Programme syllabus

Master's Programme, Machine Learning, 120 credits
Masterprogram, maskininlärning
120.0 credits

Valid for students admitted to the education from autumn 12 (HT - Autumn term; VT - Spring term).

This is a translation of the Swedish, legally binding, programme syllabus.

Programme objectives

This program syllabus, established by the CSC Undergraduate education advisory group 2011-09-07 and 2011-10-03 and then decided by the CSC dean 2011-09-15 and 2011-10-03, is valid for students beginning their studies during the academic year 2012/13. Which courses that belong to a study year is decided in the fall the year before. Please see "Study year 1” etc. or the appendices. Changes may occur in the contents of the program and in the KTH regulations, please see www.kth.se/student.

Machine Learning is an area within Computer Science where computer systems are designed to learn from large sets of examples, similarly to the learning strategies of biological systems (like humans). Recently, Machine Learning has gained great importance for the design of search engines, robots, and sensor systems, and for the processing of large scientific data sets.

The focus of the Master's program in Machine Learning is on mathematical foundations and methods for Machine Learning. The student can choose to study applications of this in Perception and Cognition or in Information Retrieval. For a closer description of the two tracks, see Appendix 2.

Besides the goals stated in the Swedish Higher Education Ordinance the following goals apply.

Knowledge and understanding

A Master of Science in Machine Learning will be able to:

- present a good knowledge of mathematical methods for Machine Learning, as well as how these are applied in either Perception and Cognition or in Information Retrieval applications,
- understand different Machine Learning problems deeply enough to select and apply suitable methods and computer tools to solve them,
- formulate and approach new Machine Learning problem settings in a scientific manner; in a creative, critical and systematic way.
Skills and abilities

A Master of Science in Machine Learning will be able to:

- work out solution strategies to different Machine Learning problems, knowing the capabilities and limitations of different methods and tools,
- work efficiently in a teamwork environment in groups with people from different scientific and engineering background,
- communicate with scientists and people active in engineering development in a competent manner both orally and in writing,
- follow and participate in research and development related to the chosen track.

Ability to make judgements and adopt a standpoint

A Master of Science in Machine Learning will be able to:

- critically judge a problem and in an independent manner acquire the information and knowledge that is necessary to establish a qualified opinion,
- formulate and approach new Machine Learning problem settings in a scientific manner; in a creative, critical and systematic way,
- identify the need for further knowledge in the field and take responsibility for keeping her/his personal knowledge up to date.

In addition to this the similar objectives for master degree defined in the Higher Education Ordinance (Högskoleförordningen) are applicable.

Extent and content of the programme

Machine Learning is a two-year (120 higher education credits) master program on the advanced level (second cycle). The instruction language is English. Some elective courses are given in Swedish.

The program consists of a basic curriculum followed by a track. Currently students can choose between the following three tracks: (i) Perception and Cognition, and (ii) Information Retrieval, and (iii) Computational Biology. The courses in the basic curriculum of each track are compulsory and constitute a little more than half of the course work.

Eligibility and selection

Students from KTH Bachelor's Programs Leading to Civilingenjör in Combination with the Machine Learning Program

A number of Bachelor’s programs at KTH give the degree of Civilingenjör in combination with Machine Learning. Students from these programs are accepted without selection to the Machine Learning program, provided that they have completed 150 higher education credits including a degree project and the courses listed below under specific admission requirements. Application is made before November 15.

Other Students
General admission requirements: See the KTH general admission requirements for Master’s programs, link below

Specific admission requirements: The prerequisites for the Master's program in Machine Learning is a Swedish or foreign degree equivalent to Bachelor’s degree of 180 higher education credits, with a level in Mathematics and Computer Science equal, or higher, than that of the following courses at KTH: SF1604 Linear Algebra (or SF1624), SF1600 Calculus in One Variable (or SF1602, SF1625), SF1601 Calculus in Several Variables (or SF1603, SF1626), SF1906 Mathematical Statistics, and DD1340 Introduction to Computer Science (or DD1320, DD1321, DD1344).

Applicants must also provide a proof of good knowledge in English, equivalent to English B (Swedish school system).

Application is made at www.antagning.se/intl/start before January 15.

Selection: The selection process is based on a total evaluation of the following selection criteria: grade point average (GPA), course work related to the program (e.g., in the fields of Machine Learning, Computer Vision, Image Processing, Speech Processing, Signal Processing, Neuroscience, Information Retrieval, or Data Mining), letter of intent, and references.


Implementation of the education

Structure of the education

This program syllabus, established by the CSC Undergraduate education advisory group 2011-09-07 and then decided by the CSC dean, is valid for students beginning their studies during the academic year 2012 /13. Which courses that belong a study year is decided in the fall the year before. Please see ”Study year 1” etc. or the appendices. Changes may occur in the contents of the program and in the KTH regulations, please see www.kth.se/student.

The duration of the academic year is 40 weeks. The academic year at KTH is divided into four periods. Each period lasts approximately seven weeks, with at least 33 days of study. Each period and is followed by an exam period. Apart from these exam periods, there are three re-exam periods; before period 3, after period 4 and before period 1.

More information can be found at http://www.kth.se/student/schema/lasarsindelning-1.1007?l=en_UK

The first year in the program is mainly dedicated to the compulsory courses in the basic curriculum as well as those of each track. The second year mainly consists of elective track courses, freely selected courses, and the degree project.

Courses

The programme is course-based. Lists of courses are included in appendix 1.
The course goals, prerequisites, contents and examination requirements are found in the course syllabus in the Course and program directory on the KTH student web. For each study year there is a course list.

For elective courses, the following restrictions apply:

- The number of credits that can be chosen per semester can be limited.
- Elective courses may not overlap a course already taken to a considerable extent.
- Courses on lower levels within a subject than the programme courses may not count as elective courses.

The basic curriculum common to both tracks corresponds to around 25 higher education credits. In each track, there is an additional set of compulsory courses of around 25 higher education credits.

To obtain sufficient depth in a track, a student is, apart from the compulsory courses, required to complete at least three courses among the profile courses for the track in question. The remaining credits are received for freely elected courses. These courses may be chosen among the profile courses of the track, other second cycle courses at KTH, and language courses at KTH. First cycle courses at KTH can also be chosen, upon permission from the Program Director.

Courses are examined in many ways, for example by home assignments that are presented either using oral presentations or written reports, computer assignments, project work or traditional written exams.

After each course a student evaluation is performed and then analyzed by the course leader in the course analysis document, which is normally published on the web, see the KTH regulations of course analyses: http://intra.kth.se/ regelverk/utbildning-forskning/grundutbildning/kursanalys

**Grading system**

Courses in the first and the second cycle are graded on a scale from A to F. A-E are passing grades, A is the highest grade. The grades pass (P) and fail (F) are used for courses under certain circumstances.

Since the grading systems differ very much between different countries, the grades are not translated from exchange studies abroad.

**Conditions for participation in the programme**

**Semester enrollment**

At the start of each semester the student is required to make a study enrollment for the next semester at My pages.

The study enrollment is required for taking new courses and for study results to be registered.

**Approved leave from studies**

Approved leave from studies means that the student does not participate in the education during at least one study period. The student has the right to return to the education at a time agreed upon, and has the right to participate in the examination of non-finished courses.
Application for an approved leave is done on according to instructions from the CSC program office. When the student decides to return to the education, he/she is required to re-enroll to the studies.

Approved leave from studies is not granted during study year 1. Exceptions may be made if there are extraordinary reasons.


**Selection of Track**

Track selection is made during the first year according to instructions from the CSC school. There are no limitations in terms of the number of students to each track.

**Selection of courses**

The student is required to apply for admission to all courses he/she wishes to take during the next semester. The student is responsible for having the recommended prerequisites. The application for admission to a course is done according to instructions from the CSC school no later than

- May 15th for the fall semester
- November 15th for the spring semester

Applications made after this date are only granted if there are vacancies in the courses. Applications to language courses with prerequisites should be preceded by a qualification test.

In a few courses, the number of participants is limited. Selection is done by the school responsible for the course.

A student may only take courses that are included in the study plan.

**Course registration**

The student must register with the school responsible for the course at the start of each course, and also report to the school responsible for the course if the studies are discontinued.

Registration to a course requires formal acceptance to the course (by the school responsible for the course). Applications should be according to instructions from the CSC school.

**Promotion to second year**

At least 45 ECTS credits have to be completed during the first academic year in order for the student to be promoted to the second year of the program.

Students who do not fulfill these requirements must – in cooperation with the CSC program office – make an individual study plan for continued studies.

Please see the KTH regulations: http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/registrering-uppflyttning/1.27217?l=en_UK
Recognition of previous academic studies

Credits for studies at another university can be transferred. An application form can be found on the KTH Student pages.

The application form is submitted to the CSC Program Office.

For in-depth information about the KTH policy for credit transfer, see http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/prestationer/policy-for-tillgodoraknande-av-hogskoleutbildning-inklusive-bedomning-av-reell-kompetens-1.27200?l=en_UK

Studies abroad

Students of the program have the possibility to spend one or two semesters of study at a foreign university, or do their degree project abroad.

For more information, contact the person responsible for International Relations at CSC.

More information can also be found at http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/utbytesstudier/1.27222

Degree project

Students admitted to the program are required to perform an individual study in the form of a degree project corresponding to 30 higher education credits. At least 60 higher education credits must be completed before the start of the degree project. Of these, 40 higher education credits must come from the (common and track-specific) compulsory courses.

It is the responsibility of the student to find a suitable project task.


For students on a Master of science of engineering program not only the requirements set by the selected Master program to begin the degree project apply but also the requirements from the Master of science of engineering program.

Degree

After completing the program, the student may apply for the Degree of Master of Science, in Swedish: teknologie masterexamen.

Information on the application process can be found on the KTH Student pages.

Requirements for the Degree of Master of Science
The Degree of Master of Science is obtained after completion of the Machine Learning program. The program is designed so that students, when they graduate, have fulfilled national requirements for a degree. This means that the students have completed courses comprising 120 higher education credits, of which at least 90 higher education credits are second cycle, and at least 60 higher education credits (including a 30 higher education credits degree project) constitute indepth studies in the main field of study.

See also the KTH regulations at http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/examina/1.27227?l=en_UK

Appendix 1 - Course list
Appendix 2 - Programme syllabus descriptions
Appendix 1: Course list

Master's Programme, Machine Learning, 120 credits (TMAIM), Programme syllabus for studies starting in autumn 2012

General courses

Year 1

Mandatory courses (33.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA2205</td>
<td>Introduction to the Philosophy of Science and Research Methodology</td>
<td>7.5 hp  Second cycle</td>
</tr>
<tr>
<td>DA2210</td>
<td>Introduction to the Philosophy of Science and Research Methodology for Computer Scientists</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2380</td>
<td>Artificial Intelligence</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2423</td>
<td>Image Analysis and Computer Vision</td>
<td>7.5 hp  Second cycle</td>
</tr>
<tr>
<td>DD2431</td>
<td>Machine Learning</td>
<td>6.0 hp  Second cycle</td>
</tr>
</tbody>
</table>

Supplementary information

Specialization streams are:

- Perception and Cognition
- Information Retrieval
- Computational Biology

Year 2

Mandatory courses (90.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD221X</td>
<td>Degree Project in Computer Science, Second Cycle</td>
<td>30.0 hp  Second cycle</td>
</tr>
</tbody>
</table>
SF288X  Degree Project in Optimization and Systems Theory, Second Cycle  30.0 hp  Second cycle
SF299X  Degree Project in Mathematical Statistics, Second Cycle  30.0 hp  Second cycle

Track, Perception and Cognition (MAIA)

Year 1

Mandatory courses (12.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD2427</td>
<td>Image Based Recognition and Classification</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2432</td>
<td>Artificial Neural Networks and Other Learning Systems</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>

Conditionally elective courses

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD2257</td>
<td>Visualization</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2401</td>
<td>Neuroscience</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2418</td>
<td>Language Engineering</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2439</td>
<td>Artificial Intelligence and Multi-agent Systems, Project Course</td>
<td>21.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2447</td>
<td>Statistical Methods in Applied Computer Science</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2450</td>
<td>Algorithmic Bioinformatics</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2476</td>
<td>Search Engines and Information Retrieval Systems</td>
<td>9.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DT2118</td>
<td>Speech and Speaker Recognition</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DT2140</td>
<td>Multimodal Interaction and Interfaces</td>
<td>7.5 hp</td>
<td>Second cycle</td>
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<tr>
<td>EL2320</td>
<td>Applied Estimation</td>
<td>7.5 hp</td>
<td>Second cycle</td>
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<tr>
<td>SF1841</td>
<td>Optimization</td>
<td>6.0 hp</td>
<td>First cycle</td>
</tr>
<tr>
<td>SF2943</td>
<td>Time Series Analysis</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SF2950</td>
<td>Applied Mathematical Statistics</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>

Supplementary information

At least three of the conditionally elective courses within the specialization must be taken.

Year 2

Mandatory courses (6.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
### Course code | Course name | Credits Edu. level
---|---|---
DD2429 | Computational Photography | 6.0 hp Second cycle

**Conditionally elective courses**

### Course code | Course name | Credits Edu. level
---|---|---
DD2387 | Program System Construction Using C++ | 6.0 hp Second cycle
DD2404 | Applied Bioinformatics | 7.5 hp Second cycle
DD2425 | Robotics and Autonomous Systems | 9.0 hp Second cycle
DD2447 | Statistical Methods in Applied Computer Science | 6.0 hp Second cycle
DT2140 | Multimodal Interaction and Interfaces | 7.5 hp Second cycle
EL2320 | Applied Estimation | 7.5 hp Second cycle
EN2202 | Pattern Recognition | 7.5 hp Second cycle
SF2940 | Probability Theory | 7.5 hp Second cycle

**Supplementary information**

At least three of the conditionally elective courses within the specialization must be taken.

### Track, Information Retrieval (MAIB)

#### Year 1

**Mandatory courses (22.5 Credits)**

### Course code | Course name | Credits Edu. level
---|---|---
DD2447 | Statistical Methods in Applied Computer Science | 6.0 hp Second cycle
DD2471 | Modern Database Systems and Their Applications | 7.5 hp Second cycle
DD2476 | Search Engines and Information Retrieval Systems | 9.0 hp Second cycle

**Conditionally elective courses**

### Course code | Course name | Credits Edu. level
---|---|---
DD1368 | Database Technology Given in Swedish | 6.0 hp First cycle
DD2257 | Visualization | 7.5 hp Second cycle
DD2352 | Algorithms and Complexity | 7.5 hp Second cycle
DD2427 | Image Based Recognition and Classification | 6.0 hp Second cycle
DD2432 | Artificial Neural Networks and Other Learning Systems | 6.0 hp Second cycle

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Study Programme for Master's Programme, Machine Learning, 120 credits batch autumn 12.  
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Supplementary information

At least three of the conditionally elective courses within the specialization must be taken.

Year 2

Conditionally elective courses

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DD2387</td>
<td>Program System Construction Using C++</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2393</td>
<td>Protocols and Principles of the Internet</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2395</td>
<td>Computer Security</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2404</td>
<td>Applied Bioinformatics</td>
<td>7.5 hp  Second cycle</td>
</tr>
<tr>
<td>DD2418</td>
<td>Language Engineering</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2429</td>
<td>Computational Photography</td>
<td>6.0 hp  Second cycle</td>
</tr>
<tr>
<td>DD2448</td>
<td>Foundations of Cryptography</td>
<td>7.5 hp  Second cycle</td>
</tr>
<tr>
<td>SF2940</td>
<td>Probability Theory</td>
<td>7.5 hp  Second cycle</td>
</tr>
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</table>

Supplementary information

At least three of the conditionally elective courses within the specialization must be taken.

Track, Computational Biology (MAIC)

Year 1

Mandatory courses (43.5 Credits)

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<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits Edu. level</th>
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<tbody>
<tr>
<td>DD2397</td>
<td>Applied Bioinformatics Track 1</td>
<td>7.5 hp  Second cycle</td>
</tr>
<tr>
<td>DD2398</td>
<td>Quantitative Systems Biology Track 2, conditionally elective track 1</td>
<td>7.5 hp  Second cycle</td>
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<tr>
<td>DD2399</td>
<td>Omic Data and Systems Biology Track 1, conditionally elective track 2</td>
<td>7.5 hp  Second cycle</td>
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<tr>
<td>DD2435</td>
<td>Mathematical Modelling of Biological Systems Track 2, could be taken year 2</td>
<td>9.0 hp  Second cycle</td>
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</table>
**Conditionally elective courses**

<table>
<thead>
<tr>
<th>Course code</th>
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<th>Credits</th>
<th>Edu. level</th>
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<tr>
<td>DD2400</td>
<td>Cellular and Molecular Biology</td>
<td>15.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2401</td>
<td>Neuroscience</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2427</td>
<td>Image Based Recognition and Classification</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2432</td>
<td>Artificial Neural Networks and Other Learning Systems</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2447</td>
<td>Statistical Methods in Applied Computer Science</td>
<td>6.0 hp</td>
<td>Second cycle</td>
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<tr>
<td>DD2476</td>
<td>Search Engines and Information Retrieval Systems</td>
<td>9.0 hp</td>
<td>Second cycle</td>
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<tr>
<td>SF1841</td>
<td>Optimization</td>
<td>6.0 hp</td>
<td>First cycle</td>
</tr>
<tr>
<td>SF2943</td>
<td>Time Series Analysis</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SF2950</td>
<td>Applied Mathematical Statistics</td>
<td>7.5 hp</td>
<td>Second cycle</td>
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**Supplementary information**

At least three of the conditionally elective courses within the specialization must be taken.

**Year 2**

**Conditionally elective courses**

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
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<tbody>
<tr>
<td>BB2250</td>
<td>Applied Gene Technology</td>
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<td>BB2440</td>
<td>Bioinformatics and Biostatistics</td>
<td>7.0 hp</td>
<td>Second cycle</td>
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<tr>
<td>DD2404</td>
<td>Applied Bioinformatics</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2429</td>
<td>Computational Photography</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2435</td>
<td>Mathematical Modelling of Biological Systems</td>
<td>9.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2447</td>
<td>Statistical Methods in Applied Computer Science</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SF2940</td>
<td>Probability Theory</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SK2530</td>
<td>Introduction to Biomedicine</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>

**Supplementary information**

At least three of the conditionally elective courses within the specialization must be taken.
Appendix 2: Specialisations

Master's Programme, Machine Learning, 120 credits (TMAIM), Programme syllabus for studies starting in autumn 2012

Track, Perception and Cognition (MAIA)

Track, Information Retrieval (MAIB)

Track, Computational Biology (MAIC)