CYBER-PHYSICAL SYSTEMS ENGINEERING (CSE)

CSE 101 | ROBOT PROTOTYPING | 4 quarter hours
(Undergraduate)
A hands-on introduction to designing and manufacturing robotic systems. Students will learn practical skills including the basics of soldering, computer-aided modeling, and 3D printing. The course includes weekly lab assignments, a comprehensive capstone project, and theoretical understanding through interactive lectures.

CSE 201 | THE FORGE: IMMERSIVE SYSTEM-BUILDING LAB I | 8 quarter hours
(Undergraduate)
First course in a two-course sequence. An immersive quarter focused on a comprehensive introduction to basic fabrication and microcontroller systems. The course will cover the basics of microcontroller board design (schematics, layouts, and PCB creation with KiCAD), firmware (how to program boards, simple and advanced toolchains with Arduino and Eclipse), and input and output devices (sensors and motors/actuators). It will also cover basic fabrication to interface and build complete systems with these microcontrollers, focused on Fusion360 and practical skills in computer controlled cutting (vinyl and laser cutters) and 3D printing.
(CSC 242 OR CSC 243) AND MAT 130 AND Instructor Permission are prerequisites for this class.

CSE 299 | HARDWARE PROJECTS | 4 quarter hours
(Undergraduate)
A course that introduces student to building basiccyber-physical systems. The course will cover basic electronics, a hardarecomputing platform (e.g., Raspberry Pi), and the API for managing hardwaredevices including serial communication, interfacing with digital and analoginputs (sensors), controlling motors, and using displays.
CSC 242 or CSC 243 is the prerequisite for this class.

CSE 301 | THE FORGE: IMMERSIVE SYSTEM-BUILDING LAB II | 8 quarter hours
(Undergraduate)
Second course in a two-course sequence. An immersive quarter focused on a comprehensive introduction to basic fabrication and microcontroller systems. The course will cover advanced firmware, wireless and wired networking protocols, APIs and application development; on the fabrication side, it will introduce computer controlled milling and casting/molding. This second quarter will allow more creative expression with fabrication skills, including large format projects, an advanced group project, and a final individual project that marries the standalone skills of the last quarter with networking and application development introduced in this quarter.
CSE 201 is a prerequisite for this class.

CSE 302 | ROBOT KINEMATICS AND DYNAMICS | 4 quarter hours
(Undergraduate)
An in-depth exploration of mechanical and motion principles in robotics, tailored for students interested in the movement aspects of various robot types, including mobile robots and robotic arms. The course covers the basics of robot movements, the relationship between position, velocity, and actuation, and combines theoretical learning with practical application through simulation and hardware labs. Students will engage in both software-based kinematic analysis and hands-on experiments.
MAT 220 is the prerequisite for this class.

CSE 303 | PLANNING AND DECISION MAKING FOR ROBOTS | 4 quarter hours
(Undergraduate)
Intricate aspects of robotic planning and autonomous decision-making, for students with a foundational understanding of robotics. The course covers mathematical modeling for robot actuation, exploring how different actuations result in movement, and delves into advanced planning methods like random sampling and random trees. The course emphasizes practical application, with simulation and hardware labs where students implement these techniques. Through lectures, discussions, hands-on labs, and a comprehensive project, students will gain deep insights into the planning algorithms and their real-world applications in robotic systems.
CSE 302 is the prerequiste for this class.

CSE 304 | RAPID PROTOTYPING TECHNOLOGIES | 4 quarter hours
(Undergraduate)
An overview of computer-aided design for 3-D modeling and prototype fabrication using 3-D printing and other technologies. PREREQUISITE(S): MAT 262.

CSE 314 | NETWORKING FOR CYBER-PHYSICAL SYSTEMS | 4 quarter hours
(Undergraduate)
Overview of computer network technologies used in cyber-physical systems. Topics covered wired and wireless network protocol stacks, serialization, real-time network programming, and utilizing cloud-based services.

CSE 316 | CYBER-PHYSICAL SYSTEM SECURITY | 4 quarter hours
(Undergraduate)
Design for security for cyber-physical systems, security breaches and enforcement, standardization, best practices, security policies, security threat and protection-in-depth modeling, vulnerability and risk assessment for cyber-physical systems, CPS security incidents and trends.
CSC 374 is a prerequisite for this class.

CSE 331 | CYBER-PHYSICAL SYSTEM ENGINEERING I | 4 quarter hours
(Undergraduate)
The first in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This first course focuses on electromagnetics and circuit analysis with applications to displays,touchpads, cameras, memory, batteries, GPS, and wireless communications. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes.
MAT 152 is a prerequiste for this class.

CSE 332 | ANALOG AND DIGITAL CIRCUITS | 4 quarter hours
(Undergraduate)
The second in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This second course covers more advanced concept in electromagnetism and electronics (transistors, amplifiers and circuit interfaces and operational amplifiers) and abstractions such as state machines along with probabilistic inference and state space search. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes.
MAT 151 is a prerequiste for this class.

CSE 333 | DIGITAL SIGNAL PROCESSING | 4 quarter hours
(Undergraduate)
The third in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This third course introduces signals and analog and digital signal processing, sampling and quantization, and control. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes.
CSE 332 is a prerequisite for this class.

CSE 341 | DIGITAL SYSTEMS | 4 quarter hours
(Undergraduate)
Design and implementation of digital systems using transistor transistor logic (TTL), SystemVerilog, and field-programmable gate arrays (FPGAs). Topics include combinational and sequential logic, storage elements, input/output, timing analysis, design trade offs, synchronous and asynchronous design methods.
CSE 332 is a prerequisite for this class.

CSE 342 | COMPUTER SYSTEM ORGANIZATION AND DESIGN | 4 quarter hours
(Undergraduate)
Overview of the design of hardware elements of computer systems. Topics include instruction set design, processor micro-architecture and pipelining, cache and virtual memory organizations, protection and sharing, I/O and interrupts, and multithreaded architectures, and embedded systems.
CSC 374 is a prerequisite for this class.

CSE 351 | EMBEDDED SYSTEMS I | 4 quarter hours
(Undergraduate)
The first of a two course sequence on programming embedded architectures in devices such as smartphones, portable gaming devices, and robots. Topics covered include embedded architectures, interaction with devices (buses, memory architectures, memory management, device drivers) and concurrency (software and hardware interrupts, timers).
CSC 374 is a prerequisite for this class.

CSE 352 | EMBEDDED SYSTEMS II | 4 quarter hours
(Undergraduate)
The second of a two course sequence on programming embedded architectures in devices such as smartphones, portable gaming devices, and robots. Topics may include real-time principles (multi-tasking, scheduling, synchronization), implementation trade-offs, profiling and code optimization (for performance and memory), and embedded software (exception handling, loading, mode-switching, programming embedded systems).
CSE 351 is a prerequisite for this class.

CSE 361 | MATHEMATICAL FOUNDATIONS OF AUTONOMOUS SYSTEMS | 4 quarter hours
(Undergraduate)
A comprehensive overview of modeling and analysis of dynamic systems including mechanical, electrical, electro-mechanical, thermal, and fluid systems. Topics include modeling using state-variable equations, input-output differential equations, transfer functions, and block diagrams, analytical solutions using the Laplace transform, and applications to modeling and designing feedback control systems.
CSE 333 and (MAT 349 or MAT 351) are prerequistes for this class.

CSE 362 | FOUNDATIONS OF CYBER-PHYSICAL COMPUTING | 4 quarter hours
(Undergraduate)
This course covers the modeling, design, and analysis of cyberphysical systems that integrate computation and physical processes. It introduces formal models that support abstractions to manage the complexity of a system design and verify the system implementation correctness. Topics include safety and liveness requirements, temporal logic, model checking, deductive verification, stability analysis of linear systems, and real-time scheduling algorithms.
CSE 352 is a prerequiste for this class.

CSE 370 | PERCEPTION AND ESTIMATION | 4 quarter hours
(Undergraduate)
Covers mathematical modeling for robot systems, state estimation in linear systems, and sensor technologies like cameras and inertial measurement units (IMUs), including their calibration. This course is designed to equip students with advanced skills in robotic perception and state estimation. Through a blend of lectures, practical labs, and project work, students will delve into both theoretical aspects and hands-on applications, gaining expertise in integrating and calibrating sensors for accurate robotic perception.
CSE 361 is the prerequisite for this class.

CSE 375 | INTRODUCTION TO ROBOTICS | 4 quarter hours
(Undergraduate)
An introduction to the field of Robotics. Topics include history of robotics, kinematics, control theory, and sensor theory. A large portion of class time will be lab based, building and programming robots using the Lego Mindstorms EV3 Robotics Kit. The programming will be using a C derivative and knowledge of C and general systems concepts is required.
CSC 373 and CSC 374 are prerequisites for this class.

CSE 377 | INTRO TO MECHATRONICS | 4 quarter hours
(Undergraduate)
Design and development of a mechatronic system incorporating sensors, actuators, and artificial intelligence.
CSE 332 is a prerequisite for this class.

CSE 393 | CYBER-PHYSICAL SYSTEMS ENGINEERING PRACTICUM I | 4 quarter hours
(Undergraduate)
The first course in a two-course sequence in which students work in small groups to implement a cyber-physical system.
CSE 333 and CSE 351 are prerequistes for this class.

CSE 394 | CYBER-PHYSICAL SYSTEMS ENGINEERING PRACTICUM II | 4 quarter hours
(Undergraduate)
The second course in a two-course sequence in which students work in small groups to implement a cyber-physical system.
CSE 393 is a prerequisite for this class.

CSE 424 | NETWORKING FOR CYBER-PHYSICAL SYSTEMS | 4 quarter hours
(Graduate)
Overview of computer network technologies used in cyber-physical systems. Topics covered wired and wireless network protocol stacks, serialization, real-time network programming, and utilizing cloud-based services.
CSC 407 is a prerequisite for this class.

CSE 426 | CYBER-PHYSICAL SYSTEM SECURITY | 4 quarter hours
(Graduate)
Design for cyber-physical system (CPS) security, security breaches and enforcement, standardization, best practices, security policies, security threat and protection-in-depth modeling, vulnerability and risk assessment for cyber-physical systems, CPS security incidents and trends. Students will carry out a CPS security-related independent project.
CSC 407 is a prerequisite for this class.

CSE 431 | CYBER-PHYSICAL SYSTEMS ENGINEERING I | 4 quarter hours
(Graduate)
The first in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This first course focuses on electromagnetics and circuit analysis with applications to displays, touchpads, cameras, memory, batteries, GPS, and wireless communications. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes. PREREQUISITES: linear algebra and a year of college physics and CSC 407.

CSE 432 | CYBER-PHYSICAL SYSTEMS ENGINEERING II | 4 quarter hours
(Graduate)
The second in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This second course covers more advanced concept in electromagnetism and electronics (transistors, amplifiers and circuit interfaces and operational amplifiers) and abstractions such as state machines along with probabilistic inference and state space search. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes.
CSE 431 is a prerequisite for this class.

CSE 433 | CYBER-PHYSICAL SYSTEMS ENGINEERING III | 4 quarter hours
(Graduate)
The third in a three-course sequence that provides a comprehensive overview of core CPS topics in an application-driven context and with an emphasis on fundamental engineering design principles of modularity and abstraction. This third course introduces signals and analog and digital signal processing, sampling and quantization, and control. Labs will be used to apply the concepts covered in class in the context of managing hardware devices and building cyber-physical system prototypes.
CSE 432 is a prerequisite for this class.

CSE 441 | DIGITAL SYSTEMS | 4 quarter hours
(Graduate)
Design and implementation of digital systems using transistor-transistor logic (TTL), SystemVerilog, and field-programmable gate arrays (FPGAs). Topics include combinational and sequential logic, storage elements, input/output, timing analysis, design tradeoffs, synchronous and asynchronous design methods.
CSE 432 is a prerequisite for this class.

CSE 442 | COMPUTER SYSTEM ORGANIZATION AND DESIGN | 4 quarter hours
(Graduate)
Overview of the design of hardware elements of computer systems. Topics include instruction set design, processor micro-architecture and pipelining, cache and virtual memory organizations, protection and sharing, I/O and interrupts, and multithreaded architectures, and embedded systems.
CSC 407 is a prerequisite for this class.

CSE 451 | EMBEDDED SYSTEMS I | 4 quarter hours
(Graduate)
The first of a two course sequence on programming embedded architectures in devices such as smartphones, portable gaming devices, and robots. Topics covered include embedded architectures, interaction with devices (buses, memory architectures, memory management, device drivers) and concurrency (software and hardware interrupts, timers).
CSC 407 is a prerequisite for this class.

CSE 452 | EMBEDDED SYSTEMS II | 4 quarter hours
(Graduate)
The second of a two course sequence on programming embedded architectures in devices such as smartphones, portable gaming devices, and robots. Topics may include real-time principles (multi-tasking, scheduling, synchronization), implementation trade-offs, profiling and code optimization (for performance and memory), and embedded software (exception handling, loading, mode-switching, programming embedded systems).
CSE 451 is a prerequisite for this class.

CSE 462 | FOUNDATIONS OF CYBER-PHYSICAL COMPUTING | 4 quarter hours
(Graduate)
This course covers the modeling, design, and analysis of cyber-physical systems that integrate computation and physical processes. It introduces formal models that support abstractions to manage the complexity of a system design and verify the system implementation correctness. Topics include safety and liveness requirements, temporal logic, model checking, deductive verification, stability analysis of linear systems, and real-time scheduling algorithms.
CSE 433 is a prerequisite for this class.

CSE 464 | RAPID PROTOTYPING TECHNOLOGIES | 4 quarter hours
(Graduate)
An overview of computer-aided design for 3-D modeling and prototype fabrication using 3-D printing and other technologies. PREREQUISITES: linear algebra.

CSE 475 | INTRODUCTION TO ROBOTICS (FORMERLY CSC 475) | 4 quarter hours
(Graduate)
An introduction to the field of Robotics. Topics include history of robotics, kinematics, control theory, and sensor theory. A large portion of class time will be lab based, building and programming robots using the Lego Mindstorms NXT Robotics Kit. The programming will be using a C derivative and knowledge of C and general systems concepts is required.
CSC 403 and CSC 421 are prerequisites for this class.

CSE 476 | LINEAR SYSTEMS | 4 quarter hours
(Graduate)
A comprehensive overview of modeling and analysis of dynamic systems including mechanical, electrical, electro-mechanical, thermal, and fluid systems. Topics include modeling using state-variable equations, input-output differential equations, transfer functions, and block diagrams, analytical solutions using the Laplace transform, and applications to modeling and designing feedback control systems.
CSE 433 is a prerequisite for this class.

CSE 477 | INTRO TO MECHATRONICS | 4 quarter hours
(Graduate)
Design and development of a mechatronic system incorporating sensors, actuators, and artificial intelligence.
CSE 432 is a prerequisite for this class.

CSE 527 | CPSE MASTER'S PROJECT | 4 quarter hours
(Graduate)
Students will work in small groups to implement a cyber-physical system.
CSE 433 and CSE 452 are prerequisites for this class.