects, computer-science development work and other advanced assignments within information technology.
• Participate 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.

• Take 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.

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

4 Admission requirements

With a Bachelor’s degree in Computer 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 before the application deadline during the first application period after the completion of the Bachelor’s degree.

4.1 Applicants with a Bachelor’s degree in Computer Science from Danish universities

Applicants with a Bachelor’s degree in the following are directly academically qualified for admission to the MSc Programme in Computer Science.

- Computer Science from the University of Copenhagen
- Computer Science from Aalborg University
- Computer Science from Aarhus University
- Computer Science from the University of Southern Denmark

4.2 Applicants with a Bachelor’s degree in Science and IT

Applicants with a Bachelor’s degree in Science and IT with the MSc admission course package in Computer Science from the University of Copenhagen are directly academically qualified for admission to the MSc programme in Computer Science.

4.3 Applicants with a related Bachelor’s degree from Danish universities

Applicants with a Bachelor’s degree in:

- Mathematics from the University of Copenhagen
- Physics from the University of Copenhagen
- Communication and IT from the University of Copenhagen
- Software Development from the IT University of Copenhagen
- Software Technology from the Technical University of Denmark
- Software from Aalborg University
- IT with a specialisation in Software Development from Aarhus University

may also be admitted if their programme includes the following:

- Courses in computer science corresponding to at least 45 ECTS, subject to the following distribution constraints:
  - A minimum of 10 ECTS within the field of programming, covering at least two substantially different programming paradigms.
  - A minimum of 10 ECTS within the field of computer systems architecture, including processor architecture, operating systems, data networks, databases, etc.
  - A minimum of 10 ECTS within the field of theoretical computer science, including algorithms and data structures, computability and complexity, formal languages, programming language theory and compilation, etc.
• Courses in mathematics corresponding to a total of at least 7.5 ECTS within the fields of discrete mathematics, linear algebra, and mathematical modelling.

4.4 Applicants with a Bachelor’s degree in Computer Science from international universities
Applicants with a Bachelor's degree in Computer Science or an equivalent subject from international universities may also be admitted if their programme includes the following:
• Courses in computer science corresponding to at least 45 ECTS, subject to the following distribution constraints:
  • A minimum of 10 ECTS within the field of programming, covering at least two substantially different programming paradigms.
  • A minimum of 10 ECTS within the field of computer systems architecture, including processor architecture, operating systems, data networks, databases, etc.
  • A minimum of 10 ECTS within the field of theoretical computer science, including algorithms and data structures, computability and complexity, formal languages, programming language theory and compilation, etc.
• Courses in mathematics corresponding to a total of at least 7.5 ECTS within the fields of discrete mathematics, linear algebra, and mathematical modelling.

4.6 Other applicants
The Faculty may also admit applicants who, after a thorough academic assessment, are deemed to possess educational qualifications equivalent to those required in Subclauses 4.1-4.

4.7 Language requirements
4.7.1 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.

4.7.2 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 Computer Science from the University of Copenhagen seeking admission by way of direct extension of their completed BSc programme.
2) Applicants with a Bachelor’s degree in Computer Science from Danish Universities
3) Applicants with a Bachelor’s degree in Science and IT with the MSc admission course package in Computer Science from the University of Copenhagen.
4) Other applicants.

If the number of qualified applicants within a category exceeds the number of places available, applicants will be prioritised according to the following criteria (listed below in prioritised order):
• Total number of ECTS within computer science and the grades obtained. If different grading systems make comparison impossible, applicants will be prioritised on the basis of an individual evaluation by the Admission Committee

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, 30 ECTS.
• Restricted elective subject elements, 30 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 (30 ECTS):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAA09013U</td>
<td>Advanced Programming</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09023U</td>
<td>Advanced Algorithms and Data Structures</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15006U</td>
<td>Advanced Computer Systems</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15007U</td>
<td>Machine Learning</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
</tbody>
</table>

6.1.2 Restricted elective subject elements
30 ECTS are to be covered as subject elements from the following list:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Block</th>
<th>ECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDAK14008U</td>
<td>Programming Massively Parallel Hardware</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10006U</td>
<td>IT Innovation and Change</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16000U</td>
<td>Algorithm Engineering</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10005U</td>
<td>Medical Image Analysis</td>
<td>Block 1</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15004U</td>
<td>Computer Game Development Project</td>
<td>Block 1+2</td>
<td>30</td>
</tr>
<tr>
<td>NDAK17000U</td>
<td>Collaborative Computing</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16009U</td>
<td>Visualization</td>
<td>Block 2</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15012U</td>
<td>Advanced Topics in Human-Centered Computing</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16007U</td>
<td>Software Engineering</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK14004U</td>
<td>Web Science</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09007U</td>
<td>Computability and Complexity</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK10009U</td>
<td>Computational Geometry</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA08006U</td>
<td>Semantics and Types</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09027U</td>
<td>Signal and Image Processing</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAA09009U</td>
<td>Numerical Optimization</td>
<td>Block 3</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16006U</td>
<td>Software Architecture</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15005U</td>
<td>Information Retrieval</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK15018U</td>
<td>Large-Scale Data Analysis</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16004U</td>
<td>Mobile Computing</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16005U</td>
<td>Program Analysis and Transformation</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK16008U</td>
<td>User Interface Technology</td>
<td>Block 4</td>
<td>7.5</td>
</tr>
<tr>
<td>NDAK14005U</td>
<td>Randomized Algorithms</td>
<td>Block 4</td>
<td>7.5</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. 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.

6.1.4 Thesis
The MSc Programme in Computer Science 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 in the MSc Programme in Computer Science is placed in block 1+2 of the second year.

For students admitted in February the academic mobility in the MSc Programme in Computer Science is placed in block 1+2 of the second 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 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

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

**Table - MSc Programme in Computer 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><strong>1st year</strong></td>
<td><strong>Advanced Programming</strong></td>
<td><strong>Advanced Computer Systems</strong></td>
<td><strong>Restricted elective</strong></td>
<td><strong>Restricted elective</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Advanced Algorithms and Data Structures</strong></td>
<td><strong>Machine Learning</strong></td>
<td><strong>Restricted elective</strong></td>
<td><strong>Restricted elective</strong></td>
</tr>
<tr>
<td><strong>2nd year</strong></td>
<td><strong>Elective</strong></td>
<td><strong>Elective</strong></td>
<td><strong>Thesis</strong></td>
<td></td>
</tr>
</tbody>
</table>

Compulsory (filled)  
Restricted elective (hashed)  
Elective (empty)

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

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

**Table - MSc Programme in Computer Science**

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

Compulsory (filled)  
Restricted elective (hashed)  
Elective (empty)

*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 2016/17
Students admitted to the MSc Programme in the academic year 2016/17 or 2015/16 must finish the programme as listed in the curriculum above with the following exceptions.

That is, the required amount of restricted elective subject elements has been reduced from 45 to 30 ECTS, and correspondingly, the amount of elective subject elements has been increased from 15 to 30 ECTS. All subject elements previously passed as restricted electives can count as electives.

Restricted elective subject elements
30 ECTS may be covered as subject elements from the following list:

- Restricted elective subject elements offered as part of this curriculum (see above)
- NDA09031U Proactive Computer Security PCS Block 4 7.5 ECTS
- NDAK16002U Computer Supported Cooperative Work CSCW Discontinued* 7.5 ECTS

* See course specific changes below.

2 General changes for students admitted in the academic year 2015/16
Students admitted to the MSc Programme in the academic year 2015/16 must finish the programme as listed in the curriculum above with the following exceptions.

That is, the required amount of restricted elective subject elements has been reduced from 45 to 30 ECTS credits, and correspondingly, the amount of elective subject elements has been increased from 15 to 30 ECTS credits. All subject elements previously passed as restricted electives can count as electives.

Restricted elective subject elements
30 ECTS may be covered as subject elements from the following list:

- Restricted elective subject elements offered as part of this curriculum (see above)
- NDAK15017U Interactive Data Exploration IDE Block 2 7.5 ECTS
- NDAK12002U Vision and Image Processing VIP Block 2 7.5 ECTS
- NTYK13012U Cluster Architectures and Computations CAC Block 2 7.5 ECTS
- NDAK14003U Discrete Optimization DO Block 3 7.5 ECTS
- NDA09031U Proactive Computer Security PCS Block 4 7.5 ECTS
- NDAK16002U Computer Supported Cooperative Work CSCW Discontinued* 7.5 ECTS
- NDAK13000U Extreme Multiprogramming XMP Discontinued* 7.5 ECTS

* See course specific changes below.

3 General changes for students admitted in the academic year 2014/15
Students admitted to the MSc Programme in the academic year 2014/15 must finish the programme as listed in the curriculum above with the following exceptions.

Compulsory subject elements
The following subject elements are to be covered (30 ECTS):

- NDAA09013U Advanced Programming Block 1 7.5 ECTS
Restricted elective subject elements
30 ECTS are to be covered as subject elements from the following list:

| Subject elements held by Department of Computer Science on MSc level (30 ECTS) |
| Project outside the course scope with principal advisor from the Department of Computer Science (up to 15 ECTS). |

4 Course specific changes

<table>
<thead>
<tr>
<th>Discontinued course</th>
<th>Interim arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Supported Cooperative Work (CSCW), (NDAK16002U), 7.5 ECTS</td>
<td>The course was restricted elective in the academic year 2016/17 or earlier. The course was offered for the last time in the academic year 2016/17 and a third exam is offered in the academic year 2017/18. The course is identical with Collaborative Computing (CollComp) (NDAK17000U), 7.5 ECTS.</td>
</tr>
<tr>
<td>Extreme Multiprogramming (NDAK13000U), 7.5 ECTS</td>
<td>The course was restricted elective in the academic year 2016/17 or earlier. The course was offered for the last time in the academic year 2016/17 and a third exam is offered in the academic year 2017/18.</td>
</tr>
<tr>
<td>Information Retrieval and Interaction (NDAK13001U), 7.5 ECTS</td>
<td>The course was restricted elective in the academic year 2014/15. The course was offered for the last time in the academic year 2014/15 and a third exam is offered in the academic year 2015/16. The course is identical to Information Retrieval (IR) (NDAK15005U), 7.5 ECTS.</td>
</tr>
<tr>
<td>Principles of Computer Systems Design (NDAA09004U), 7.5 ECTS</td>
<td>The course was a compulsory subject element in the academic year 2014/15. The course was offered for the last time in the academic year 2014/15 and a third exam is offered in the academic year 2015/16. The course has changed title and is equivalent to Advanced Computer Systems (ACS) (NDAK15006U), 7.5 ECTS credits.</td>
</tr>
<tr>
<td>Statistical Methods for Machine Learning (NDAA09028U), 7.5 ECTS</td>
<td>The course was a compulsory subject element in the academic year 2014/15. The course was offered for the last time in the academic year 2014/15 and a third exam is offered in the academic year 2015/16. The course has changed title and is equivalent to Machine Learning (ML) (NDAK15007U), 7.5 ECTS</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 analyze 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 summarize 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:**
- Identify and solve a non-trivial problem within computer science, or with a significant computational or IT content.
- Independently plan and execute, with limited supervision, a research project around the problem, and report its findings and conclusions to high standards of correctness and integrity.
- Assess and discuss the significance and relevance of the obtained results to the scientific discipline of computer science, as well as any possible technological or societal implications.