Artificial Intelligence, B.S.

Bachelor of Science in Artificial Intelligence

Overview

Students in the BSAI program within the School of Computer Science are expected to acquire the following skills upon graduation:

- Understand how to distill a real-world challenge as an artificial intelligence problem, involving explicit representation and learning of symbolic and numeric models; reasoning about such models; and using such models for decision making, action selection, and interaction with humans.
- Design, analyze, implement, and use state-of-the-art AI and machine learning techniques for dealing with real-world data, including data involving vision, language, perception, and uncertainty.
- Master the core concepts of computer science, with emphasis on data structures, programming, computing systems, and algorithm design, performance, and correctness across a variety of metrics (e.g., time, space, parallel vs. sequential implementation, what is computable).
- Master the fundamentals of discrete mathematics, logic, theorem proving and explanation, probability and statistics, and optimization.
- Describe, specify, and develop large-scale, open-ended artificial intelligence systems subject constraints such as performance, available data, and need for transparency. Communicate technical material effectively to technical and non-technical audiences.
- Work productively both individually and in teams.
- Recognize the social impact of artificial intelligence and the underlying responsibility to consider the ethical, privacy, moral, and legal implications of artificial intelligence technologies.

Students who graduate with a bachelors degree in AI, will have the computer science savvy and skills our students are known for, with the added expertise in machine learning and automated reasoning that you'll need to build the AI of tomorrow.

Curriculum

BSAI majors will take core courses in math and statistics, computer science, artificial intelligence and ethics, along with general education courses in science and engineering, and humanities and arts.

Math and Statistics

All of the following:		Units
15-151	Mathematical Foundations for Computer Science (if not offered, substitute 21-127)	12
21-120	Differential and Integral Calculus	10
21-122	Integration and Approximation	10
21-241	Matrices and Linear Transformations	11
21-259	Calculus in Three Dimensions or 21-266, or 21-268, or 21-269	10
Probability and Statistics (one of the following options):		
36-218	Probability Theory for Computer Scientists	9
15-259	Probability and Computing	12
21-325 & 36-226	Probability and Introduction to Statistical Inference	18
21-425 & 36-226	Probability and Martingales and Introduction to Statistical Inference	18
36-225 & 36-226	Introduction to Probability Theory and Introduction to Statistical Inference	18
36-235 & 36-236	Probability and Statistical Inference I and Probability and Statistical Inference II	18
plus Modern Regression:		
36-401	Modern Regression	9

Computer Science

All of the following:		Units
15-122	Principles of Imperative Computation (students without credit or a waiver for 15-112, Fundamentals of Programming and Computer Science, must take 15-112 before 15-122)	12
15-150	Principles of Functional Programming	12
15-210	Parallel and Sequential Data Structures and Algorithms	12
15-213	Introduction to Computer Systems	12
15-251	Great Ideas in Theoretical Computer Science	12

Artificial Intelligence

All of the following AI core courses:		Units
07-280	Artificial Intelligence and Machine Learning I	12
07-380	Artificial Intelligence and Machine Learning II	12
plus one of the following AI core courses:		
11-411	Natural Language Processing	12
16-385	Computer Vision	12

One Decision Making and Robotics course (min. 9 units):		Units
15-386	Neural Computation	9
15-482	Autonomous Agents	12
15-494	Cognitive Robotics: The Future of Robot Toys	12
16-350	Planning Techniques for Robotics	12
16-362	Mobile Robot Algorithms Laboratory	12
16-384	Robot Kinematics and Dynamics	12
others as designated by the AI Undergraduate Program		

One Machine Learning course from the following (min. 9 units):		
10-403	Deep Reinforcement Learning & Control	12
10-405	Machine Learning with Large Datasets (Undergraduate)	12
10-414	Deep Learning Systems: Algorithms and Implementation	12
10-417	Intermediate Deep Learning	12
10-418	Machine Learning for Structured Data	12
10-422	Foundations of Learning, Game Theory, and Their Connections	12
10-423	Generative AI	12
10-424	Bayesian Methods in Machine Learning	12
10-425	Introduction to Convex Optimization	12
11-441	Machine Learning with Graphs	9
11-485	Introduction to Deep Learning	12
36-402	Advanced Methods for Data Analysis	9
others as designated by the AI Undergraduate Program		

One Perception and Language course from the following (min. 9 units):		
11-442	Search Engines	9
11-492	Speech Technology for Conversational AI	12
15-387	Computational Perception	9
15-463	Computational Photography	12
others as designated by the AI Undergraduate Program		

One Human-AI Interaction course from the following (min. 12 units):		
05-317	Design of Artificial Intelligence Products	12
05-318	Human AI Interaction	12
05-391	Designing Human Centered Software	12
16-467	Introduction to Human Robot Interaction	12
others as designated by the AI Undergraduate Program		

School of Computer Science Electives

Two general computer science electives:	Units
These electives can be from any SCS department (Computational Biology [02-], Human-Computer Interaction [05-], Interdisciplinary [07-], Machine Learning [10-], Language Technologies [11-], Computer Science [15-], Robotics [16-], or Software & Societal Systems [17-]). They must be 200-level or above and at least 9 units each, with the following exceptions:	18
Students who take two of the major-intro mini-courses (02-180, 05-180, 07-180, or 16-180) during their first year may combine these two mini-courses together to count as one SCS elective;	
The following courses do NOT count as SCS electives: 02-201, 02-223, 02-250, 02-261, 05-200, 07-402, 11-423, 15-351, 16-211, 16-223, 16-224, 16-397, 16-480, 17-200, 17-333, 17-562; Some IDEATE courses and some SCS undergraduate and graduate courses might not be allowed based on course content. Always consult with an AI undergraduate advisor before registration to determine eligibility for this requirement.	

Ethics Course

One of the following courses:		Units
16-161	Artificial Intelligence and Humanity	12
16-735	Ethics and Robotics	12
17-200	Ethics and Policy Issues in Computing	9
80-249	AI, Society, and Humanity	9

SCIENCE AND ENGINEERING

All candidates for the bachelor's degree in Artificial Intelligence must complete a minimum of 36 units offered by the Mellon College of Science (MCS) and/or the College of Engineering (CIT). These courses offer students an opportunity to explore scientific and engineering domains that can influence their effectiveness as computer scientists upon graduation.

Requirements for this component of the degree are listed under the SCS main page under General Education Requirements (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofcomputerscience/#genedtext).

Humanities and Arts

All candidates for the bachelor's degree in Artificial Intelligence must complete a minimum of 63 units offered by the College of Humanities & Social Sciences and/or the College of Fine Arts. These courses offer students breadth in their education and perspectives and provide students with a better appreciation of social, artistic, cultural, political and economic issues that can influence their effectiveness as computer scientists upon graduation.

Requirements for this component of the degree are listed under the SCS main page under General Education Requirements (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofcomputerscience/general-education/). **SPECIAL NOTE FOR AI STUDENTS: AI majors must satisfy Category 1 of the General Education requirements by taking one of the following Cognitive Studies (Category 1A) courses:**

85-110	Cognitive Psychology	9
85-213	Human Information Processing and Artificial Intelligence	9
85-408	Visual Cognition	9
85-421	Language and Thought	9
85-413	Perception	9

SCS First year seminar

The following course is designed to acquaint incoming students with computer science at CMU:

07-128	First Year Seminar	3

CoRE@CMU

The following course is required of all CMU students:

99-101	Core@CMU	3

Free Electives

A free elective is any Carnegie Mellon course. However, a maximum of nine (9) units of Physical Education and/or Military Science (ROTC) and/or Student-Led (StuCo) courses may be used toward fulfilling graduation requirements.

Summary of Degree Requirements

Area	Courses	Units
Mathematics	7	**71**
Computer Science	5	**60**
Artificial Intelligence	7	**75**
SCS Electives	2	**18**
Ethics	1	**9**
Science/Engineering	4	**36**
Humanities/Arts (includes Cognitive Studies)	7	**63**
SCS First Year Seminar	1	**3**
Core@CMU	1	**3**
Free Electives	varies	**22**
		360

Undergraduate Research Thesis

AI majors may use the SCS Honors Research Thesis as part of their degree. The SCS Honors Undergraduate Research Thesis (07-599) typically starts in the fall semester of the senior year, and spans the entire senior year. Students receive a total of 36 units of academic credit for the thesis work, 18 units per semester. Up to 18 units can be counted toward SCS elective requirements (9 per semester for 2 semesters maximum). Students interested in research may also consider using 07-300 Research and Innovation in Computer Science in their junior year since this course will introduce students to various research projects going on in the School of Computer Science that may lead to a senior thesis. This course leads to a subsequent practicum that allows students to complete a small-scale research study or experiment and present a research poster. Students who use the practicum to start their senior thesis can use these units toward the required 36 units.

For more information about the SCS Honors Research Thesis, refer to the SCS Honors Research Thesis (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofcomputerscience/#scshonorsresearchthesistext) section for learning objectives, application requirements and expected outcomes.

BSAI Roadmap: Sample Course Sequence

The sample given below is for a student who already has credit for introductory programming and introductory calculus. Students with no credit for introductory programming will take 15-112 in their first semester and shift some CS courses to later semesters after consulting with their academic advisor; students with no credit for calculus will take 21-120 in their first semester and shift 21-122 and 21-259 to subsequent semesters. These students should still be able to complete their degree in four years given the light load of their senior year. Students with credit for 21-120 and 21-122 may start with a more advanced math class (e.g. 21-241) in their first year. It is recommended that students keep their academic load lighter for their senior fall semester to account for offsite job interviews or for their senior spring semester to account for visits to graduate schools.

FRESHMAN YEAR:

Fall		Units
07-128	First Year Seminar	3
15-122	Principles of Imperative Computation	12
15-151	Mathematical Foundations for Computer Science	12
21-122	Integration and Approximation	10
76-101	Interpretation and Argument	9
99-101	Core@CMU	3
		49

Spring		Units
xx-180	Two Major Introduction Minis (02-180, 05-180, 07-180, 16-180)	10
15-150	Principles of Functional Programming	12
15-213	Introduction to Computer Systems	12
21-241	Matrices and Linear Transformations	11
		45

SOPHOMORE YEAR:

Fall		Units
07-280	Artificial Intelligence and Machine Learning I	12
15-210	Parallel and Sequential Data Structures and Algorithms	12
36-218	Probability Theory for Computer Scientists	9
xx-xxx	Science and Engineering Elective	9
xx-xxx	Ethics Elective	9
		51

Spring		Units
07-380	Artificial Intelligence and Machine Learning II	12
15-251	Great Ideas in Theoretical Computer Science	12
21-259	Calculus in Three Dimensions	10
85-xxx	Cognitive Studies Elective	9
xx-xxx	Humanities and Arts Elective	9
		52

JUNIOR YEAR:

Fall		Units
11-411	Natural Language Processing	12
or 16-385	Computer Vision	
36-401	Modern Regression	9
xx-xxx	AI Elective: Machine Learning	9
xx-xxx	Humanities and Arts elective	9
xx-xxx	Free Elective	9
		48

Spring		Units
xx-xxx	AI Elective: Human-AI Interaction	12
xx-xxx	AI Elective: Decision Making and Robotics	9
xx-xxx	Science and Engineering elective	9
xx-xxx	Humanities and Arts elective	9
xx-xxx	Free Elective	9
		48

SENIOR YEAR:

Fall		Units
xx-xxx	AI Elective: Perception and Language	9
xx-xxx	SCS Elective	9
xx-xxx	Science and Engineering Elective	9
xx-xxx	Humanities and Arts Elective	9
		36

Spring		Units
xx-xxx	SCS Elective	9
xx-xxx	Humanities and Arts Elective	9
xx-xxx	Free Elective	9
xx-xxx	Science and Engineering Elective	9
		36

Minimum number of units required for the degree:360

The flexibility in the curriculum allows many different schedules, of which the above is only one possibility. Some elective courses are offered only once per year (Fall or Spring). AI cluster electives (decision making and robotics, machine learning, perception and language, and human-AI interaction) may be taken in any order and in any semester if prerequisites are met and seats are available. Constrained electives are shown in the specific semesters in the schedule above as an example only. Students should consult with their academic advisor to determine the best elective options depending on course availability, their academic interests and their career goals.