Computer Engineering, B.S.

Program Learning Outcomes for B.S. in Computer Engineering

Students pursuing the B.S. in Computer Engineering are required to:

- Earn an overall GPA of 2.500 for all required lower division major courses.
- Earn an overall GPA of 2.000 for all required major courses.
- Complete all courses in the major for a letter grade of "C-" or higher, except those where the default grading option is P/NP.
- Complete a minimum of 21 credits from upper division courses in the major.

Majors are required to enroll in FFC 100B - First Year Foundations: Grand Challenges in Science and Engineering to satisfy their General Education requirement.

Grand Challenges Initiative (3 credits)

GCI 150 - Grand Challenges in Science and Engineering I

GCI 150 - Grand Challenges in Science and Engineering I

This research seminar is a continuation of the Grand Challenges FFC. It is designed to provide a mentored experience for teams as they pursue possible solutions to their grand challenges. Faculty serving as team mentors will use evidence-based approaches to improve students' critical thinking, problem-solving and communication skills. Faculty are joined by a number of external experts who provide students with additional insights into their challenges, introduce them to a diversity of careers in science, and serve as the foundation of a professional network. In this phase, teams are encouraged to grow, evolve, and even recruit new members across campus, as it becomes clearer what skills are needed to advance towards their goals. This course may not be taken concurrently with GCI 200 or GCI 250. Letter grade. (Offered every semester.) **1 credit**

GCI 200 - Grand Challenges in Science and Engineering II

GCI 200 - Grand Challenges in Science and Engineering II

Prerequisite, GCI 150. This seminar is a continuation of the Grand Challenges in Science and Engineering series. It is designed to provide a mentored experience for teams as they pursue possible solutions to their grand challenges. Faculty serving as team mentors will use evidence-based approaches to improve students' critical thinking,

problem-solving and communication skills. Faculty are joined by a number of external experts who provide students with additional insights into their challenges, introduce them to a diversity of careers in science, and serve as the foundation of a professional network. In this phase, teams are encouraged to grow, evolve, and even recruit new members across campus, as it becomes clearer what skills are needed to advance towards their goals. This course may not be taken concurrently with GCI 150 or GCI 250. Letter grade. (Offered every semester.) **1 credit**

GCI 250 - Grand Challenges in Science and Engineering III

GCI 250 - Grand Challenges in Science and Engineering III

Prerequisite, GCI 150 and GCI 200. This seminar is a continuation of the Grand Challenges in Science and Engineering series. It is designed to provide a mentored experience for teams as they pursue possible solutions to their grand challenges. Faculty serving as team mentors will use evidence-based approaches to improve students' critical thinking, problem-solving and communication skills. Faculty are joined by a number of external experts who provide students with additional insights into their challenges, introduce them to a diversity of careers in science, and serve as the foundation of a professional network. In this phase, teams are encouraged to grow, evolve, and even recruit new members across campus, as it becomes clearer what skills are needed to advance towards their goals. This course may not be taken concurrently with GCI 150 or GCI 200. Letter grade. (Offered every semester.) **1 credit**

lower-division core requirements (39-40 credits)

requirements (31 credits)

ENGR 101 - Foundations of Design and Fabrication

ENGR 101 - Foundations of Design and Fabrication

Students gain first-hand experience with design and fabrication as a foundation of engineering. Using technologies such as additive manufacturing (eg. 3D printing), embedded systems and software, and electronics, students will work together to develop innovative solutions to interesting problems. This course is offered in a hybrid format only. Pass/No Pass. (Offered every semester.) **3 credits**

PHYS 101 - General Physics I

PHYS 101 - General Physics I

Prerequisite, MATH 110 or MATH 115. Corequisite, PHYS 101L or previous credit for PHYS 101L. Students learn how to apply the core principles of calculus-based physics to everyday situations, including connections to chemistry, computation, and engineering. Students develop broadly applicable critical thinking, approximation, and problem-solving skills. Topics include symmetry, particles and fields, measurement error, reference frames, kinematics, conservation (of energy, momentum, angular momentum), interactions, transfer (as power, force, torque), and small oscillations. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

PHYS 101L - General Physics I Laboratory

PHYS 101L - General Physics I Laboratory

Prerequisite, MATH 110, or MATH 115. Corequisite, PHYS 101 or previous credit for PHYS 101. Students solidify understanding of the physical concepts explored in PHYS 101 by designing experiments that test hypotheses, analyzing data with experimental uncertainty, and drawing valid conclusions from results. This course introduces concepts as needed in parallel with PHYS 101 to provide a complementary perspective on the same material. Letter grade with Pass/No Pass option. (Offered every semester.) **1 credit**

PHYS 102 - General Physics II

PHYS 102 - General Physics II

Prerequisites, PHYS 101, and MATH 111, or MATH 115. Corequisite, PHYS 102L or previous credit for PHYS 102L. Students explore the principles of electricity and magnetism and learn to understand the roles they play in our everyday experiences. Students develop broadly applicable critical thinking, approximation, and problem-solving skills. Topics include the study of electromagnetic fields and motions of charged objects using vector calculus, DC and AC circuit design, magnetic induction and wireless power, and basic properties of light and electromagnetic radiation. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

PHYS 102L - General Physics II Laboratory

PHYS 102L - General Physics II Laboratory

Prerequisites, PHYS 101. Corequisite, PHYS 102 or previous credit for PHYS 102. Students solidify understanding of the physical concepts explored in PHYS 102 by designing experiments that test hypotheses, analyzing data with experimental uncertainty, and drawing valid conclusions from results. This course introduces concepts as needed in parallel with PHYS 102 to provide a complementary perspective on the same material. Letter grade with Pass/No Pass option. (Offered every semester.) **1 credit**

PHYS 201 - General Physics III

PHYS 201 - General Physics III

Prerequisite, PHYS 102. Students continue exploring the principles of physics and their applications to microscopic and macroscopic phenomena. Students develop broadly applicable critical thinking, approximation, and problem-solving skills. Topics include waves, sound, thermodynamics, fluids, relativity, and quantum theory. Letter grade with Pass/No Pass option. (Offered spring semester.) **3 credits**

EENG 200 - Electronics and Circuits I

EENG 200 - Electronics and Circuits I

Prerequisite, MATH 110 or MATH 115. Corequisite, EENG 200L. Students begin their study of electronics and circuits by studying electricity (current, energy, voltage, power), electronic components (resistors, capacitors, diodes, etc), and fundamental laws for circuits. Students will gain hands on experience building circuits with solderless breadboards in a separate laboratory component. Letter grade with Pass/No Pass option. (Offered spring semester.) **3 credits**

EENG 200L - Lab - Electronics and Circuits I

EENG 200L - Lab - Electronics and Circuits I

Prerequisite, MATH 110 or MATH 115. Corequisite, EENG 200. Lab component of EENG 200. Letter grade with Pass/No Pass option. (Offered spring semester.) **1 credit**

MATH 215 - Introduction to Linear Algebra and Differential Equations

MATH 215 - Introduction to Linear Algebra and Differential Equations

Prerequisite, MATH 111 or MATH 116. Introduction to the solutions of ordinary differential equations and their connection to linear algebra. Topics include matrix algebra, systems of linear equations, vector spaces, inner product spaces, linear transformations, eigenvalues and eigenvectors, differential equations, systems of linear differential equations, and the Laplace transform. Letter grade. (Offered fall semester.) **3 credits**

CPSC 230 - Computer Science I

CPSC 230 - Computer Science I

Prerequisite, MATH 100. Students are introduced to problem-solving methods and algorithm development through an interactive and easy-to-learn programming language, Python. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

CENG 231 - Systems Programming

CENG 231 - Systems Programming

Prerequisite, CPSC 230. Corequisite, CENG 231L. This course introduces students to concepts and techniques in systems programming with the programming languages C and C++ in a *nix environment. Students will gain insight into hardware-software interfaces through hands-on projects involving system calls, concurrency, network programming, memory mapping, and low-level mechanisms for inter-process communication. A laboratory component will allow students to implement conceptual ideas in code for enterprise, real-time, and embedded hardware targets. Letter grade with Pass/No Pass option. (Offered spring semester.) **3 credits**

CENG 231L - Lab - Systems Programming

CENG 231L - Lab - Systems Programming

Prerequisite, CPSC 230. Corequisite, CENG 231. Laboratory component of CENG 231. Letter grade with Pass/No Pass option. (Offered spring semester.) **1 credit**

MATH 250 - Discrete Mathematics I

MATH 250 - Discrete Mathematics I

Prerequisite, MATH 101 or equivalent. This course provides the student with an introduction to the fundamental mathematics of discrete phenomena and computation. This is a key course in the CPSC curriculum as it provides the theoretical background needed for many upper-division courses including Data Structures (combinatorics, formal languages), Logic Design (Boolean algebras, number representation) and Integrated Circuit Design (automata theory, finite state minimization, graph layout). Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

one of the following sequences (8-9 credits)

sequence 1

MATH 110 - Single Variable Calculus I

MATH 110 - Single Variable Calculus I

Prerequisite, MATH 101 or equivalent. Students study single variable functions, limits and continuity, differentiation, applications of derivatives (approximations, curve plotting, optimization), antiderivatives, the definite integral, and applications of integration. Students who take MATH 109 or MATH 110 may not also receive credit for MATH 115. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

MATH 111 - Single Variable Calculus II

MATH 111 - Single Variable Calculus II

Prerequisite, MATH 110 or MATH 115. Further techniques and applications of integration, transcendental functions, exponential models, logistic equations, infinite and power series, Taylor's theorem, parametric equations, and polar coordinates. Students who take MATH 111 or MATH 210 may not also receive credit for MATH 116. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

MATH 210 - Multivariable Calculus

MATH 210 - Multivariable Calculus

Prerequisite, MATH 111. Students learn the calculus of functions of two or more variables, vector-valued functions, multiple integrals, and integration in vector fields. Students who take MATH 111 or MATH 210 may not also receive credit for MATH 116. Letter grade with Pass/No Pass option. (Offered fall semester.) **3 credits**

sequence 2

MATH 115 - Accelerated Calculus Part I: Differentiation and Integration

MATH 115 - Accelerated Calculus Part I: Differentiation and Integration

Prerequisite, MATH 101 or equivalent. This course is an intensive introduction to the calculus of elementary functions and its applications to science. Students study fundamental concepts of limits, continuity, and derivatives, and explore the derivatives and integrals of polynomials, rational functions, exponentials, logarithms, and trigonometric functions, followed by the chain rule, implicit differentiation, logarithmic differentiation, applications of differentiation, optimization, definite integrals, Riemann sums and the fundamental theorem of Calculus, applications of integration, integration techniques and methods, sequences and series, introduction to differential equations, power series. Students who take MATH 109 or MATH 110 may not also receive credit for MATH 115. Letter grade. (Offered fall semester.) **4 credits**

MATH 116 - Accelerated Calculus Part II: Series, Differential Equations and Multivariable Calculus

MATH 116 - Accelerated Calculus Part II: Series, Differential Equations and Multivariable Calculus

Prerequisite, MATH 115. This course is the second part of an intensive introduction to the calculus of elementary functions and its applications to science. Students will explore Taylor Series, model exponential growth, sinusoidal oscillation, and logistic convergence through simple differential equations, continue with calculus of functions of two or more variables and of vector-valued functions. Optimization of functions of several variables, Lagrange multipliers, multiple integrals and integration of vector fields, divergence and curl, line and surface integration, Green, Stokes, and Divergence Theorems. This is the second part of a two-semester accelerated Calculus course. Students who take MATH 111 or MATH 210 may not also receive credit for MATH 116. Letter grade. (Offered spring semester.) **4 credits**

colloquium requirement (3 credits)

Students must complete three 1-credit sections of CENG 298 - Computer Engineering Colloquium.

upper-division requirements (24 credits)

EENG 300 - Electronics and Circuits II

EENG 300 - Electronics and Circuits II

Prerequisite, EENG 200. Corequisite, EENG 300L. Students continue their study of circuits, focusing on the transition from DC to AC circuits. This course introduces students to phasors and their application in simplifying the analysis of AC circuits, as well as exploring AC power calculations, filters, and the practical use of Laplace transforms for solving circuit differential equations. Letter grade with Pass/No Pass option. (Offered fall semester.) **3 credits**

EENG 300L - Lab - Electronics and Circuits II

EENG 300L - Lab - Electronics and Circuits II

Prerequisite, EENG 200L. Corequisite, EENG 300. Lab component of EENG 300. Letter grade with Pass/No Pass option. (Offered fall semester.) **1 credit**

CENG 330 - Digital Logic Design I

CENG 330 - Digital Logic Design I

Prerequisite, CPSC 231 or CENG 231. Corequisite, CENG 330L. Students learn the fundamental principles and practice of digital logic. The course covers binary numbers and arithmetic. Students study Boolean algebra as a method of reasoning about sequential circuits including truth tables and Karnaugh maps, logic minimization, gates and flip-flops, sequential logic and combinatorial logic. The course requires one hour of supervised work in a laboratory in addition to three hours per week of lecture. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

CENG 330L - Lab - Digital Logic Design I

CENG 330L - Lab - Digital Logic Design I

Prerequisite, CENG 231 or CPSC 231. Corequisite, CENG 330. Laboratory component of CENG 330. Letter grade with Pass/No Pass option. (Offered every semester.) **1 credit**

CPSC 350 - Data Structures and Algorithms

CPSC 350 - Data Structures and Algorithms

Prerequisite, CPSC 231 or CENG 231. Students study core data structures and algorithms, such as arrays, stacks, lists, queues, trees, hash tables, graphs; search and sort. Students engage on projects that involve individually chosen advanced data structures and algorithms. The focus is on applications of data structures and algorithms, utilization of existing practical data sets, and performance trade-offs. Letter grade. (Offered every semester.) **3 credits**

CENG 351 - Computer Architecture I

CENG 351 - Computer Architecture I

Prerequisite, CENG 330. Students learn the organization and structure of the major hardware components of computers to understand the mechanics of information transfer and control within a digital computer system and the fundamentals of logic design. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

CENG 366 - Digital Logic Design II

CENG 366 - Digital Logic Design II

Prerequisite, CENG 330. Corequisite, CENG 366L. This course introduces combinational and sequential logic circuits, including decoders, multiplexers, flip-flops, arithmetic circuits, and implementations of finite state machines using hardware design languages and FPGA boards. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 366L - Lab - Digital Logic Design II

CENG 366L - Lab - Digital Logic Design II

Prerequisite, CENG 330. Corequisite, CENG 366. Laboratory Component of CENG 366. Letter grade with Pass/No Pass option. (Offered as needed.) **1 credit**

CPSC 380 - Operating Systems

CPSC 380 - Operating Systems

Prerequisite, CPSC 350. The course emphasizes the major principles of operating system design and the interrelationship between the operating system and the hardware. (Offered every year.) **3 credits**

CENG 465 - Integrated Circuit Design I

CENG 465 - Integrated Circuit Design I

Prerequisite, CENG 330. This course introduces students to the analysis and design of digital integrated circuits including combinational (static and dynamic) and sequential logic integrated circuits using CMOS technology. Students will learn transistor structure, circuit schematic, physical design, Design Rule Checking, Layout Versus Schematic checking, circuit extraction, and simulation using CAD tools. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

electives (9 credits)

Students, in consultation with and approval of the engineering advising committee, will design individual elective programs to suit their academic goals. Electives may be satisfied by any of the following courses.

PHYS 340 - Quantum Information Science

PHYS 340 - Quantum Information Science

(Same as CPSC 320.) Prerequisites, CPSC 230 or PHYS 220. Students discover features of information storage and processing that appear when classical bit states 0 and 1 are upgraded to quantum bits in superposition states. Topics include reversible computation, circuit and adiabatic models, quantum hardware, error correction, and quantum algorithms with advantage like those of Deutch-Josza, Simon, Grover, and Shor. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CPSC 349 - Human Factors

CPSC 349 - Human Factors

Prerequisite, CPSC 230 or GAME 230. Students study the foundations of human factors, with emphasis on user interface design and user experience. Topics include engineering psychology, design constraints, memory models, visual and auditory processing, and human-centered design. Letter grade with Pass/No Pass option. (Offered every year.) **3 credits**

CENG 350 - Embedded Systems

CENG 350 - Embedded Systems

Prerequisite, CENG 231. An in-depth study of the high-level abstract modeling concepts and the lower-level fundamental programming aspects of real-time embedded systems development. The primary focus is in the design, development and validation of microprocessor-based real-time embedded systems. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 352 - Computer Architecture II

CENG 352 - Computer Architecture II

Prerequisite, CENG 351. Topics include the design and analysis of instruction set processors, memory management, multi-processors, and networks. Letter grade with Pass/No Pass option. (Offered as reading and conference only.) **3 credits**

CENG 353 - Wireless Communication

CENG 353 - Wireless Communication

Prerequisite, CPSC 353. Wireless networks play an increasingly important role in the world of communications. This course provides an introduction to various current and next generation wireless networking technologies, and undertakes a detailed exploration of fundamental architectural and design principles used at all layers. Related protocols and their performance are studied using formal analytical tools and realistic simulations. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CPSC 353 - Data Communications and Computer Networks

CPSC 353 - Data Communications and Computer Networks

Prerequisite, CENG 231 or CPSC 231 or CPSC 236. Students explore the principles and techniques of data communications and give special emphasis to networks and distributed systems. The I.S.O. Reference Model for open systems interconnection will be investigated and the function and operation of each protocol layer analyzed in detail. Letter grade with Pass/No Pass option. (Offered every semester.) **3 credits**

ISP 363 - Cybersecurity 1

ISP 363 - Cybersecurity 1

Prerequisite, CPSC 353. Students are exposed to the world of cybersecurity. Emphasis is placed on understanding, recognizing, and patching security exploits. Students will use standard industry tools and techniques to gain hands-on experience in this rapidly-growing field. Note that students majoring in computer science, computer engineering, software engineering, or data analytics may not use ISP 363 as an elective in the major if they are also minoring in Information Security and Policy. Letter grade with Pass/No Pass option. (Offered every year.) **3 credits**

CENG 370 - Topics in Computer Engineering

CENG 370 - Topics in Computer Engineering

Advanced topics in computer engineering. Letter grade with Pass/No Pass option. May be repeated for credit. (Offered as needed.) **3 credits**

CENG 380 - Real-Time Operating Systems

CENG 380 - Real-Time Operating Systems

Prerequisites, CENG 350, CPSC 380. The theory and practice of developing real-time and embedded systems. The course provides an integrated approach to developing low-power systems with hardware, software, sensors, actuators, controllers and networking. Students will learn to develop a programmable embedded platform from scratch, interface a variety of sensors and actuators for interactive systems, build a gaming system, program an emulator to play retro games, control an autonomous robot and write

an RTOS kernel from scratch. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 381 - Modeling and Simulation

CENG 381 - Modeling and Simulation

Prerequisite, CENG 231. Fundamentals and techniques for designing and using simulation, modeling, and optimization algorithms with applications in system performance modeling, business infrastructure modeling, and distributed and parallel computing. An introduction to advanced complex systems models. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 382 - Digital Signal Processing

CENG 382 - Digital Signal Processing

Prerequisites, CENG 381 and MATH 116 or MATH 210. This course covers the techniques and tools of modern digital signal processing. Techniques for processing signals are examined including discrete-time linear systems, finite impulse response digital filters, infinite impulse response digital filters, fast Fourier transforms, response of LTI systems to statistical signals, digital filter design, and applications. Students will gain insight into evaluating DSP systems and justifying choices among alternative designs. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 390 - Robotics

CENG 390 - Robotics

Prerequisites, CENG 231 or CPSC 231 and EENG 200. Students discover the fundamentals of kinematics, dynamics, and control of robot manipulators, robotic vision, and sensing. In addition, elementary principles on proximity, tactile, and force sensing, vision sensors, camera calibration, stereo construction, and motion detection are presented. Students gain hands on experience through a series of assignments in which they build and test their own robot. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CPSC 453 - Network Implementation and Security

CPSC 453 - Network Implementation and Security

Prerequisite, CPSC 353. Students explore the principles and techniques for implementing TCP/IP based networks using Microsoft Windows and Linux servers and clients, including the skills to configure, customize, optimize, troubleshoot, and integrate networks. Letter grade with Pass/No Pass option. (Offered as needed.) **3 credits**

CENG 466 - Integrated Circuit Design II

CENG 466 - Integrated Circuit Design II

Prerequisites, CENG 330, CENG 465. Recommended, PHYS 102. The course integrates theoretical and functional ideas from Digital Logic I with the physical electronics covered in Integrated Circuit Design I toward the design of real-world integrated circuits. The course also introduces the student to VLSI CAD tools for physical design. Letter grade with Pass/No Pass option. (Offered as reading and conference only.) **3 credits**

Professional Portfolio (1 credit)

Students must complete a 1-credit section of ENGR 397 - Engineering Portfolio Design.

total credits 79-80

Computer Engineering, B.S. Suggested 4-year Plan

Computer Engineering, B.S. Suggested 4-year Plan