Programme syllabus

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

Valid for students admitted to the education from autumn 16 (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 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. Some elective courses are given in Swedish.

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 A3-Theory and A4-Computer Science.

**Eligibility and selection**

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

*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: SF1604 Linear algebra (or SF1624), SF1625 Calculus in one variable, SF1626 Calculus in several variables, SF1901 Probability theory and statistics, DD1337 Programming and DD1338 Algorithms and Data Structures (or DD1320, DD1321, DD1340, DD1344).

The specific requirements may be considered as not fulfilled if the applicant's average grades are in the lower third of the grading scale of the applicant graduate university (over the approved level). For example, below C for a university with grades A-F.
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
4. merit rating
5. references
6. proficiency in English

The evaluation scale is 1-75.

Further information

Complete information on the eligibility requirements can be found in the local admission policy of KTH, see

http://intra.kth.se/regelverk/utbildning-forskning/grundutbildning/antagning/

and on the KTH Studies web pages: http://www.kth.se/en/studies/programmes/master/admission

**Implementation of the education**

**Structure of the education**

This programme syllabus, decided by the CSC dean 2015-09-17 is valid for students starting the programme during the study year 2016/2017. 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/student/schema/

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.
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 25 ECTS credits. In each track, there is an additional set of compulsory courses of around 25 ECTS credits.

A student in the Machine learning track is required to take at least four courses, listed in A.2, which apply machine learning to particular application domains. He must also take at least two courses from those listed in A.3 and A.4. 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://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.

*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://intra.kth.se/en/regelverk/utbildning-forskning/grundutbildning/

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://intra.kth.se/en/regelverk/utbildning-forskning/grundutbildning/prestationer/

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.

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

**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://intra.kth.se/en/regelverk/utbildning-forskning/grundutbildning/examensarbete/

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 indepth studies in the main field of study.

See also the KTH regulations at http://intra.kth.se/en/regelverk/utbildning-forskning/grundutbildning/examina/

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 2016

Programme syllabus

Established Programme syllabus as PDF:

- Valid for studies starting in autumn 2016

General courses

Year 1

Mandatory courses (30.0 Credits)

<table>
<thead>
<tr>
<th>Course code</th>
<th>Course name</th>
<th>Credits</th>
<th>Edu. level</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA2205</td>
<td>Introduction to the Philosophy of Science and Research Methodology</td>
<td>7.5 hp</td>
<td>Second cycle</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>DD2431</td>
<td>Machine Learning</td>
<td>6.0 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>DD1368</td>
<td>Database Technology</td>
<td>6.0 hp</td>
<td>First cycle</td>
</tr>
<tr>
<td>DD1387</td>
<td>Program System Construction Using C++</td>
<td>6.0 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>
</tbody>
</table>
DD2401  Neuroscience  7.5 hp  Second cycle
DD2402  Advanced Individual Course in Computational Biology  6.0 hp  Second cycle
DD2404  Applied Bioinformatics  7.5 hp  Second cycle
DD2423  Image Analysis and Computer Vision  7.5 hp  Second cycle
DD2424  Deep Learning in Data Science  7.5 hp  Second cycle
DD2432  Artificial Neural Networks and Other Learning Systems  6.0 hp  Second cycle
DD2447  Artificial Intelligence and Multi Agent Systems  15.0 hp  Second cycle
DD2448  Statistical Methods in Applied Computer Science  6.0 hp  Second cycle
Can be read in study year 2.
DD2448  Foundations of Cryptography  7.5 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
DH2642  Interaction Programming and the Dynamic Web  7.5 hp  Second cycle
DT2112  Speech Technology  7.5 hp  Second cycle
DT2119  Speech and Speaker Recognition  7.5 hp  Second cycle
EL2320  Applied Estimation  7.5 hp  Second cycle
Can be read in study year 2.
EQ2340  Pattern Recognition  7.5 hp  Second cycle
ID2213  Logic Programming  7.5 hp  Second cycle
SF1811  Optimization  6.0 hp  First cycle
SF2568  Parallel Computations for Large- Scale Problems  7.5 hp  Second cycle
SF2930  Regression Analysis  7.5 hp  Second cycle
SF2940  Probability Theory  7.5 hp  Second cycle
SF2943  Time Series Analysis  7.5 hp  Second cycle

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 grouping 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.

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:
DD1368 Database Technology, 6 hp,
DD2476 Search Engines and Information Retrieval Systems, 9 hp,
DD2471 Modern Database Systems and Their Applications, 7,5 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.

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,
SF2945 Time Series Analysis, 6 hp,
SF2940 Probability theory, 7,5 hp.

MACHINE LEARNING:
EQ2340 Pattern Recognition, 7,5 hp,
DD2432 Artificial Neural Networks and Other Learning Systems, 6 hp.

A.4 Conditionally Elective Courses - Computer Science

PARALLEL COMPUTING:
SF2568 Parallel Computations for Large-Scale Problems, 6 hp.

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

Software Engineering:
DD1387 Program System Construction Using C++, 6 hp. (only in Swedish)
DH2642 Interaction Programming and the Dynamic Web 7.5 hp
ID2213 Logic Programming, 7.5 hp

Security:
DD2395 Computer security, 6 hp,
DD2448 Foundations of Cryptography, 7.5 hp.

Year 2

Mandatory courses (123.0 Credits)

<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>DA221X</td>
<td>Degree Project in Computer Science and Communication, Second Cycle</td>
<td>30.0 hp</td>
<td>Second cycle</td>
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<td></td>
<td>For students admitted to a Master programme at CSC</td>
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<tr>
<td>DA222X</td>
<td>Degree Project in Computer Science and Communication, Second Cycle</td>
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<td>Second cycle</td>
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<td></td>
<td>Engineering students admitted to a master programme at CSC</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>
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</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>DD1368</td>
<td>Database Technology</td>
<td>6.0 hp</td>
<td>First cycle</td>
</tr>
<tr>
<td>DD1388</td>
<td>Program System Construction Using C++ Given in Swedish</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>
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<td>DD2352</td>
<td>Algorithms and Complexity</td>
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<td>Second cycle</td>
</tr>
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<td>DD2401</td>
<td>Neuroscience</td>
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</tr>
<tr>
<td>DD2402</td>
<td>Advanced Individual Course in Computational Biology</td>
<td>6.0 hp</td>
<td>Second cycle</td>
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<td>DD2404</td>
<td>Applied Bioinformatics</td>
<td>7.5 hp</td>
<td>Second cycle</td>
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<td>DD2418</td>
<td>Language Engineering</td>
<td>6.0 hp</td>
<td>Second cycle</td>
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<tr>
<td>DD2423</td>
<td>Image Analysis and Computer Vision</td>
<td>7.5 hp</td>
<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>
<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>DD2437</td>
<td>Artificial Neural Networks and Deep Architectures</td>
<td>7.5 hp</td>
<td>Second cycle</td>
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</table>
DD2438 Artificial Intelligence and Multi Agent Systems 15.0 hp Second cycle
DD2447 Statistical Methods in Applied Computer Science 6.0 hp Second cycle
DD2476 Search Engines and Information Retrieval Systems 9.0 hp Second cycle
DH2642 Interaction Programming and the Dynamic Web 7.5 hp Second cycle
DT2112 Speech Technology 7.5 hp Second cycle
DT2119 Speech and Speaker Recognition 7.5 hp Second cycle
EL2320 Applied Estimation 7.5 hp Second cycle
EQ2340 Pattern Recognition 7.5 hp Second cycle
ID2213 Logic Programming 7.5 hp Second cycle
SF1811 Optimization 6.0 hp First cycle
SF2568 Parallel Computations for Large-Scale Problems 7.5 hp Second cycle
SF2930 Regression Analysis 7.5 hp Second cycle
SF2940 Probability Theory 7.5 hp Second cycle
SF2943 Time Series Analysis 7.5 hp Second cycle

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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.

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:
DD1368 Database Technology, 6 hp,
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.

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.

MACHINE LEARNING:
EQ2340 Pattern Recognition, 7,5 hp,
DD2432 Artificial Neural Networks and Deep Architectures, 7,5 hp.

A.4 Conditionally Elective Courses - Computer Science

PARALLEL COMPUTING:
SF2568 Parallel Computations for Large-Scale Problems, 6 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

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 2016

Programme syllabus

Established Programme syllabus as PDF:

- Valid for studies starting in autumn 2016

This programme has no specialisations.