# ROBOTICS CERTIFICATE

Robotics and embodied AI are where AI meets the physical world. Think humanoid robots, drones, self-driving cars, warehouse robots, autonomous ocean and space exploration, automated farming, and more. Prepare yourself for this rapidly growing interdisciplinary field by earning the undergraduate Robotics Certificate.

Smaller in scope than majors or minors, certificates usually are offered in areas of concentration for which no major or minor exists and are comprised of at least 4 units of coursework.  Certificates are conferred concurrent with the student's undergraduate degree. They do not appear on the diploma, but are noted on the transcript. The Robotics certificate consists of 6 units of coursework from disciplines including mechanical engineering, computer science, electrical and computer engineering, and biomedical engineering.

To earn the Robotics certificate, a student must complete at least one unit of coursework from each of the categories below. While a course may be listed in more than one category, a single course cannot be used to satisfy two categories.

- Robotics Fundamentals: foundations of robotics and mathematical abstractions
- Experimental Robotics: hands-on experience with robots
- Artificial Intelligence and Machine Learning

The three additional units may be chosen from these categories or the other approved courses listed below.

At least 4 units of coursework must be unique to this certificate program. These 4 units cannot be applied to any other minor or certificate program, or the major requirements of any degree program. Such coursework may fulfill McCormick Social Sciences/Humanities (Theme), WCAS distribution requirements, or other unrestricted electives.

| Course | Title |
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| *Robotics Fundamentals (at least 1 unit)* | |
| MECH_ENG 301-0 | Introduction to Robotics Laboratory |
| or COMP_SCI 301-0 | Introduction to Robotics Laboratory |
| MECH_ENG 314-0 | Machine Dynamics |
| MECH_ENG 449-0 | Robotic Manipulation |

| Course | Title |
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| *Experimental Robotics (at least 1 unit)* | |
| MECH_ENG 301-0 | Introduction to Robotics Laboratory |
| or COMP_SCI 301-0 | Introduction to Robotics Laboratory |
| MECH_ENG 333-0 | Introduction to Mechatronics |
| MECH_ENG 410-0 | Quadrotor Design and Control |
| or COMP_SCI 410-0 | Autonomous Quadrotor Design and Control |
| MECH_ENG 433-0 | Advanced Mechatronics |
| MECH_ENG 472-1 | Robot Design Studio |
| MECH_ENG 472-2 | Robot Design Studio |
| MECH_ENG 495-0 | Selected Topics in Mechanical Engg (Embedded Systems in Robotics) |

| Course | Title |
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| *Artificial Intelligence and Machine Learning (at least 1 unit)* | |
| COMP_ENG 395-0 | Special Topics in Computer Engineering (Embedded Artificial Intelligence) |
| or COMP_ENG 495-0 | Special Topics in Computer Engineering |
| COMP_SCI 348-0 | Introduction to Artificial Intelligence |
| COMP_SCI 349-0 | Machine Learning |
| COMP_SCI 449-0 | Deep Learning |
| ELEC_ENG 373-0 | Deep Reinforcement Learning |
| or ELEC_ENG 473-0 | Deep Reinforcement Learning |
| ELEC_ENG 375-0 | Machine Learning: Foundations, Applications, and Algorithms |
| or ELEC_ENG 475-0 | Machine Learning: Foundations, Applications, and Algorithms |
| MECH_ENG 455-0 | Active Learning in Robotics |
| MECH_ENG 469-0 | Machine Learning and Artificial Intelligence for Robotics |
| or COMP_SCI 469-0 | Machine Learning & Artificial Intelligence for Robotics |
| MECH_ENG 495-0 | Selected Topics in Mechanical Engg (Sensing, Navigation, and Machine Learning for Robotics) |

| Course | Title |
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| *Other approved courses* | |
| BMD_ENG 465-0 | Biomechanical Modeling & Simulation of Human Movement |
| BMD_ENG 467-0 | Biomedical Robotics |
| COMP_ENG 364-0 | CyberPhysical Systems Design and Application |
| or COMP_ENG 464-0 | Cyber-Physical Systems Design and Application |
| COMP_ENG 395-0 | Special Topics in Computer Engineering (Connected and Autonomous Vehicles: Challenges and Design) |
| or COMP_ENG 495-0 | Special Topics in Computer Engineering |
| COMP_SCI 302-0 | Artifical Life |
| or CHEM_ENG 395-0 | Special Topics in Chemical Engineering |
| or MECH_ENG 495-0 | Selected Topics in Mechanical Engg |
| COMP_SCI 353-0 | Natural & Artificial Vision |
| COMP_SCI 409-0 | Swarms and Multi-Robot Systems |
| or MECH_ENG 409-0 | Swarms and Multi-Robot Systems |
| ELEC_ENG 332-0 | Introduction to Computer Vision |
| ELEC_ENG 360-0 | Introduction to Feedback Systems |
| ELEC_ENG 374-0 | Introduction to Digital Control |
| ELEC_ENG 470-0 | Introduction to Nonlinear Control Theory |
| MECH_ENG 395-0 | Special Topics in Mechanical Engineering (Vehicle Dynamics and Design) |
| MECH_ENG 454-0 | Numerical Methods in Optimal Control of Nonlinear Systems |
| MECH_ENG 495-0 | Selected Topics in Mechanical Engg (Soft Robotics) |
| Maximum of one of the following three courses: | |
| COMP_ENG 346-0 | Microcontroller System Design |
| or COMP_SCI 346-0 | Microcontroller System Design |
| ELEC_ENG 326-0 | Electronic System Design I |
| ELEC_ENG 327-0 | Electronic System Design II: Project |

Project/Independent Study credits (MECH_ENG 399-0/499-0, COMP_SCI 399-0/499-0, etc.) cannot be used to satisfy the curriculum requirements of the robotics certificate. Certificate students interested in performing research are encouraged to seek opportunities with faculty in the Center for Robotics and Biosystems (https://www.robotics.northwestern.edu/people/faculty.html) or other robotics faculty.