Programme syllabus

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

Valid for students admitted to the education from autumn 17 (HT - Autumn term; VT - Spring term).

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

Programme objectives

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 programme in Machine Learning is on mathematical foundations and methods for Machine Learning. These application areas include topics such as computer vision, speech communication, robotics, information retrieval and/or computational biology.

In addition to this comes the Higher Education Ordinance goals for the degree.

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 a number of application domains.
- 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 ECTS credits) master programme on the advanced level (second cycle). The instruction language is English.

The curriculum consists of a basic block of courses, followed by three blocks, A2-Application domains, A3-Theory and A4-Computer Science.
Four courses must be taken from the block A2-Application domains and two from the group of courses in A3-Theory and A4-Computer Science.

**Eligibility and selection**

*General admission requirements:* See the KTH general admission requirements for Master’s programmes

*Specific admission requirements:* The prerequisites for the Master’s programme in Machine Learning is a Swedish or foreign degree equivalent to Bachelor’s degree of 180 ECTS credits, with a level in Mathematics and Computer Science equal, or higher, than that of the following courses at KTH: SF1624 Algebra and geometry, SF1625 Calculus in one variable, SF1626 Calculus in several variables, SF1901 Probability theory and statistics, DD1337 Programming and DD1338 Algorithms and Data Structures.

Selection: If the number of applicants exceeds the number of places there will be a selection from the following criterias:

1. evaluation of university
2. grades from previous study
3. motivation to study
The evaluation scale is 1-75.

**Implementation of the education**

**Structure of the education**

This programme syllabus, decided by the CSC dean 2016-09-15 is valid for students starting the programme during the study year 2017/2018. Which courses that belong a study year is decided in the fall the year before. Changes may occur in the contents of the programme and in the KTH regulations, please see www.kth.se/student.

The KTH academic year is 40 weeks, divided into four periods.

For details about the structure of the academic year see http://www.kth.se/en/

The first semester in the programme is dedicated to the compulsory courses in the basic curriculum. The second and the third semester consist of the blocks and the elective courses. The last semester is dedicated to the degree project.

**Courses**

The programme is course-based. Lists of courses are included in appendix 1.

Courses

The course goals, prerequisites, contents and examination requirements are found in the course syllabus in the Course and programme 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 30 ECTS credits.

A student in the Machine learning programme is required to take at least 4 courses, listed in A.2, which applied machine learning to particular application domains. He must also take at least 2 courses from those listed in A.3-Theory and A.4-Computer Science. These latter set of courses focus on theory and software engineering. The remaining credits are obtained from freely elected courses. These courses may be chosen from among the profile courses of the track, other second cycle courses at KTH, and language courses at KTH. Undergraduate courses at KTH can also be chosen, upon permission from the Programme 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 analysed by the course leader in the course analysis document, which is normally published on the web, see the KTH regulations of course analyses: http://www.kth.se/en/

**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.

**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**

Application to the course is done:

- 1 to 15 May for the autumn semester
- 1 to 15 November for the spring semester

with student kth.se account via universityadmissions.se

If the student is not doing their course selections by this system his/her application is only considered upon availability.

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, at course start, register for each course. Course registration for compulsory as well as elective courses must be done individually. If the student registers for a course and then decides to not continue, the student must remove the registration within three weeks after the course has started via the personal menu. If this is not done the student must complete the course.

Registration to a course requires formal acceptance to the course.

**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 programme.

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

Please see the KTH regulations: http://www.kth.se/en/

**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 Programme Office.

For in-depth information about the KTH policy for credit transfer, see http://www.kth.se/en/

**Studies abroad**

Students of the programme 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.

**Degree project**

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

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

More information about the rules for degree projects at KTH can be found at http://www.kth.se/en/

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

After completing the programme, the student may apply for the degree "Teknologie Masterexamen", translated to English "Master of Science".

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 programme. The programme 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 ECTS credits, of which at least 90 ECTS credits are second cycle, and at least 60 ECTS credits (including a 30 ECTS credits degree project) constitute in depth studies in the main field of study.

See also the KTH regulations at http://www.kth.se/en/

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 2017

General courses

Year 1

Mandatory courses (31.5 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA2205</td>
<td>Introduction to the Philosophy of Science and Research</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td></td>
<td>Methodology</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td></td>
<td>Can be taken in year 2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DD2301</td>
<td>Program Integrating Course in Machine Learning</td>
<td>3.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2380</td>
<td>Artificial Intelligence</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2421</td>
<td>Machine Learning</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2434</td>
<td>Machine Learning, Advanced Course</td>
<td>7.5 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>DD1388</td>
<td>Program System Construction Using C++</td>
<td>7.5 hp</td>
<td>First cycle</td>
</tr>
<tr>
<td>DD2257</td>
<td>Visualization</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2352</td>
<td>Algorithms and Complexity</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2395</td>
<td>Computer Security</td>
<td>6.0 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>DD2402</td>
<td>Advanced Individual Course in Computational Biology</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2404</td>
<td>Applied Bioinformatics</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td></td>
<td>The course can be taken in Year 2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DD2418</td>
<td>Language Engineering</td>
<td>6.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2423</td>
<td>Image Analysis and Computer Vision</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2424</td>
<td>Deep Learning in Data Science</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
<td>Credits</td>
<td>Cycle</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------------------------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
<td>9.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2429</td>
<td>Computational Photography</td>
<td>6.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2435</td>
<td>Mathematical Modelling of Biological Systems</td>
<td>9.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2437</td>
<td>Artificial Neural Networks and Deep Architectures</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2438</td>
<td>Artificial Intelligence and Multi Agent Systems</td>
<td>15.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2447</td>
<td>Statistical Methods in Applied Computer Science</td>
<td>6.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2448</td>
<td>Foundations of Cryptography</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DD2476</td>
<td>Search Engines and Information Retrieval Systems</td>
<td>9.0 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DH2642</td>
<td>Interaction Programming and the Dynamic Web</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DT2112</td>
<td>Speech Technology</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>DT2119</td>
<td>Speech and Speaker Recognition</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>EL2320</td>
<td>Applied Estimation</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>EQ2340</td>
<td>Pattern Recognition</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>ID2213</td>
<td>Logic Programming</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>ID2221</td>
<td>Data-Intensive Computing</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>ID2222</td>
<td>Data Mining</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>ID2223</td>
<td>Scalable Machine Learning and Deep Learning</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>SF1811</td>
<td>Optimization</td>
<td>6.0 hp</td>
<td>First</td>
</tr>
<tr>
<td>SF2568</td>
<td>Parallel Computations for Large-Scale Problems</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>SF2930</td>
<td>Regression Analysis</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>SF2940</td>
<td>Probability Theory</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
<tr>
<td>SF2943</td>
<td>Time Series Analysis</td>
<td>7.5 hp</td>
<td>Second</td>
</tr>
</tbody>
</table>

**Supplementary information**

**A.1.2. Common Elective Courses**

Selected freely from all Second cycle courses and language courses given at KTH. First cycle courses at KTH may be taken upon permission from the Programme Director. Not more than 30 ECTS credits in total can be acquired from First cycle courses.

A student must take at least 4 courses from the grouping listed in A.2 and at least 2 courses from the group of courses in A.3 and A.4.

**A.2 Conditionally Elective Courses - Application Domains**

**COMPUTER VISION:**
DD2423 Image Analysis and Computer Vision, 7.5 hp,
DD2424 Deep learning in Data Science, 7.5 hp,
DD2429 Computational photography, 6 hp.
Language Processing: Speech & Text
DT2112 Speech Technology, 7.5 hp,
DT2119 Speech and Speaker Recognition, 7.5 hp
DD2418 Language Engineering, 6.0 hp

VISUALIZATION:
DD2257 Visualization, 7.5 hp

ROBOTICS:
DD2438 Artificial Intelligence and Multi Agent Systems, 15 hp
DD2425 Robotics and Autonomous Systems, 9 hp

DATABASES/INFORMATION RETRIEVAL:
DD2476 Search Engines and Information Retrieval Systems, 9 hp

COMPUTATIONAL BIOLOGY:
DD2435 Mathematical Modelling of Biological Systems, 9 hp,
DD2401 Neuroscience, 7.5 hp,
DD2402 Advanced Individual Course in Computational Biology, 6 hp,
DD2404 Applied Bioinformatics, 7,5 hp.

MACHINE LEARNING:
EQ2340 Pattern Recognition, 7,5 hp
DD2437 Artificial Neural Networks and Deep Architectures, 7,5 hp
ID2222 Data Mining 7.5
ID2223 Scalable Machine Learning and Deep Learning 7.5

A.3 Conditionally Elective Courses - Theory

MATHEMATICS:
EL2320 Applied Estimation, 7.5 hp
SF1811 Optimization, 6 hp

STATISTICS & PROBABILITY:
DD2447 Statistical Methods in Applied Computer Science, 6 hp,
SF2930 Regression Analysis, 7,5 hp,
SF2943 Time Series Analysis, 7,5 hp,
SF2940 Probability theory, 7,5 hp.

A.4 Conditionally Elective Courses - Computer Science

PARALLEL COMPUTING:
SF2568 Parallel Computations for Large- Scale Problems, 6 hp
ID2221 Data-Intensive Computing, 7.5 hp
THEORY:
DD2352 Algorithms and Complexity, 7,5 hp

Software Engineering:
DD1388 Program System Construction Using C++, 7,5 hp (only in Swedish)
DH2642 Interaction Programming and the Dynamic Web 7,5 hp
ID2213 Logic Programming, 7,5 hp

Databases:
DD1368 Database Technology, 6 hp

Security:
DD2395 Computer security, 6 hp,
DD2448 Foundations of Cryptography, 7,5 hp.

Year 2

Mandatory courses (93.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA233X</td>
<td>Degree Project in Computer Science and Engineering, specializing in Machine Learning, Second Cycle</td>
<td>30.0 hp</td>
<td>Second cycle</td>
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<tr>
<td>DD2301</td>
<td>Program Integrating Course in Machine Learning</td>
<td>3.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SF288X</td>
<td>Degree Project in Optimization and Systems Theory, Second Cycle</td>
<td>30.0 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>SF299X</td>
<td>Degree Project in Mathematical Statistics, Second Cycle</td>
<td>30.0 hp</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>

Conditionally elective courses

<table>
<thead>
<tr>
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<th>Credits</th>
<th>Edu. level</th>
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<tr>
<td>DD1388</td>
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<td>Image Analysis and Computer Vision</td>
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<td>Second cycle</td>
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<tr>
<td>DD2424</td>
<td>Deep Learning in Data Science</td>
<td>7.5 hp</td>
<td>Second cycle</td>
</tr>
<tr>
<td>DD2425</td>
<td>Robotics and Autonomous Systems</td>
<td>9.0 hp</td>
<td>Second cycle</td>
</tr>
</tbody>
</table>
DD2429  Computational Photography  
DD2435  Mathematical Modelling of Biological Systems  
DD2437  Artificial Neural Networks and Deep Architectures  
DD2438  Artificial Intelligence and Multi Agent Systems  
DD2447  Statistical Methods in Applied Computer Science  
DD2448  Foundations of Cryptography  
DD2476  Search Engines and Information Retrieval Systems  
DH2642  Interaction Programming and the Dynamic Web  
DT2112  Speech Technology  
DT2119  Speech and Speaker Recognition  
EL2320  Applied Estimation  
EQ2341  Pattern Recognition and Machine Learning  
ID2213  Logic Programming  
ID2221  Data-Intensive Computing  
ID2222  Data Mining  
ID2223  Scalable Machine Learning and Deep Learning  
SF1811  Optimization  
SF2568  Parallel Computations for Large-Scale Problems  
SF2930  Regression Analysis  
SF2940  Probability Theory  
SF2943  Time Series Analysis  

Supplementary information

A.1.2. Common Elective Courses

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A.2 Conditionally Elective Courses - Application Domains

COMPUTER VISION:
DD2423 Image Analysis and Computer Vision, 7.5 hp,  
DD2424 Deep learning in Data Science, 7.5 hp,  
DD2429 Computational photography, 6 hp.

Language Processing: Speech & Text
DT2112 Speech Technology, 7.5 hp,  
DT2119 Speech and Speaker Recognition, 7.5 hp  
DD2418 Language Engineering, 6.0 credits
VISUALIZATION:
DD2257 Visualization, 7,5 hp.

ROBOTICS:
DD2438 Artificial Intelligence and Multi Agent Systems, 15 hp,
DD2425 Robotics and Autonomous Systems, 9 hp.

DATABASES/INFORMATION RETRIEVAL:
DD2476 Search Engines and Information Retrieval Systems, 9 hp

COMPUTATIONAL BIOLOGY:
DD2435 Mathematical Modelling of Biological Systems, 9 hp,
DD2401 Neuroscience, 7,5 hp,
DD2402 Advanced Individual Course in Computational Biology, 6 hp,
DD2404 Applied Bioinformatics, 7,5 hp.

MACHINE LEARNING:
EQ2341 Pattern Recognition and Machine Learning, 7,5 hp,
DD2432 Artificial Neural Networks and Other Learning Systems, 6 hp.
ID2223 Scalable Machine Learning and Deep Learning 7.5
ID2222 Data Mining 7.5

A.3 Conditionally Elective Courses - Theory

MATHEMATICS:
EL2320 Applied Estimation, 7,5 hp,
SF1811 Optimization, 6 hp

STATISTICS & PROBABILITY:
DD2447 Statistical Methods in Applied Computer Science, 6 hp,
SF2930 Regression Analysis, 7,5 hp,
SF2943 Time Series Analysis, 7,5 hp,
SF2940 Probability theory, 7,5 hp.

A.4 Conditionally Elective Courses - Computer Science

PARALLEL COMPUTING:
SF2568 Parallel Computations for Large- Scale Problems, 6 hp
ID2221 Data-Intensive Computing, 7.5 credits

THEORY:
DD2352 Algorithms and Complexity, 7,5 hp.

Software Engineering:
DD1388 Program System Construction Using C++, 7.5 hp. (only in Swedish)
DH2642 Interaction Programming and the Dynamic Web 7.5 hp
ID2213 Logic Programming, 7.5 hp

**Databases:**
DD1368 Database Technology, 6 hp

**Security:**
DD2395 Computer security, 6 hp
DD2448 Foundations of Cryptography, 7.5 hp
Appendix 2: Specialisations

Master's Programme, Machine Learning, 120 credits (TMAIM), Programme syllabus for studies starting in autumn 2017

This programme has no specialisations.