

# ARTIFICIAL INTELLIGENCE MAJOR, BS IN ENGINEERING

Students must also complete the Undergraduate Registration Requirement (<https://catalogs.northwestern.edu/undergraduate/requirements-policies/undergraduate-registration-requirement/>) and the degree requirements of their home school.

## Requirements (48 units)

### Core Courses (26 units)<sup>1</sup>

| Course                                                                                                                                                                                                                                                                                                  | Title                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <b>4 mathematics courses</b>                                                                                                                                                                                                                                                                            |                                                                |
| MATH 220-1                                                                                                                                                                                                                                                                                              | Single-Variable Differential Calculus                          |
| MATH 220-2                                                                                                                                                                                                                                                                                              | Single-Variable Integral Calculus                              |
| MATH 228-1                                                                                                                                                                                                                                                                                              | Multivariable Differential Calculus for Engineering            |
| COMP_SCI 212-0                                                                                                                                                                                                                                                                                          | Math Foundations of CS Part 1: Discrete Math for CS            |
| <b>4 units of basic science chosen according to McCormick basic science guidelines</b><br>( <a href="https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext">https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext</a> ) |                                                                |
| PHYSICS 135-1<br>& PHYSICS 136-1                                                                                                                                                                                                                                                                        | General Physics<br>and General Physics Laboratory <sup>2</sup> |
| Plus an additional 2.66 units from the list of basic science courses                                                                                                                                                                                                                                    |                                                                |
| <b>3 engineering foundations courses</b> ( <a href="https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext">https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext</a> )                                                  |                                                                |
| <b>3 design, communications, and innovation courses</b> ( <a href="https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext">https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext</a> )                                   |                                                                |
| <b>7 social sciences/humanities courses</b> ( <a href="https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext">https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext</a> )                                               |                                                                |
| <b>5 unrestricted electives</b> ( <a href="https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext">https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext</a> )                                                           |                                                                |

### Major Program (22 units)

| Course                                                                                                                                                                                                                                                                                                                         | Title                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| <b>5 required courses</b>                                                                                                                                                                                                                                                                                                      |                                                                       |
| COMP_SCI 180-0<br>or COMP_SCI 111-0                                                                                                                                                                                                                                                                                            | Software Design & Composition<br>Fundamentals of Computer Programming |
| COMP_SCI 208-0                                                                                                                                                                                                                                                                                                                 | Data Structures & Algorithms (Formerly Comp_Sci 214)                  |
| COMP_SCI 211-0                                                                                                                                                                                                                                                                                                                 | Programming in Systems-Level Languages                                |
| COMP_SCI 348-0                                                                                                                                                                                                                                                                                                                 | Introduction to Artificial Intelligence                               |
| COMP_SCI 349-0                                                                                                                                                                                                                                                                                                                 | Machine Learning                                                      |
| <b>4 advanced elective courses</b>                                                                                                                                                                                                                                                                                             |                                                                       |
| Any 300-level or higher class, or introductory courses that directly support computer science (COG_SCI 207-0, COMP_ENG 203-0, COMP_ENG 205-0, COMP_SCI 1CA, COMP_SCI 260-0, COMP_SCI 262-0, COMP_SCI 265-0, COMP_SCI 296-0, COMP_SCI 298-0, GEN_ENG 211-0, GEN_ENG 251-0, MATH 228-2, MATH 230-2, MECH_ENG 233-0) <sup>3</sup> |                                                                       |
| <b>5 breadth courses</b> (p. 1)                                                                                                                                                                                                                                                                                                |                                                                       |
| <b>1 societal impact course</b> (p. 2)                                                                                                                                                                                                                                                                                         |                                                                       |
| <b>7 technical electives</b> (p. 2)                                                                                                                                                                                                                                                                                            |                                                                       |

<sup>1</sup> See general requirements (<https://catalogs.northwestern.edu/undergraduate/engineering-applied-science/#requirementstext>) for details.

<sup>2</sup> PHYSICS 135-1 General Physics can be replaced by GEN\_ENG 212-0 Engineering Physics - Dynamics (Note: if replaced by GEN\_ENG 212-0 Engineering Physics - Dynamics another 1/3 unit of science is

needed to fulfill the science requirement). Courses can be chosen from McCormick-approved basic science categories of Chemistry, Physics, Biological Science, Earth & Planetary Science or Astronomy.

<sup>3</sup> Scores of 4 or 5 on the **AP CS A** exam or scores of 5, 6, or 7 on the **IB CS HL** exam transfer to Northwestern as **COMP\_SCI 1CA**.

## Breadth Courses

**Domain Area requirements** (students must take one course in five of the six categories)

### Advanced ML/NLP

| Course         | Title                                             |
|----------------|---------------------------------------------------|
| COMP_SCI 337-0 | Natural Language Processing: Classical Approaches |
| COMP_SCI 449-0 | Deep Learning                                     |
| COMP_SCI 461-0 | Large Language Models                             |
| IEMS 351-0     | AI-Enabled Sequential Decision Making             |

### Theoretical Foundations

| Course         | Title                                                                         |
|----------------|-------------------------------------------------------------------------------|
| COMP_SCI 332-0 | Online Markets                                                                |
| COMP_SCI 336-0 | Design & Analysis of Algorithms                                               |
| COMP_SCI 496-0 | Special Topics in Computer Science (Foundations of Reliable Machine Learning) |
| COMP_SCI 496-0 | Special Topics in Computer Science (Theoretical Foundations of Data Science)  |

### Symbolic AI

| Course         | Title                                                                                   |
|----------------|-----------------------------------------------------------------------------------------|
| COMP_SCI 325-0 | Artificial Intelligence Programming                                                     |
| COMP_SCI 344-0 | Design of Computer Problem Solvers                                                      |
| COMP_SCI 371-0 | Knowledge Representation and Reasoning                                                  |
| COMP_SCI 396-0 | Special Topics in Computer Science (Declarative Programming for Game AI)                |
| COMP_SCI 396-0 | Special Topics in Computer Science (Reasoning and Planning in the Foundation Model Era) |
| COMP_SCI 496-0 | Special Topics in Computer Science (Agent AI)                                           |
| COMP_SCI 496-0 | Special Topics in Computer Science (Logic in AI)                                        |

### Software and Systems Engineering for AI

| Course                                                                        | Title                                                                                                                                                                                                                    |
|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COMP_SCI 303-0                                                                | Full Stack Software Engineering                                                                                                                                                                                          |
| COMP_SCI 310-0                                                                | Scalable Software Architectures                                                                                                                                                                                          |
| COMP_SCI 358-0<br>or COMP_ENG 358-0                                           | Introduction to Parallel Computing<br>Introduction to Parallel Computing                                                                                                                                                 |
| COMP_SCI 368-0<br>or COMP_SCI 468-0<br>or COMP_ENG 368-0<br>or COMP_ENG 468-0 | Programming Massively Parallel Processors with CUDA<br>Programming Massively Parallel Processors with CUDA<br>Programming Massively Parallel Processors with CUDA<br>Programming Massively Parallel Processors with CUDA |
| COMP_SCI 394-0                                                                | Agile Software Development                                                                                                                                                                                               |
| ES_APPM 344-0                                                                 | High Performance Scientific Computing                                                                                                                                                                                    |

## Systems that Interact with Humans

| Course                              | Title                                                                                                      |
|-------------------------------------|------------------------------------------------------------------------------------------------------------|
| COMP_SCI 317-0                      | Sports, Technology and Learning                                                                            |
| COMP_SCI 329-0                      | HCI Studio                                                                                                 |
| COMP_SCI 330-0                      | Human Computer Interaction                                                                                 |
| COMP_SCI 333-0                      | Interactive Information Visualization                                                                      |
| COMP_SCI 347-0<br>or COMP_SCI 447-0 | Conversational AI                                                                                          |
| COMP_SCI 396-0<br>or COMP_SCI 496-0 | Special Topics in Computer Science (Mobile and Ubiquitous Computing)<br>Special Topics in Computer Science |
| COMP_SCI 497-0                      | Special Projects in Computer Science (Explanation and reproducibility in data-driven science)              |
| COG_SCI 207-0                       | Introduction to Cognitive Modeling                                                                         |
| DSGN 395-0                          | Special Topics (Designing with AI)                                                                         |

## Systems that Navigate the World

| Course                              | Title                                                                                                                |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| COMP_SCI 301-0<br>or MECH_ENG 301-0 | Introduction to Robotics Laboratory                                                                                  |
| COMP_SCI 353-0                      | Natural & Artificial Vision                                                                                          |
| COMP_SCI 396-0<br>or COMP_SCI 496-0 | Special Topics in Computer Science (Machine Learning and Sensing)<br>Special Topics in Computer Science              |
| COMP_SCI 469-0<br>or MECH_ENG 469-0 | Machine Learning & Artificial Intelligence for Robotics<br>Machine Learning and Artificial Intelligence for Robotics |
| COMP_ENG 395-0<br>or COMP_ENG 495-0 | Special Topics in Computer Engineering (Embedded Artificial Intelligence)<br>Special Topics in Computer Engineering  |
| ELEC_ENG 332-0                      | Introduction to Computer Vision                                                                                      |
| MECH_ENG 455-0                      | Active Learning in Robotics                                                                                          |
| MECH_ENG 495-0                      | Selected Topics in Mechanical Engg (Sensing, Navigation, and Machine Learning for Robotics)                          |

## Societal Impact Course

### Societal impact course list

| Course                                      | Title                                                               |
|---------------------------------------------|---------------------------------------------------------------------|
| Majors must take one course from this list. |                                                                     |
| COMP_SCI 260-0                              | Introduction to Law and Digital Technologies                        |
| COMP_SCI 265-0                              | AI and International Security                                       |
| COMP_SCI 311-0                              | Inclusive Making                                                    |
| COMP_SCI 314-0                              | Technology and Human Interaction                                    |
| COMP_SCI 387-0                              | Responsible Software Engineering                                    |
| COMP_SCI 396-0                              | Special Topics in Computer Science (Computing, Ethics, and Society) |
| COMM_ST 358-0                               | Algorithms and Society                                              |
| COMM_ST 378-0                               | Online Communities and Crowds                                       |
| COMM_ST 379-0                               | Digital Propaganda and Repression                                   |

## Technical electives

Majors must take seven technical electives. **Any 300- or 400-level COMP\_SCI course** may be taken as a technical elective. In addition the following courses may also be taken as technical electives:

## Technical electives list

| Course                              | Title                                                                                                          |
|-------------------------------------|----------------------------------------------------------------------------------------------------------------|
| COMP_SCI 213-0                      | Introduction to Computer System                                                                                |
| IEMS 301-0                          | Introduction to Statistical Learning                                                                           |
| IEMS 304-0                          | Statistical Learning for Data Analysis                                                                         |
| IEMS 305-0                          | Foundations of Modern Machine Learning                                                                         |
| ES_APPM 345-0                       | Applied Linear Algebra                                                                                         |
| ES_APPM 479-0                       | Data Driven Methods for Dynamical Systems                                                                      |
| COMP_ENG 303-0                      | Advanced Digital Design                                                                                        |
| COMP_ENG 329-0                      | The Art of Multicore Concurrent Programming                                                                    |
| COMP_ENG 334-0<br>or ELEC_ENG 334-0 | Fundamentals of Blockchains and Decentralization<br>Fundamentals of Blockchains and Decentralization           |
| COMP_ENG 346-0                      | Microcontroller System Design                                                                                  |
| COMP_ENG 355-0                      | ASIC and FPGA Design                                                                                           |
| COMP_ENG 356-0                      | Introduction to Formal Specification & Verification                                                            |
| COMP_ENG 357-0                      | Design Automation in VLSI                                                                                      |
| COMP_ENG 358-0                      | Introduction to Parallel Computing                                                                             |
| COMP_ENG 361-0                      | Computer Architecture I                                                                                        |
| COMP_ENG 362-0                      | Computer Architecture Projects                                                                                 |
| COMP_ENG 364-0<br>or COMP_ENG 464-0 | CyberPhysical Systems Design and Application<br>Cyber-Physical Systems Design and Application                  |
| COMP_ENG 365-0<br>or COMP_ENG 465-0 | Internet-of-things Sensors, Systems, And Applications<br>Internet-of-things Sensors, Systems, And Applications |
| COMP_ENG 366-0<br>or COMP_ENG 466-0 | Embedded Systems<br>Embedded Systems                                                                           |
| COMP_ENG 368-0<br>or COMP_ENG 468-0 | Programming Massively Parallel Processors with CUDA<br>Programming Massively Parallel Processors with CUDA     |
| COMP_ENG 452-0                      | Adv Computer Architecture                                                                                      |
| COMP_ENG 453-0                      | Parallel Architectures                                                                                         |
| COMP_ENG 456-0                      | Modern Topics in Computer Architecture                                                                         |
| COMP_ENG 459-0                      | VLSI Algorithmics                                                                                              |
| ELEC_ENG 326-0                      | Electronic System Design I                                                                                     |
| ELEC_ENG 332-0                      | Introduction to Computer Vision                                                                                |
| ELEC_ENG 375-0                      | Machine Learning: Foundations, Applications, and Algorithms                                                    |
| ELEC_ENG 433-0                      | Statistical Pattern Recognition                                                                                |
| ELEC_ENG 435-0                      | Deep Learning: Foundations, Applications, and Algorithms                                                       |