ROBOTICS (ROB-GY)

ROB-GY 996X MS Project (3-6 Credits)
Typically offered Fall, Spring, and Summer terms
This course is an engineering project under faculty guidance. A written project proposal and final report must be submitted to the department head and the adviser and may be extended to a thesis with the project adviser's recommendation. Credit only upon completion of project. | Prerequisite: Graduate standing, advisor and instructor approval
Grading: Satisfactory/Unsatisfactory
Repeatable for additional credit: Yes

ROB-GY 997X MS THESIS IN MECHATRONICS AND ROBOTICS (3-9 Credits)
Typically offered Fall and Spring
The master's thesis presents results of original investigation in the student's specialty. This effort can be an extension of ROB-GY 996X, with approval of the project adviser. Continuous registration is required. Maximum of 9 credits of ROB-GY 996X / ROB-GY 997X are counted toward the degree. | Prerequisite: Graduate standing, advisor and instructor approval.
Grading: Satisfactory/Unsatisfactory
Repeatable for additional credit: Yes

ROB-GY 5103 Mechatronics (3 Credits)
Typically offered Fall
Introduction to theoretical and applied mechatronics, design and operation of mechatronics systems; mechanical, electrical, electronic, and opto-electronic components; sensors and actuators including signal conditioning and power electronics; microcontrollers—fundamentals, programming, and interfacing; and feedback control. Includes structured and term projects in the design and development of proto-type integrated mechatronic systems.
Grading: Grad Poly Graded
Repeatable for additional credit: No

ROB-GY 6003 FOUNDATIONS OF ROBOTICS (3 Credits)
Typically offered Fall
his course presents the concepts, techniques, algorithms, and state-of-the-art approaches for mobile robots and robot manipulators covering modeling, control and simulation. The class will focus on direct and inverse kinematics problem, Denavit-Hartenberg representation, Euler and RPY angles, homogeneous transformations, Manipulator Jacobian, differential relationships, force and moment analysis, inverse Jacobian, trajectory generation and path planning. The final part will involve robot arm dynamics and PD and PID controllers for robotic manipulators, practical robotic system implementation aspects, limitations and constraints, and sensors and actuators. The students will practice these concepts using Matlab or an equivalent simulation environment. | Prerequisite: Graduate Standing
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: Graduate Standing.

ROB-GY 6013 Mathematics for Robotics (3 Credits)
Typically offered Fall
The student who completes this course will gain a fundamental understanding of the principles underlying mathematics and numerical methods for dynamical systems, with particular reference to robotic systems. He/she will be able to use mathematical tools and computational methods for formulating and solving the modeling, estimation, planning, optimization, and control problems related to robotic systems. The course will employ real-world robotics examples throughout the introduction to and applications of mathematical, numerical and simulation approaches. | Prerequisite: Graduate Standing
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: Graduate Standing.

ROB-GY 6103 Advanced Mechatronics (3 Credits)
Typically offered Spring
Introduction to, applications of, and hands-on experience with microcontrollers and single-board computers for embedded system applications. Specifically, gain familiarity with the fundamentals, anatomy, functionality, programming, interfacing, and protocols for the Arduino microcontroller, multi-core Propeller microcontroller, and single-board computer Raspberry Pi. Includes mini-projects and term projects in the design and development of proto-type integrated mechatronic systems. | Prerequisites: ME-GY 5913
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: ME-GY 5913.

ROB-GY 6113 MICROELECTROMECHANICAL SENSORS AND ACTUATOR FOR ROBOTS (3 Credits)
Typically offered occasionally
This course presents the fundamentals of fabrication, modeling, analysis, and design of micro/nano sensors and actuators. Students will be exposed to the state of the art of micro/nano fabrication. They will gain familiarity with multiphysics phenomena at the micro/nano scale toward an improved understanding of fundamental sensing and actuation principles. Such knowledge will, in turn, inform the use of commercial software to design and simulate micro/nano devices for real world application.
Grading: Grad Poly Graded
Repeatable for additional credit: No

ROB-GY 6203 ROBOT PERCEPTION (3 Credits)
Typically offered Fall
fulfil their tasks safely, accurately, and efficiently. This requires an intelligent extraction of both geometric and semantic information from sensory input (mainly visual sensors such as cameras/LIDAR). This course aims to combine the established theories of geometric vision and the recent progress in pattern recognition in the context of robotic/intelligent systems. Students will study and practice the basic theories of computer vision and machine learning through relevant applications. For example, pose estimation of a robotic agent from onboard cameras, 3D reconstruction for map creation, object detection/segmentation for obstacle avoidance, tracking for target following, place recognition from images when GPS is unreliable, and so on. | Prerequisite: Graduate Standing
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: Graduate Standing.

ROB-GY 6213 ROBOT LOCALIZATION AND NAVIGATION (3 Credits)
Typically offered Spring
This course presents the concepts, techniques, algorithms, and state-of-the-art approaches for robot perception, localization, and mapping. The course will show the theoretical foundations and will also have a substantial experimental component based on Matlab/ROS. The course will start from basic concepts in probability and then introduce probabilistic approaches for data fusion such as Bayes Filters, Kalman Filter, Extended Kalman Filter, Unscented Kalman Filter, and Particle Filter. Then, the course will introduce the SLAM problem showing how this has recently been solved using batch optimization and graph methods. Finally, mapping algorithms will also be briefly discussed.| Prerequisites: ECE-GY 6253 or ME-GY 6703 or ME-GY 6923 or department approval
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: ECE-GY 6253 or ME-GY 6703 or ME-GY 6923 or department approval.

ROB-GY 6313 Robotic Gait and Manipulation (3 Credits)
Typically offered occasionally
Review of fundamental robot kinematics, dynamics, and control. Types of robotic manipulation. Design and control of robotic manipulators. Robotic hand and arm. Robotic manipulation modeling, simulation, and experiments. Gait types of legged systems. Biped and quadruped systems. Human walking and running, and passive dynamics. Design and control of biped walking robots. Robotic gait modeling, simulation, and experiments. Focus on hands-on experience in design, fabrication, and control of simple mechanisms. | Prerequisite: ME-GY 6913
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: ME-GY 6913.

ROB-GY 6323 REINFORCEMENT LEARNING AND OPTIMAL CONTROL FOR ROBOTICS (3 Credits)
Typically offered Spring
What kind of movements should a robot perform in order to walk, jump or manipulate objects? Can it compute optimal behaviors online? Can it learn this directly from trial and error? This course will introduce modern methods for robotics movement generation based on numerical optimal control and reinforcement learning. It will cover fundamental topics in numerical optimal control (Bellman equations, differential dynamic programming, model predictive control) and reinforcement learning (actor-critic algorithms, model-based reinforcement learning, deep reinforcement learning) applied to robotics. It will also contain hands-on exercises for real robotic applications such as walking and jumping, object manipulation or acrobatic drones. Recommended background in at least one of the following: linear systems; robotics; machine learning; convex optimization; programming (python). | Prerequisite: ROB-UY 6003 or ECE-GY 6253 or ME-GY 6703
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: ROB-UY 6003 or ECE-GY 6253 or ME-GY 6703.

ROB-GY 6333 NETWORKED ROBOTICS SYSTEMS, COOPERATIVE CONTROL AND SWARMING (3 Credits)
Typically offered Fall
The student who completes this course will gain an advanced understanding of the analysis and control of networked dynamical systems, with a specific accent on networked robotic systems. He/she will be able to study the properties of networked robotic systems through the analysis of the intertwining properties of the network structure and of the individual dynamics of the single robot. Moreover, he/she will be able to understand and design algorithms for distributed control of teams of mobile agents and robots. | Prerequisite: ROB-GY 6003 or ECE-GY 6253 or ME-GY 6703
Grading: Grad Poly Graded
Repeatable for additional credit: No

ROB-GY 6413 Robots for Disability (3 Credits)
Typically offered occasionally
This course will introduce personal, societal, and technological challenges related to physical disability, cognitive disability, and senior living. After an introduction to these challenges, students will learn about current state of art mechatronics and robotics solutions to handle these problems. Finally, they will apply their mechatronics and robotics learning to produce novel robotics solutions to address a specific problem related to a disability. | Prerequisite: ME-GY 5913 or permission of instructor.
Grading: Grad Poly Graded
Repeatable for additional credit: No

ROB-GY 6423 INTERACTIVE MEDICAL ROBOTICS (3 Credits)
Typically offered Spring
In this course, we will investigate the application, functionality, and theoretical aspects of the state-of-the-art interactive robotic technologies in medicine. The focus of the course will be on advanced surgical, and neurorehabilitative robotic systems. Technological aspects, such as instrumentation, actuation, mechanisms, imaging, and signal acquisition, will be introduced. Also, theoretical aspects related to control, dynamics, kinematics, haptics, stability, passivity, human-robot interaction, teleoperation, machine learning and bio-signal processing will be discussed in the context of medical robotic systems. Students are expected to be fluent in MATLAB and have solid background in at least two of the following four topics: signal processing, dynamics, control, robotics. | Prerequisite: ECE-GY 5223 or ECE-GY 6253 or ME-GY 6703 or ME-GY 6923 or equivalent or department's permission
Grading: Grad Poly Graded
Repeatable for additional credit: No
Prerequisites: ECE-GY 5223 or ECE-GY 6253 or ME-GY 6703 or ME-GY 6923 or equivalent or department's permission.