# B.S. IN SOFTWARE ENGINEERING

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ENR 160</td>
<td>Introduction to Engineering</td>
<td>3</td>
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<tr>
<td>ENR 465</td>
<td>Engineering Design Seminar</td>
<td>1</td>
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<tr>
<td>ENR 490</td>
<td>Engineering Design Project</td>
<td>3</td>
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<tr>
<td>Choose one introductory programming course:</td>
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<tr>
<td>COS 100</td>
<td>Introduction to Programming</td>
<td>3</td>
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<tr>
<td>COS 205</td>
<td>Scientific Computing</td>
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<tr>
<td>COS 105</td>
<td>Computer Science 1</td>
<td>4</td>
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<tr>
<td>COS 212</td>
<td>Computer Science 2</td>
<td>4</td>
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<tr>
<td>COS 214</td>
<td>Computer Architecture</td>
<td>4</td>
</tr>
<tr>
<td>COS 216</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
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<tr>
<td>COS 301</td>
<td>Operating Systems</td>
<td>4</td>
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<td>COS 313</td>
<td>Database Systems</td>
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<td>COS 318</td>
<td>Web Programming</td>
<td>3</td>
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<tr>
<td>COS 371</td>
<td>Organization of Programming Languages</td>
<td>3</td>
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<tr>
<td>COS 386</td>
<td>Data Communications and Computer Networks</td>
<td>3</td>
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<td>COS 420</td>
<td>Software Process</td>
<td>3</td>
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<td>COS 450</td>
<td>Humans and Computers</td>
<td>3</td>
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<tr>
<td>COS 477</td>
<td>Software Engineering</td>
<td>3</td>
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<tr>
<td>BUS 334</td>
<td>Principles of Project Management</td>
<td>3</td>
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<tr>
<td>MAT 124M</td>
<td>Calculus 1</td>
<td>4</td>
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<tr>
<td>MAT 207M</td>
<td>Statistical Analysis</td>
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<tr>
<td>MAT 211</td>
<td>Linear Algebra</td>
<td>3</td>
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<tr>
<td>MAT 241</td>
<td>Discrete Mathematics</td>
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<th>Code</th>
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<tbody>
<tr>
<td>Major</td>
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<tr>
<td>General Education</td>
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<tr>
<td>Electives</td>
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<td>Total Credits</td>
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Courses whose number is followed by a letter fulfill a General Education requirement.

**COS 100 • Introduction to Programming** 3 Credits.
An introduction to programming using a current procedural (imperative) programming language. Standard data types and control structures are introduced.
*Offered: Fall, Interim.*

**COS 105 • Computer Science 1** 4 Credits.
Introduction to fundamental search and sort algorithms, analysis, design methodologies, and object-oriented programming. Strong emphasis on theory. Extensive programming assignments in a current object-oriented computer language.
*Prerequisites: COS 100, COS 205, or equivalent proficiency; MAT 123M, MAT 124M, MAT 125, or equivalent proficiency. Offered: Spring. Special Notes: Not designed as a computer literacy course. Includes 6 lab hours.*

**COS 205 • Scientific Computing** 3 Credits.
Introduction to programming in C and C++ with an emphasis on issues relevant to scientific computing such as machine error, performance, and implementation of common numerical algorithms.
*Prerequisites: MAT 124M. Offered: Fall, Spring.*

**COS 212 • Computer Science 2** 4 Credits.
Elementary data structures such as file structures, linked lists, and simple trees. Extensive programming assignments in a current computer language.
*Prerequisites: COS 105 or COS 205 with consent of instructor. Special Notes: Includes 6 lab hours. Offered: Fall.*

**COS 214 • Computer Architecture** 4 Credits.
Assembly and machine language to study computer organization and structure, including addressing techniques, digital logic and representation of numbers and arithmetic. Also includes an introduction to C.
*Prerequisites: COS 212. Offered: Spring.*

**COS 216 • Data Structures and Algorithms** 3 Credits.
Advanced data structures, algorithms, and algorithm analysis. Extensive programming assignments in a current object-oriented computer language.
*Prerequisites: COS 212; MAT 241. Offered: Spring.*
COS 301 • Operating Systems 4 Credits.
Computer organization, structure of operating systems, memory management, process management, resource allocation, and operating system monitors. Alternative approaches to operating system design.
Prerequisites: COS 214; knowledge of C or C++. Offered: Fall.

COS 313 • Database Systems 3 Credits.
Relational and object-oriented databases, schemas, and normalization. Database management systems, SQL, concurrent transactions, logging/disaster recovery, and query optimization. Application program interaction with database management systems.
Prerequisites: COS 216. Offered: Fall, even # years.

COS 318 • Web Programming 3 Credits.
An examination of the foundational technologies used for creating web applications. Includes client and server programming, as well as fundamentals of cloud services, including security, storage, and reliability.
Prerequisites: COS 216. Special Notes: Some knowledge of HTML and the basics of JavaScript are expected. Offered: Fall.

COS 320 • Computer Graphics Programming 3 Credits.
An introduction to the drawing methods, geometrical transforms, and illumination models that are fundamental to computer graphics programming. Topics include modeling of 2D and 3D objects, local and global illumination simulation, shading, color models, procedural modeling, and discrete (fragment) techniques including texture mapping. A current graphics API is used, including custom shaders.
Prerequisites: COS 216. Offered: Fall, odd # years.

COS 334 • Data Mining and Machine Learning 3 Credits.
An introduction to widely-used techniques for extracting information from large data sets such as medical databases, credit reports, weather history, and the stock market. Includes algorithms for nominal and ordinal data and metrics to measure their performance. Students will implement common algorithms with real data and choose appropriate algorithms for different applications.
Prerequisites: COS 216. Offered: Spring, even # years.

COS 337K • Behavioral Robotics 3 Credits.
Control and automation are fundamental aspects of human, animal, and machine behavior. These topics will be considered from philosophical and psychological perspectives and explored through robotics and other hands-on experimental labs, in order to develop both a practical and theoretical understanding of behavior.
Prerequisites: Laboratory Science (D) course; Mathematics (M) course. Special Note: Carries cross credit in psychology. Offered: Interim.

COS 351 • High-Performance Computing 3 Credits.
Fundamental concepts and techniques for parallel computation in C/C++ (load balancing, communication, synchronization, serial program decomposition) using an industry-standard parallel computing library.
Prerequisites: COS 205, COS 214. Offered: Interim.

COS 371 • Organization of Programming Languages 3 Credits.
Formal programming language specification using various grammars and the Backus-Naur Form. Data types and structures, control structures, and data flow of several programming languages, including interpreters and compilers. Introduction to parsing and lexical analysis.
Prerequisites: COS 216. Offered: Spring, even # years.

COS 386 • Data Communications and Computer Networks 3 Credits.
Data communications including interprocess communication, computer networking, and associated software protocols. Topics include network topologies, point-to-point network protocols, local area networks, and interconnection of networks.
Prerequisites: COS 301. Offered: Spring, odd # years.

COS 389 • Artificial Intelligence 3 Credits.
Basic concepts and techniques of artificial intelligence, including representation, notational structures, searches, control structures, and logic programming languages. Samples of current work in several application areas including natural language systems, expert systems, and neural networks.
Prerequisites: COS 216. Offered: Spring, odd # years.
B.S. in Software Engineering

COS 420 • Software Process 3 Credits. Balancing the various real-world challenges that a software engineer encounters, including ambiguity, conflicting requirements, task-time estimation, team dynamics, requests from customers, product managers or architects. A team-based software project on a modern computer science topic will be developed during the semester.

Prerequisites: COS 216. Special Notes: Cross listed with ENR 420. COS 477 is a recommended prerequisite. Offered: Spring, odd # years.

COS 450 • Humans and Computers 3 Credits. Examines the ways that humans and computers interact. Issues in user experience and human-machine interaction are explored. Christian and professional ethics in the development and application of computing technology are extensively examined.

Prerequisites: COS 216. Offered: Interim, even # years. Special Notes: Students may not receive credit for both COS 450 and GES 334K.

COS 477 • Software Engineering 3 Credits. Formal approach to the design and development of software. Multiple process models discussed and compared. Other topics include design patterns, project management and estimation, team management, formal methods, documentation, system and data description, verification and validation, and process improvement.

Prerequisites: COS 216. Special Notes: Cross listed with ENR 477. Offered: Spring, odd # years.

COS 490 • Topics in Computer Science 3 Credits. A seminar to provide an in-depth survey of a recent trend or field in the rapidly changing discipline of computer science. Students work on a significant project and explore the future implications of the current topic.

Prerequisites: COS 216. Offered: Occasionally.

ENR 260 • Careers in Engineering and Physics Seminar 1 Credit. Focus on developing careers in high-technology fields such as engineering and physics. Emphasis on exploring some of the wide variety of specific careers possible through methods such as video, lecture, tours, and guest speakers. Development of practical professional skills such as writing resumes and cover letters, accumulating connections and experience, and developing techniques for interviewing.

Prerequisites: PHY 296/297. Offered: Fall. Special Notes: Carries cross-credit in physics.

ENR 304 • Engineering Materials 3 Credits. An introduction to the structure-property relationships of engineering materials; atomic structure and bonding, including crystal structures; imperfections in solids; strength of materials; strengthening mechanisms; phase transformations; heat treatment and control of microstructures; bulk properties of materials.

Prerequisites: ENR 160; MAT 125; CHE 208/208D; PHY 292/292D. Corequisites: Concurrent enrollment in ENR 305 is required. Offered: Spring, odd # years.

ENR 305 • Engineering Materials Lab 1 Credit. Laboratory experience accompanying ENR 304. Corequisites: Concurrent enrollment in ENR 304 is required. Offered: Spring, odd # years.

ENR 306 • Digital Logic and Design 3 Credits. Introduction to digital logic and design. Topics may include Boolean algebra, design and optimization of combinational and sequential logic, the use of programmable logic devices such as FPGA, VHDL or Verilog modeling, and an introduction to processors and memory. Extensive lab experience in the simulation, design, construction and testing of digital circuits.

Prerequisites: PHY 302/303, MAT 125. Corequisites: Concurrent registration in ENR 307 is required. Offered: Spring, even # years.

ENR 307 • Digital Logic and Design Lab 1 Credit. Lab experience accompanying ENR 306. Corequisites: Concurrent registration in ENR 306 is required. Offered: Spring, even # years.
ENR 308 • Statics and Mechanics of Materials 4 Credits.
Force and moment vectors, equilibrium of rigid bodies in two and three dimensions; trusses, friction, centroids, and moments of inertia. Linear elasticity; introduction to stress and strain analysis applied to beams, vessels, pipes, and combined loading; stress and strain; axial, flexural, and torsional deflections for linear elastic materials.
Prerequisites: MAT 223 (may be taken concurrently); PHY 292/292D. Offered: Spring, odd # years.

ENR 316 • Analog Circuitry and Design 3 Credits.
Prerequisites: PHY 302; PHY 303; [MAT 222 or MAT 224 (may be taken concurrently)] Corequisites: Concurrent registration in ENR 317 is required. Offered: Fall, odd # years.

ENR 317 • Analog Circuitry & Design Lab 1 Credit.
Lab experience accompanying ENR 316. Corequisites: Concurrent registration in ENR 316 is required. Offered: Fall, odd # years.

ENR 318 • Engineering Thermal Science 3 Credits.
Prerequisites: PHY 292/292D; MAT 223. Offered: Spring, even # years.

ENR 320 • Mathematical Methods in Physics and Engineering 4 Credits.
Development of skill in mathematical techniques useful in the solution of physics and engineering problems. Included are vector analysis; line and surface integrals; Fourier analysis; partial differential equations; and probability and statistics.
Prerequisites: [MAT 222 or MAT 224 (may be taken concurrently)]; MAT 223. Offered: Fall. Special Notes: Carries cross-credit in physics.

ENR 326 • Circuit Analysis & Simulations 4 Credits.
Circuit analysis techniques as applied to: sinusoidal steady state analysis with power calculations, first and second order transient analysis in both time and Laplace domains, three-phase circuits and magnetically coupled circuits. Additional topics include: frequency response, resonance, filters, Bode plots. Simulation of electrical and electronic circuits will be emphasized.
Prerequisites: PHY 302; PHY 303. Offered: Spring, odd # years.

ENR 328 • Computer Aided Design and Engineering 3 Credits.
Computer graphics and computer aided design techniques required for engineering graphical communication. Advanced techniques may include use of graphics primitives, construction functions, transformations, image control, dimensioning, and layers. Two-dimensional drawing, three-dimensional wireframe, surface modeling, and simulation modeling will be introduced.
Prerequisites: ENR 160; ENR 308; MAT 223. Offered: Interim.

ENR 336 • Signals and Systems 4 Credits.
Continuous-and discrete-time signals and systems. Topics include: definitions and properties of signals and systems, convolution, solution of differential and difference equations, Laplace and Z transforms, and Fourier analysis. Emphasis is on applications to signal processing, communication and control systems.
Prerequisites: MAT 222; PHY 302/303; ENR/PHY 352/353. Offered: Fall, even # years.

ENR 348 • Heat Transfer 3 Credits.
Further development of the understanding of thermodynamics, fluid mechanics, mathematics, and physics. Problems in heat transfer and system design are emphasized for systems in which thermal transport processes are important.
Prerequisites: ENR 318 and one of the following: MAT 222, MAT 223, MAT 224. Offered: Spring, odd # years.
ENR 352 • Computer Methods in Physics and Engineering 3 Credits.
Application of the computer to solving applied problems of interest to physicists and engineers. Computer techniques are developed for numerical methods, simulation models, and data acquisition and control in the laboratory.
Prerequisites: MAT 223; PHY 296/297 (grade of C or better) or consent of instructor. Corequisites: Concurrent registration in ENR 353 is required. Offered: Spring. Special Notes: PHY 302/303 is a recommended prerequisite. Carries cross-credit in physics.

ENR 353 • Computer Methods in Physics and Engineering Lab 1 Credit.
Laboratory experience accompanying ENR 352. Corequisites: Concurrent registration in ENR 352 is required. Offered: Spring. Special Notes: Carries cross-credit in physics.

ENR 356 • Fundamentals of Design and Manufacturing 3 Credits.
Introduction to basic design principles relevant to manufacturing, material of manufacturing, and related structure and properties. Material processing, behavior, and failure in design and manufacturing. Characterization of process capabilities and parts.
Prerequisites: ENR 160; ENR 304/305; ENR 308; MAT 223. Offered: Fall, odd # years.

ENR 358 • Design of Mechanical Components and Systems 3 Credits.
Concepts of mechanical component design with an emphasis on product design and fabrication. Learning to develop and to set up a mechanical component design problem. Selection of standard mechanical components such as lubrication and bearings, gears, shaft design, springs, and fasteners. Analysis and synthesis of motion in machines. Displacement, velocity, and acceleration of mechanisms. Course culminates with an open-ended project designing and fabricating a system that fulfills customer specifications.
Prerequisites: ENR 356; PHY 340. Corequisites: Concurrent enrollment in ENR 359 is required. Offered: Spring, even # years.

ENR 359 • Design of Mechanical Components and Systems Lab 1 Credit.
Laboratory experience accompanying ENR 358. Corequisites: Concurrent enrollment in ENR 358 is required. Offered: Spring, even # years.

ENR 402 • Mechanical Systems and Measurements Lab 3 Credits.
A laboratory course focused on careful measurements of physical properties such as temperature, pressure, stress, force, emissivity, and vibration modes. Emphasis is placed on experimental methods, statistical estimates of experimental uncertainty, methods of calibration, transducers for mechanical measurement, data acquisition and processing. Appropriate written and oral presentations of measurements.
Prerequisites: ENR 304/305; MAT 223; PHY 296/297. Offered: Fall, odd # years.

ENR 420 • Software Process 3 Credits.
Balancing the various real-world challenges that a software engineer encounters, including ambiguity, conflicting requirements, task-time estimation, team dynamics, requests from customers, product managers or architects. A team-based software project on a modern computer science topic will be developed during the semester.
Prerequisites: COS 216; ENR 477 recommended. Special Notes: Cross listed with COS 420. Offered: Spring, odd # years.

ENR 422 • Fluid Mechanics 3 Credits.
Laws of statics, kinematics, and dynamics applied to fluid mechanics. Integral and differential conservation laws for mass, momentum, and energy. Dimensional analysis, viscous pipe flow, boundary layers, separated flows, and potential flow.
Prerequisites: MAT 223; PHY 296/297 (grade of C or better) or consent of instructor. Corequisites: Concurrent registration in ENR 423 is required. Special Notes: Carries cross-credit in physics. Offered: Fall.

ENR 423 • Fluid Mechanics Lab 1 Credit.
Laboratory experience accompanying ENR 422. Corequisites: Concurrent registration in ENR 422 is required. Offered: Fall. Special Notes: Carries cross-credit in Physics.
ENR 424 • Materials and Devices 3 Credits.
Theory and application of condensed matter and materials. Physical origin of electrical, optical, mechanical, thermal, and magnetic properties. Emphasis on devices such as pn junction diodes, LEDs, piezoelectrics, and sensors. An accompanying lab explores characterization of materials and the design, fabrication, and testing of devices.
Prerequisites: PHY 302/303 or PHY 312/313. Corequisites: Concurrent registration in ENR 425 is required. Offered: Fall, even # years. Special Notes: Carries cross-credit in physics.

ENR 425 • Materials and Devices Lab 1 Credit.
Laboratory component of ENR 424. Corequisites: Concurrent registration in ENR 424 required. Offered: Fall, even # years. Special Notes: Carries cross-credit in physics.

ENR 436 • Microprocessors 3 Credits.
Advanced principles of microcomputer hardware and software. Topics include computer organization, instruction sets and addressing modes, assembly language programming, arithmetic and logic operations, input/output, buffers, interrupts and special purpose features such as A/D converters.
Prerequisites: ENR 306; ENR 307. Corequisites: Concurrent registration in ENR 436 is required. Offered: Fall, even # years.

ENR 437 • Microprocessors Lab 1 Credit.
Lab experience accompanying ENR 436. Corequisites: Concurrent registration in ENR 436 is required. Offered: Fall, even # years.

ENR 446 • Control Systems 3 Credits.
Time and frequency domain representation of feedback control systems. Topics include: stability criteria, root locus methods, frequency response techniques, digital implementation and hardware considerations.
Prerequisites: PHY 302; MAT 222 or MAT 224 (may be taken concurrently). Corequisites: Concurrent registration in ENR 447 is required. Offered: Spring, odd # years.

ENR 447 • Control Systems Lab 1 Credit.
Lab experience accompanying ENR 446. Corequisites: Concurrent registration in ENR 446 is required. Offered: Spring, odd # years.

ENR 450 • Topics in Applied Physics and Engineering 3-4 Credits.
Topics selected from various fields of engineering and applied physics for the purpose of illustrating the practical application of physical principles. Emphasis on developing the skills and viewpoints commonly used by engineers and industrial physicists.
Prerequisites: ENR 320 (may be taken concurrently); MAT 222 or MAT 224. Offered: Occasionally. Special Notes: Carries cross-credit in physics, Course may be repeated when a different topic is emphasized, The field of engineering or applied physics is announced prior to registration.

ENR 465 • Engineering Design Seminar 1 Credit.
Prepares students for engineering practice through a major design experience. Design projects have a major engineering component to them, and are intentionally multi-disciplinary in nature. Students work in teams to design a system to meet a given specification that requires the incorporation of relevant engineering standards.
Prerequisites: Senior standing and a declared major in engineering. Offered: Fall.

ENR 477 • Software Engineering 3 Credits.
Formal approach to the design and development of software. Design methodologies include object-oriented design, components, design patterns, and event-driven design. Project management, walkthroughs, documentation, team programming, and the development of a significant software project.
Prerequisites: COS 216. Special Notes: Cross listed with COS 477. Offered: Fall, odd # years.

ENR 490 • Engineering Design Project 3 Credits.
Prepares students for engineering practice through a major design and prototyping experience. The design produced in ENR 465 will be the basis for building a prototype system. The prototype will incorporate relevant engineering standards. Final designs and prototypes are documented in a professional manner and presented publicly.
Prerequisites: ENR 465. Offered: Spring