ROBOTICS, MINOR

The field of robotics integrates sensing, information processing, and movement to accomplish specific tasks in the physical world. As such, it encompasses several topics, including mechanics and dynamics, kinematics, sensing, signal processing, control systems, planning, and artificial intelligence. Applications of these concepts appear in many areas including medicine, manufacturing, space exploration, disaster recovery, ordinance disposal, deep-sea navigation, home care, and home automation.

The faculty of the Laboratory for Computational Sensing and Robotics (LCSR), in collaboration with the academic departments and centers of the Whiting School of Engineering, offers a robotics minor in order to provide a structure in which undergraduate students at Johns Hopkins University can advance their knowledge in robotics while receiving recognition on their transcript for this pursuit. The minor is not "owned" by any one department, but rather it is managed by the LCSR itself. Any student from any department within the university can work toward the minor.

Robotics is fundamentally integrative and multidisciplinary. Therefore, any candidate for the robotics minor must develop a set of core skills that cut across these disciplines, as well as obtain advanced supplementary skills.

Please visit https://lcsr.jhu.edu/robotics-minor/ for current course listings and full minor policies.

Core Skills Include the Following

- Robot kinematics and dynamics (R)
- Systems theory, signal processing and control (S)
- Computation and sensing (C)

Supplementary advanced skills may be obtained in specialized applications, such as space, medicine, or marine systems; or in one of the three core areas listed above.

The full minor course listing, provided below and available at https://lcsr.jhu.edu/robotics-minor/, specifies which courses fulfill these requirements. **Please always check the website for the most up-to-date listing of courses.** Note that **all** core areas must be covered, but that **any** advanced/supplementary courses can be chosen from the list. This allows students to strike a balance between breadth and depth.

Advising

- Students who decide to pursue the minor should first fill out a course plan for the Robotics minor, using the checkout form found here: https://lcsr.jhu.edu/robotics-minor/. This form should be sent to Alison Morrow (alison.morrow@jhu.edu) for review.
- Then, students who decide to pursue the minor should complete the "Request a New major/Minor" form, which can be initiated in SIS Self-Service under the Online Forms screen. Students will be assigned a minor advisor during this process.
- Complete the Requirements Checkout tables in the Check Out sheet, downloadable from https://lcsr.jhu.edu/robotics-minor/. Students should meet with their minor advisor periodically (at least once per year), bringing a copy of this form for review.
- During senior year, students must also note the Robotics Minor on their Application for Graduation.
- When all requirements have been completed, take the completed form to Alison Morrow for review and signature.
- If you have any questions about the minor, please contact Alison Morrow (alison.morrow@jhu.edu) (alison.morrow@jhu.edu).

The minor is managed by the faculty of the LCSR in collaboration with academic departments and centers of the Whiting School of Engineering (https://engineering.jhu.edu/). If you have suggestions/questions regarding the minor, please direct them to Professor Louis Whitcomb at llw@jhu.edu.

Program Requirements

Undergraduates qualify for the minor provided they have taken at least 18 credits (at the 300-level or above, with a C- or above) from an approved list of courses available below and at https://lcsr.jhu.edu/robotics-minor/ with the following requirements and restrictions:

- Between 6 and 12 credits chosen to cover the three core skills (R, S, C).
- At least 6 credits chosen from advanced supplementary skills (Sup).
- At least 3 credits of the 18 must be a laboratory course (Lab) (at least 15 hours of laboratory time that includes working with physical hardware and/or real data).

At most 3 credits of the 18 can be an independent research or individual study with a faculty member on the list of approved faculty advisers.

- At least 6 credits must be primarily listed in a department other than the student's home department (it is acceptable if such a course is cross-listed in the student's home department).
- At most one course up to 3 credits (including independent research or individual study) may be taken S/U, but all other courses must be taken for a letter grade.

Graduate levels of the same course may be substituted for the undergraduate levels listed below without additional permissions.

Course Number/Title	Lab	R	S	C	Sup
EN.520.340 Introduction to Mechatronics		X		X	
EN.520.344 Introduction to Digital Systems Processing			X		X
EN.520.353 Control Systems			X		
EN.520.412 Machine Learning for Signal Processing			X		
EN.520.414 Image Processing & Analysis			X	X	
EN.520.415 Image Process & Analysis II			X	X	
EN.520.417 Computation for Engineers				X	
EN.520.418 Modern Convex Optimization			X	X	
EN.520.424 FPGA Synthesis Lab				X	X
EN.520.432 Medical Imaging Systems				X	X
EN.520.433 Medical Image Analysis			X		X
EN.520.435 Digital Signal Processing			X		X
EN.520.448 Electronics Design Lab	X			X	X

EN.520.450 Advanced Micro-Processor Lab	X			X	X
EN.520.454 Control Systems Design	X		X		X
EN.520.462 Leading Innovation and Design Team					X
EN.520.463 Leading Innovation and Design Team					X
EN.520.601 Linear Systems Theory			X		
EN.520.612 Machine Learning for Signal Processing			X		
EN.530.343 Design and Analysis of Dynamical Systems	X	X	X		
EN.530.420 Robot Sensors/ Actuators	X	X		X	
EN.530.421 Mechatronics	X	X		X	
EN.530.424 Dynamics of Robots and Spacecraft		X			X
EN.530.446/EN.530.646 Robot Devices, Kinematics, Dynamics, and Control		X	X		X
EN.530.470 Space Vehicle Dynamics & Control		X	X		
EN.530.486 Mechanics of Locomotion		X			X
EN.530.603 Applied Optimal Control		X	X	X	X
EN.530.645 Kinematics		X			X
EN.530.678 Nonlinear Control and Planning in Robotics		X	X	X	X
EN.530.691 Haptic Interface Design for Human-Robot Interaction		X		X	X
EN.530.707 Robot System Programing	X	X		X	X
EN.530.782 Haptic Applications	X	X		X	X
EN.553.361 Intro to Optimization			X		
EN.553.493 Mathematical Image Analysis			X	X	X
EN.580.471 Principles of Design of BME Instrumentation	X			X	
EN.580.472 Medical Imaging Systems				X	X
EN.580.571 Honors Instrumentation	X			X	X
EN.601.455 Computer Integrated Surgery I	X	X	X		X
EN.601.456 Computer Integrated Surgery II	X	X		X	X
EN.601.461 Computer Vision	X			X	X
EN.601.463 Algorithms for Sensor-Based Robotics		X	X	X	
EN.601.464 Artificial Intelligence				X	X
EN.601.475 Machine Learning				X	X
EN.601.476 Machine Learning: Data to Models				X	X
EN.601.482 Machine Learning: Deep Learning			X	X	
EN.601.490 Introduction to Human-Computer Interaction				X	
EN.601.491 Human-Robot Interaction				X	
EN.601.760 FFT in Graphics & Vision	X	X	X		