

ARTIFICIAL INTELLIGENCE, BSE

The rapid rise of big data, machine learning, and artificial intelligence have resulted in tremendous breakthroughs that are having horizontal impact across many disciplines, in engineering, computing and beyond. The need for cutting edge AI engineers is tremendous, as are the research and innovation opportunities in this rapidly evolving field. Above all there is tremendous potential for having a positive societal impact in numerous applications domains (health, energy, transportation, robotics, computer vision, human machine interfaces, national security) in addition to networks and society.

Curriculum Artificial Intelligence (ARIN) Major Requirements

37 course units are required.

Code	Title	Course Units
Computing		
CIS 1100	Introduction to Computer Programming	1
CIS 1200	Programming Languages and Techniques I	1
CIS 1210	Programming Languages and Techniques II	1
CIS 2450	Big Data Analytics	1
CIS 3200	Introduction to Algorithms	1
Math and Natural Science		
MATH 1400	Calculus, Part I	1
MATH 1410	Calculus, Part II	1
	or MATH 1610 Honors Calculus	
CIS 1600	Mathematical Foundations of Computer Science	1
ESE 2030	Linear Algebra with Applications to Engineering and AI	1
ESE 3010	Engineering Probability	1
	or STAT 4300 Probability	
ESE 4020	Statistics for Data Science	1
	or ESE 5420 Statistics for Data Science	
	Natural Science elective (http://catalog.upenn.edu/attributes/euns/) ¹	1
Artificial Intelligence		
	12 course units, with at least one course unit from each of the following 6 categories. Note that one course cannot satisfy multiple categories, so, e.g., if you take ESE 4210 for Optimization & Control then you must still take another Project course.	12
<i>Introduction to AI</i>		
CIS 4210	Artificial Intelligence	
	or CIS 5210 Artificial Intelligence	
ESE 2000	Artificial Intelligence Lab: Data, Systems, and Decisions	
<i>Machine Learning</i>		
CIS 4190	Applied Machine Learning	

	or CIS 5190 Applied Machine Learning	
CIS 5200	Machine Learning	
<i>Signals & Systems</i>		
ESE 2100	Introduction to Dynamic Systems	
ESE 2240	Signal and Information Processing	
<i>Optimization & Control</i>		
ESE 3040	Introduction to Optimization	
ESE 4210	Control For Autonomous Robots	
<i>Vision & Language</i>		
CIS 4300	Natural Language Processing	
	or CIS 5300 Natural Language Processing	
CIS 4810	Computer Vision & Computational Photography	
	or CIS 5810 Computer Vision & Computational Photography	
<i>AI Project</i>		
CIS 3500	Software Design/Engineering	
CIS 4300	Natural Language Processing	
	or CIS 5300 Natural Language Processing	
CIS 4810	Computer Vision & Computational Photography	
	or CIS 5810 Computer Vision & Computational Photography	
ESE 3060	Deep Learning: A Hands-on Introduction	
ESE 3600	TinyML: Tiny Machine Learning for Embedded Systems	
ESE 4210	Control For Autonomous Robots	
NETS 2120	Scalable and Cloud Computing	
NETS 2130	Crowdsourcing and Human Computation	
<i>AI Electives</i>		
Remaining course units from any of the six categories above, or any of the following:		
<i>Machine Learning Electives</i>		
CIS 3333	Mathematics of Machine Learning	
CIS 6200	Advanced Topics in Machine Learning	
CIS 6250	Theory of Machine Learning	
ESE 4380	Machine Learning for Time-Series Data	
	or ESE 5380 Machine Learning for Time-Series Data	
ESE 5140	Graph Neural Networks	
ESE 5460	Principles of Deep Learning	
ESE 6450	Deep Generative Models	
ESE 6740	Information Theory	
<i>Optimization, Systems, and Control Electives</i>		
ESE 3030	Stochastic Systems Analysis and Simulation	
ESE 5000	Linear Systems Theory	
ESE 5050	Feedback Control Design and Analysis	
ESE 5060	Introduction to Optimization Theory	
ESE 6050	Modern Convex Optimization	
ESE 6060	Combinatorial Optimization	
ESE 6180	Learning for Dynamics and Control	
ESE 6190	Model Predictive Control	
<i>Other AI Electives</i>		
BE 5210	Brain-Computer Interfaces	

CIS 4120	Introduction to Human Computer Interaction	
or CIS 5120	Introduction to Human Computer Interaction	
CIS 4500	Database and Information Systems	
or CIS 5500	Database and Information Systems	
CIS 5360	Fundamentals of Computational Biology	
CIS 5800	Machine Perception	
CIS 6500	Advanced Topics in Databases	
MEAM 5200	Introduction to Robotics	
MEAM 6200	Advanced Robotics	
ESE 4040	Engineering Markets	
ESE 6150	F1/10 Autonomous Racing Cars	
ESE 6500	Learning in Robotics	
NETS 3120	Theory of Networks	
NETS 4120	Algorithmic Game Theory	

Senior Design

CIS 4000	Senior Project	1
or ESE 4500	Senior Design Project I - EE and SSE	
or MEAM 4450	Mechanical Engineering Design Projects	
or BE 4950	Senior Design Project	
or MSE 4950	Senior Design	
or CBE 4000	Introduction to Product and Process Design	
CIS 4010	Senior Project	1
or ESE 4510	Senior Design Project II - EE and SSE	
or MEAM 4460	Mechanical Engineering Design Projects	
or BE 4960	Senior Design Project	
or MSE 4960	Senior Design	
or CBE 4590	Product and Process Design Projects	

Technical Electives

Three course units from Engineering, Math or Natural Science or listed at https://advising.cis.upenn.edu/tech-electives (http://catalog.upenn.edu/attributes/eums/) ²	3
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General Electives³

AI Ethics Elective

CIS 4230	Ethical Algorithm Design	1
or CIS 5230	Ethical Algorithm Design	
or LAWM 5060	ML: Technology Law	

Cognitive Science Elective

Select one of the following Cognitive Science electives:	1	
COGS 1001	Introduction to Cognitive Science	
LING 0500	Introduction to Formal Linguistics	
LING 2500	Introduction to Syntax	
LING 3810	Semantics I	
PHIL 1710	Introduction to Logic	
PHIL 2640	Introduction to Philosophy of Mind	
PHIL 4721	Logic and Computability 1	
PHIL 4840	Philosophy of Psychology	
PSYC 1210	Introduction to Brain and Behavior	
PSYC 1340	Perception	
PSYC 1230	Cognitive Neuroscience	
PSYC 1310	Language and Thought	
PSYC 2737	Judgment and Decisions	

Select 3 Social Science or Humanities courses	3
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Select 2 Social Science or Humanities or Technology in Business & Society courses 2

Free Elective

Select 1 course unit of free elective. 1

Total Course Units 37

¹ The Natural Science elective can be satisfied with appropriate AP credits, e.g., AP Physics. (a list of approved Natural Science course can be found on the SEAS UG Handbook (<https://ugrad.seas.upenn.edu/student-handbook/courses-requirements/natural-science-courses/>))

² May contain at most one CU of 1000-level courses.

³ Must include a Writing Seminar (a list of approved Writing Seminars can be found in the SEAS Undergraduate Handbook (<https://ugrad.seas.upenn.edu/student-handbook/courses-requirements/writing-courses/>)).

The degree and major requirements displayed are intended as a guide for students entering in the Fall of 2024 and later. Students should consult with their academic program regarding final certifications and requirements for graduation.
