

Machine Learning, Minor

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www.ml.cmu.edu/academics/minor-in-machine-learning.html (<http://www.ml.cmu.edu/academics/minor-in-machine-learning.html>)

Machine Learning Minor

Machine learning and statistical methods are increasingly used in many application areas including natural language processing, speech, vision, robotics, and computational biology. The Minor in Machine Learning allows undergraduates to learn about the core principles of this field.

Curriculum

Prerequisites

Students must complete the prerequisites for 10-301 or 10-315 or 07-280. To view the prerequisites for 10-301 or 07-280, please click on the respective course. For each prerequisite, a grade of C or higher is required.

Core Courses (24 units)

Students must take two core courses, each being at least 12 credits

Core Courses	Units
10-301 Introduction to Machine Learning	12
or 10-315 Introduction to Machine Learning (SCS Majors)	
or 07-280 Artificial Intelligence and Machine Learning I	
10-403 Deep Reinforcement Learning & Control	12
or 10-405 Machine Learning with Large Datasets (Undergraduate)	
or 10-414 Deep Learning Systems: Algorithms and Implementation	
or 10-417 Intermediate Deep Learning	
or 10-418 Machine Learning for Structured Data	
or 10-422 Foundations of Learning, Game Theory, and Their Connections	

Electives (27 Units)

The Machine Learning Minor requires at least 3 electives of at least 9 units each in Machine Learning. Students may select one of the following options to satisfy the electives requirement:

- 3 Principal courses
- 2 Principal courses + 1 Interdisciplinary course
- 2 Principal courses + 1 semester of CS Senior Honors Thesis or Senior Research
- 1 Principal course + 2 semesters of CS Senior Honors Thesis or Senior Research

Students should note that some of these elective courses (those at the 600-level and higher) are primarily aimed at graduate students, and so should make sure that they are adequately prepared for them before enrolling.

Graduate-level cross-listings of these courses can also be used for the ML Minor, if the student is adequately prepared for the more advanced version and the home department approves the student's registration.

Principal Courses

10-403	Deep Reinforcement Learning & Control	12
or 10-703	Deep Reinforcement Learning & Control	
10-405	Machine Learning with Large Datasets (Undergraduate)	12
or 10-605	Machine Learning with Large Datasets	
or 10-745	Scalability in Machine Learning	
10-414	Deep Learning Systems: Algorithms and Implementation	12
or 10-714	Deep Learning Systems: Algorithms and Implementation	
10-417	Intermediate Deep Learning	12
or 11-485	Introduction to Deep Learning	
or 10-707	Advanced Deep Learning	
10-418	Machine Learning for Structured Data	12
or 10-618	Machine Learning for Structured Data	

or 10-708	Probabilistic Graphical Models	
10-422	Foundations of Learning, Game Theory, and Their Connections	12
10-423	Generative AI	12
or 10-623	Generative AI	
10-425	Introduction to Convex Optimization	12
or 10-625	Introduction to Convex Optimization	
or 10-725	Optimization for Machine Learning	
10-613	Machine Learning Ethics and Society	12
10-643	Socio-technical Evaluations of Generative AI	12
or 10-743	Socio-technical Evaluations of Generative AI	
10-735	Responsible AI	12
10-777	Historical Advances in Machine Learning	12
36-401	Modern Regression	9
Other courses as approved		

Note: Courses must come from separate lines. For example, if 10-417 Intermediate Deep Learning is used for the ML Minor, 11-485 Introduction to Deep Learning cannot also be used for the ML Minor.

Interdisciplinary Electives

02-510	Computational Genomics	12
03-511	Computational Molecular Biology and Genomics	9
10-335	Art and Machine Learning	12
11-411	Natural Language Processing	12
11-441	Machine Learning with Graphs	9
11-481	Generative AI for Biomedicine	12
or 11-781	Generative AI for Biomedicine	
11-661	Language and Statistics	12
11-731	Machine Translation and Sequence-to-Sequence Models	12
11-751	Speech Recognition and Understanding	12
11-755	Machine Learning for Signal Processing	12
11-777	Multimodal Machine Learning	12
15-281	Artificial Intelligence: Representation and Problem Solving	12
15-386	Neural Computation	9
15-388	Practical Data Science	9
15-482	Autonomous Agents	12
16-311	Introduction to Robotics	12
16-385	Computer Vision	12
16-720	Computer Vision	12
16-745	Optimal Control and Reinforcement Learning	
16-824	Visual Learning and Recognition	12
16-831	Introduction to Robot Learning	12
17-537	Artificial Intelligence Methods for Social Good	9
36-402	Advanced Methods for Data Analysis	9
36-462	Special Topics: Statistical Machine Learning	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-700	Probability and Mathematical Statistics	12
Other courses as approved		

SCS Senior Honors Thesis

The SCS Senior Honors Thesis (<http://coursecatalog.web.cmu.edu/schools-colleges/schoolofcomputerscience/honors-research-thesis/>) consists of 36 units of academic credit for this work. Up to 24 units (12 units each semester) may be counted towards the ML Minor. Students must consult with the Computer Science Department for information about the SCS Senior Honors Thesis. Once both student and advisor agree upon a project, the student should submit a one-page research proposal to the Machine Learning Concentration Director to confirm that the project will count for the Machine Learning Concentration.

07-599	SCS Honors Undergraduate Research Thesis	Var.
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Senior Research

Senior research consists of 2 semesters of 10-500 Senior Research Project, totaling 24 units and counting as 2 electives.

The research must be a year-long senior project, supervised or co-supervised by a Machine Learning Core or Affiliated Faculty member. It is almost always conducted as two semester-long projects, and must be done in senior year.

Interested students should contact the faculty they wish to advise them to discuss the research project, before the semester in which research will take place. Once both student and advisor agree upon a project, the student should submit a one-page research proposal to the Machine Learning Minor Director to confirm that the project will count for the Machine Learning Minor.

The student **should email the ML Minor Director a brief update (two paragraphs) on their progress at the end of the Fall semester, and will** present the work at the Meeting of the Minds (<https://www.cmu.edu/uro/MoM/>) and submit a year-end write-up to the Minor Director at the end of Senior year.

10-500	Senior Research Project	24
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Double Counting

No course in the Machine Learning Minor may be counted towards another SCS minor. Additionally, at least 3 courses (each being at least 9 units) must be used for only the Machine Learning Minor, not for any other major, minor, or concentration. (These double counting restrictions apply specifically to the Core Courses and the Electives. Prerequisites may be counted towards other majors, minors, and concentrations and do not count towards the 3 courses that must be used for only the Machine Learning Minor.)

Grades

All courses for the Machine Learning Minor, including prerequisites, must be passed with a C or better.

Admission

The Machine Learning Minor is open to undergraduate students in any major at Carnegie Mellon outside the School of Computer Science. (SCS students should instead consider the Machine Learning Concentration.) Students should apply for admission at least one semester before their expected graduation date, but are encouraged to apply as soon as they have taken the prerequisite classes for the minor. The application can be found on the Machine Learning Minor website.