Computer Science and Engineering

Chair, Associate Professor J. Denning
Professors S. Brandle, A. White
Associate Professor D. Read
Assistant Professors O. Ayano, B. Messick, J. Mikels

In support of the overall Taylor University mission, the mission of Computer Science and Engineering is to:

- Honor God in all we do
- Pursue excellence
- Help students become
  - Outstanding computer scientists
  - Exceptional systems analysts
  - Committed Christians
  - Highly motivated to serve

Baccalaureate majors are offered by the department:

- **Computer Science (BA)**
  A concentration is required in either Applied or Digital Media.
- **Computer Science (BS)**
  A concentration is required in Cybersecurity, Digital Media Systems, Information Systems and Analysis, or Theory.
- **Computer Engineering (BS)**
  Combination of fundamental engineering, computer science, and electronics curricula. Program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

Each year the Department of Computer Science and Engineering offers at least ten sanctioned events such as special lectures, workshops, or colloquiums. All majors are required to participate in at least 21 sanctioned events before completing COS 491.

Information Systems and Analytics for Bachelor of Science Degree

The information systems and analytics program is offered by the Computer Science and Engineering Department. *For a description of the program and requirements for majors outside of the department, refer to* **Academic Programs and Requirements** *and* **Academic Departments and Courses** *sections of this catalog.*

Computer Engineering (BS)

Intimate knowledge of both physics and computer science is the foundation of the design and development of powerful and efficient embedded computer systems. The Computer Engineering major is offered jointly by the Computer Science and Engineering and the Physics and Engineering Departments and focuses on the theoretical and applied operation of computer hardware and software.

The computer engineering program is accredited by the Engineering Accreditation Commission of ABET, 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700.

Program Objectives:

1. Prepare our graduates to serve others dependably, most importantly their employer, customers, and community.
2. Prepare our graduates to practice technical competence, producing reliable engineering designs.
3. Prepare our graduates to exercise creativity in their work, fostering innovative solutions.
4. Prepare our graduates to pursue growth in their faith, social understanding, and technical competence so that they can adapt to meet the needs of an ever-changing world.

The Bachelor of Science degree with a major in Computer Engineering requires 98 hours. Majors are required to attend 21 sanctioned events. Majors are also required to complete a comprehensive examination during their senior year. This examination includes a major design and implementation project (COS 493, 494, 495), written and oral presentation of this work, and a written examination over coursework in the major field. *All major courses must be completed with a grade of C- or better and are included in the major GPA.*

Physics and Engineering Requirements

PHY 211	4	University Physics I
PHY 212	5	University Physics II
ENP 104	3	Introduction to Engineering and Software Tools
ENP 231	4	Introduction to Electric Circuits
ENP 253	4	Electrical Circuits II
ENP 261	3	Digital Systems Design
ENP 332	4	Control Systems
ENP 341	4	Microcomputer Interfacing
ENP 392	3	Junior Engineering Project
ENP 405	1	Engineering Ethics
ENP 431	4	Advanced Electronics and Microcircuits

Mathematics Requirements

MAT 151	4	Calculus I
MAT 215	3	Discrete Mathematics for Computer Science
MAT 230	4	Calculus II
MAT 240	4	Calculus III
MAT 251	4	Differential Equations
MAT 352	4	Mathematical Statistics

Computer Science Requirements

COS 103	1	Computer Science and Engineering: New Majors Orientation
COS 121	4	Foundations of Computer Science
COS 130	3	Computational Problem Solving for Engineers
COS 265	4	Data Structures and Algorithms
COS 284	3	Introduction to Computer Systems
COS 331	3	Data Communications
COS 340	3	Software Engineering
COS 381	3	Computer Architecture
COS 393	2	Practicum
COS 421	3	Operating Systems
COS 491	1	Computer Science Senior Capstone
COS 493	2	Engineering Senior Capstone I
COS 494	3	Engineering Senior Capstone II
COS 495	1	Engineering Senior Capstone II

Computer Science (BA)

The Bachelor of Arts degree with a major in Computer Science requires the completion of two years of one foreign language and 62-64 major hours including a concentration in Applied or Digital Media. Majors are required to attend 21 sanctioned events. Majors are also required to complete a comprehensive examination during their senior year. This examination includes an implementation project, written and oral presentation of this work, and a written examination over coursework in the major field. The project and presentation portions of this examination are included in COS 492 Senior Project. Courses may not be used to fulfill more than one requirement: core or concentration. *All major courses must be completed with a grade of C- or better and are included in the major GPA.*

Core Requirements

COS 103	1	Computer Science and Engineering: New Majors Orientation
COS 109	3	Computer and Network Operations
COS 120	4	Introduction to Computational Problem Solving
COS 121	4	Foundations of Computer Science
COS 143	3	Interactive Webpage Development
COS 243	3	Multi-tier Web Application Development
COS 265	4	Data Structures and Algorithms
COS 393	3	Practicum
COS 491	1	Computer Science Senior Capstone
COS 492	3	Senior Project

Select one course from the following:

COS 311	3	Ethics in Computer Science
COS 321H	3	Ethics and Technology

Concentrations—Students must select one of the following concentrations:

Applied

COS 232	3	Computer and Network Security I
COS 284	3	Introduction to Computer Systems
MAT 151	4	Calculus I
MAT 210	4	Introductory Statistics
MAT 215	3	Discrete Mathematics for Computer Science

Select one course from the following:

COS 320	3	Algorithm Design
COS 382	3	Language Structures
COS 435	3	Theory of Computation

Select 12 credits from the following:

COS ___	1-12	Computer Science Elective
MAT 230	4	Calculus II
MAT 240	4	Calculus III
MAT 251	4	Differential Equations
MAT 310	3	Mathematical Modeling with Numerical Analysis
MAT 345	4	Linear Algebra
MAT 401	3	Operations Research
MGT 403	3	Operations Management
NAS 480	1	Seminar
SYS 214	3	Principles of Human Computer Interaction
SYS 352	3	Knowledge Based Systems
SYS 402	3	Modeling and Simulation
SYS 411	3	Machine Learning

Digital Media

COS 350	3	Computer Graphics
ART 152	3	Visual Communication
ART 154	1	Digital Tools: Illustrator
ART 156	1	Digital Tools: Photoshop
ART 253	3	Foundations of Photography
ART 456	4	Motion Design
FMA 215	3	Audio Production
FMA 220	3	Film and Video Production
SYS 214	3	Principles of Human Computer Interaction

Select one course from the following:

COS 331	3	Data Communications
COS 351	3	Computer Vision
COS 424	3	Surfaces and Modeling
COS 486	3	Game Engine Architecture
SYS 310	3	E-Commerce

Select one course from the following:

ART 151	3	Two-Dimensional Design
ART 251	3	Typography
ART 353	3	Commercial Photography
CAC 345	3	Writing for Interactive Media
FMA 230	3	Scriptwriting

Computer Science (BS)

The Bachelor of Science degree with a major in Computer Science requires the completion of 76-92 major hours including a concentration in Cybersecurity, Digital Media Systems, Information Systems and Analysis, or Theory. Majors are required to attend 21 sanctioned events. Majors are also required to complete a comprehensive examination during their senior year. This examination includes an implementation project, written and oral presentation of this work, and a written examination over coursework in the major field. Courses may not be used to fulfill more than one requirement: core or concentration. *All major courses must be completed with a grade of C- or better and are included in the major GPA.*

Core Requirements

COS 103	1	Computer Science and Engineering: New Majors Orientation
COS 109	3	Computer and Network Operations
COS 120	4	Introduction to Computational Problem Solving
COS 121	4	Foundations of Computer Science
COS 143	3	Interactive Webpage Development
COS 232	3	Computer and Network Security I
COS 243	3	Multi-tier Web Application Development
COS 265	4	Data Structures and Algorithms
COS 491	1	Computer Science Senior Capstone
MAT 151	4	Calculus I
MAT 210	4	Introductory Statistics

Select one course from the following:

COS 311	3	Ethics in Computer Science
COS 321H	3	Ethics and Technology

Concentrations—*Students must select one of the following concentrations:*

Cybersecurity

COS 284	3	Introduction to Computer Systems				
COS 323	3	Computer and Network Security II				
COS 331	3	Data Communications				
COS 343	3	Database Systems				
COS 393	3	Practicum				
COS 411	3	Digital Forensics				
COS 421	3	Operating Systems				
COS 432	3	Software Reverse Engineering and Analysis				
COS 492	3	Senior Project				
MAT 215	3	Discrete Mathematics for Computer Science				
POS 350	3	International Security				

Select two courses from the following:

COS 280	3	Introduction to Artificial Intelligence
COS 320	3	Algorithm Design
COS 381	3	Computer Architecture
COS 382	3	Language Structures
COS 435	3	Theory of Computation
COS 436	3	Parallel and Distributed Computing
SYS 411	3	Machine Learning

Digital Media Systems

ART 152	3	Visual Communication
ART 154	1	Digital Tools: Illustrator
ART 156	1	Digital Tools: Photoshop
ART 253	3	Foundations of Photography
ART 456	4	Motion Design
COS 326	3	Data Visualization
COS 350	3	Computer Graphics
COS 393	3	Practicum
COS 492	3	Senior Project
FMA 215	3	Audio Production
FMA 220	3	Film and Video Production
MAT 382	3	Advanced Statistical Methods
SYS 214	3	Principles of Human Computer Interaction
SYS 330	3	Human Relations in Organizations
SYS 390	3	Information Systems Analysis
SYS 394	4	Information Systems Design

Select one course from the following:

COS 331	3	Data Communications
COS 351	3	Computer Vision
COS 424	3	Surfaces and Modeling
COS 486	3	Game Engine Architecture
SYS 310	3	E-Commerce

Select one course from the following:

ART 151	3	Two-Dimensional Design
ART 251	3	Typography
ART 353	3	Commercial Photography
CAC 345	3	Writing for Interactive Media
FMA 230	3	Scriptwriting

Select one course from the following:

ENT 422	3	New Venture Planning
MGT 201	3	Introduction to Business
MGT 403	3	Operations Management
SYS 214	3	Principles of Human Computer Interaction
SYS 310	3	E-Commerce
SYS 352	3	Knowledge Based Systems

Information Systems and Analytics

COS 284	3	Introduction to Computer Systems
COS 326	3	Data Visualization
COS 393	3	Practicum
COS 492	3	Senior Project
MAT 215	3	Discrete Mathematics for Computer Science
MAT 382	3	Advanced Statistical Methods
SYS 330	3	Human Relations in Organizations
SYS 390	3	Information Systems Analysis
SYS 394	4	Information Systems Design

Select one course from the following:

COS 320	3	Algorithm Design
COS 382	3	Language Structures
COS 435	3	Theory of Computation

Select 12 credits from the following:

COS ___	1-12	Computer Science Elective
MAT 230	4	Calculus II
MAT 240	4	Calculus III
MAT 251	4	Differential Equations
MAT 310	3	Mathematical Modeling with Numerical Analysis
MAT 345	4	Linear Algebra
MAT 401	3	Operations Research
MGT 403	3	Operations Management
NAS 480	1	Seminar
SYS 214	3	Principles of Human Computer Interaction
SYS 352	3	Knowledge Based Systems
SYS 402	3	Modeling and Simulation
SYS 411	3	Machine Learning

Select one of the following:

MAT 311	3	Introduction to Data Science
MAT 401	3	Operations Research
SYS 402	3	Modeling and Simulation
SYS 411	3	Machine Learning

Theory

COS 284	3	Introduction to Computer Systems
COS 310	1	Current Literature Survey
COS 320	3	Algorithm Design
COS 382	3	Language Structures
COS 435	3	Theory of Computation
COS 452	3	Research I
COS 453	3	Research II
MAT 215	3	Discrete Mathematics for Computer Science

Select two courses from the following:

COS 381	3	Computer Architecture
COS 421	3	Operating Systems
COS 436	3	Parallel and Distributed Computing

Select 15 credits from the following:

COS ___	1-15	Computer Science Elective
MAT 230	4	Calculus II
MAT 240	4	Calculus III
MAT 251	4	Differential Equations
MAT 310	3	Mathematical Modeling with Numerical Analysis
MAT 345	4	Linear Algebra
MAT 401	3	Operations Research
MGT 403	3	Operations Management
NAS 480	1	Seminar
SYS 214	3	Principles of Human Computer Interaction
SYS 352	3	Knowledge Based Systems
SYS 402	3	Modeling and Simulation
SYS 411	3	Machine Learning

Computer Science Minor

A Computer Science minor requires 25 hours. Courses may not meet both a requirement and elective. *All minor courses must be completed with a grade of C- or better and are included in the minor GPA.*

Minor Requirements

COS 109	3	Computer and Network Operations
COS 120	4	Introduction to Computational Problem Solving
COS 121	4	Foundations of Computer Science
COS 143	3	Interactive Webpage Development

Select one course from the following:

COS 311	3	Ethics in Computer Science
COS 321H	3	Ethics and Technology

Electives

Select additional electives to complete the 25-hour requirement from any of the following:

COS 1__	1-16	Any 100-level COS course
COS 2__	1-16	Any 200-level COS course
COS 3__	1-16	Any 300-level COS course
COS 4__	1-16	Any 400-level COS course
MAT 215	3	Discrete Mathematics for Computer Science
SYS 214	3	Principles of Human Computer Interaction
SYS 352	3	Knowledge Based Systems
SYS 411	3	Machine Learning

Cybersecurity Minor

A Cybersecurity minor requires 26 hours. *All minor courses must be completed with a grade of C- or better and are included in the minor GPA.*

Minor Requirements

COS 109	3	Computer and Network Operations
COS 121	4	Foundations of Computer Science
COS 232	3	Computer and Network Security I
COS 311	3	Ethics in Computer Science
COS 323	3	Computer and Network Security II
COS 331	3	Data Communications

Select one course from the following:

COS 120	4	Introduction to Computational Problem Solving
SYS 120	4	Introduction to Problem Solving

Select one course from the following:

COS 393	3	Practicum
COS 450	3	Directed Research

Information Systems Minor

An Information Systems minor requires 26-27 hours. *All minor courses must be completed with a grade of C- or better and are included in the minor GPA. Minor is not available to students completing the information systems and analytics curriculum included within a major.*

Minor Requirements

COS 143	3	Interactive Webpage Development
SYS 214	3	Principles of Human Computer Interaction
SYS 390	3	Information Systems Analysis
SYS 394	4	Information Systems Design

Select one course from the following:

COS 109	3	Computer and Network Operations
SYS 101	3	Introduction to Systems

Select one course from the following:

COS 120	4	Introduction to Computational Problem Solving
SYS 120	4	Introduction to Problem Solving

Select one course from the following:

PSY 425	3	Industrial-Organizational Psychology
SYS 330	3	Human Relations in Organizations

Select one course from the following:

___ 393	3-4	Practicum
SYS 393	3-4	Practicum

Computer Science Courses

COS 101   **2 hours**
Information Technology Concepts
The course focuses on practical understanding and application of computing technology in educational, small business, or organizational environments. Specific topics include an overview of operating systems, application software, computing hardware, telecommunications, networking, and information management systems and analysis. In addition, it heavily emphasizes the impact of technology on modern society and the ethical issues related to use of information and communication systems. *This course is offered through Taylor University Online (TUO) and does not count toward any major, minor, or foundational core curriculum requirement for residential students.*

COS 102   **3 hours**
Fundamentals of Systems and Computing
An introduction to the basic concepts of "system" and "process" with particular emphasis on computing systems. Major topics include systems thinking, quality, problem solving, and design. Computing-specific topics include algorithms, networks, computer hardware, and basic relational database concepts. The learning experience features field trips and guest lectures. *Offered Fall semester.*

COS 103   **1 hour**
Computer Science and Engineering: New Majors Orientation
Provides an introduction to the Computer Science and Engineering majors focusing on the habits, mindset, and requirements for success in the major. The course includes an overview of the discipline with an exploration of various career paths in computing (e.g., industry, missions, graduate school). A significant portion of the course involves a weekend retreat with faculty, staff, and graduating seniors. Lastly, students are introduced to integrating faith and computing. *Offered Fall semester.*

COS 104   **2 hours**
Computing and Culture – Applications and Context
An introduction to the ideas of computational technology including the use of applications, ethical foundations, and the understanding of the context of technology in our world. Analysis from a Christian perspective is emphasized. Topics discussed include algorithmic thinking, artificial intelligence, organization of data, internet and security, hardware, software, and the history of computers. Important skills covered in the course include web design, office productivity applications, information literacy, and an introduction to the process of programming. *Meets foundational core computation requirement.*

COS 105   **1 hour**
Ethics, Computing, and Society
As computing technology becomes more complex and less visible, we understand less about how the world functions. Our worldview is impacted by technology in ways that are not recognized and, therefore, not critically evaluated, particularly with a Christian understanding. This course is designed to introduce students to the context of computation in their world. Through writing, discussions, and class assignments, students will gain an understanding of computing technology that goes beyond its use and explores the impact of technology on our world view. The context provided includes an introduction to the issues in our society associated with ethics and technology. Main topics addressed include applying major ethical theories, intellectual property, privacy, and putting technology into context with a Christian perspective. *This course is available only to transfer students who have credit in an acceptable computer competency course and will meet the foundational core computation requirement for such students.*

COS 109   **3 hours**
Computer and Network Operations
A study of the concepts, principles, tools, and constraints related to computer and network operations, including the following topics: shell scripting, information technology system components, systems policy and governance, operating systems management, network devices, and virtual machines. Students will install and configure commodity operating systems, manage users, analyze system logs, write scripts to automate systems administration, review and write information technology policies, and related activities.

COS 120   **4 hours**
Introduction to Computational Problem Solving
Approaches to computing solutions for problems from a variety of subject areas are examined and provide motivation for the study of the development of algorithms and their implementation. Programming concepts are introduced incrementally in order to solve increasingly complex problems. Good algorithm design and program structure are emphasized. Introductory data structures and software engineering principles are stressed. An introduction to object-oriented programming is included. *Three hours of lecture and two hours of lab per week. Meets foundational core computation requirement.*

COS 121   **4 hours**
Foundations of Computer Science
This course builds on COS 120 by emphasizing object-oriented programming and including concepts of computer science such as computational complexity simulation and recursion. The use and implementation of data structures such as lists, stacks, queues, and trees are introduced as they are needed in developing algorithms for problems studied. Additional topics include the Linux operating system and tools, source code versioning, unit testing, and code refactoring. *Three hours of lecture and two hours of lab per week. Prerequisite: COS 120 or COS 130 or SYS 120.*

COS 130   **3 hours**
Computational Problem Solving for Engineers
This introductory programming course will take a similar approach to solving problems as COS 120. The differences will be an accelerated pace and using computational tools (emphasis on the C language) expected to be used in the various fields of engineering. *Meets foundational core computation requirement. Offered Spring semester.*

COS 143   **3 hours**
Interactive Webpage Development
In this comprehensive webpage development course, students will gain the fundamental skills and knowledge to create engaging and well-designed web pages that respond to user interactions. Through a hands-on approach, students will learn how to utilize the essential technologies, including HTML5, CSS3, and JavaScript, to craft interactive elements, manipulate the Document Object Model (DOM), and retrieve JSON data from remote servers for page updates. *Prerequisite: COS 120 or COS 130 or SYS 120.*

COS 170   **1-4 hours**
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

COS 230   **3 hours**
Missions Technology
A survey and in-depth study of the range of technology applied to Christian missions. Theory and issues in sustainable application are developed. Interaction with mission agencies and a practical project are included.

COS 232   **3 hours**
Computer and Network Security I
A study of the fundamentals of operating systems, network, and application security. Major areas of exploration include fundamental security design principles, application vulnerability analysis, network penetration testing, basic cryptography, and defensive programming techniques. *Prerequisite: COS 121. Offered Fall semester.*

COS 243   **3 hours**
Multi-tier Web Application Development
The course will explore how to develop a complete web application with implementation separating concerns between content delivery, business logic, and data storage. An emphasis on a modern MVC platform will be used to provide the separation of concerns. Additionally, core database knowledge for a functioning application will be explored including data modeling for a relational database, common SQL queries, data normalization foreign key constraints, and aggregate operations. *Prerequisites: COS 121 and COS 143.*

COS 265   **4 hours**
Data Structures and Algorithms
A survey of data structures and algorithms that operate on them, with an emphasis on abstract data types and analysis of computational complexity. *Three hours of lecture and two hours of lab per week. Prerequisite: COS 121.*

COS 270   **1-4 hours**
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

COS 280   **3 hours**
Introduction to Artificial Intelligence
A survey of the field of artificial intelligence. Major areas of exploration include search, logic, learning, knowledge representation, problem solving, natural language processing, computer vision, robotics, expert systems, and neural networks. An introduction to Lisp is included. *Prerequisite: COS 121.*

COS 284   **3 hours**
Introduction to Computer Systems
An integrated introduction to computer hardware architecture, operating systems, and their interaction. Assembly language and operating system programming are emphasized. *Prerequisites: COS 121 and MAT 215. Offered Spring semester.*

COS 306   **3 hours**
Introduction to Bioinformatics
This course is designed to introduce students to concepts of bioinformatics, as well as basic bioinformatics skills, using the R programming language. The course will explore methods and datasets spanning from the level of DNA (genomics) up to the organismal and ecosystem level. Bioinformatics is an interdisciplinary field combining concepts of biology, computer science, and statistics to analyze and interpret biological datasets and solve complex questions. *Two hours of lecture and one hour of one hour of coding/data analysis in a computer lab per week. Prerequisites: BIO 203 or instructor permission. Offered Fall semester of even years.*

COS 310   **1 hour**
Current Literature Survey
A survey of computer science literature. Students lead discussions over papers and topics of interest and produce a literature survey that could serve as a basis for an undergraduate research.

COS 311   **3 hours**
Ethics in Computer Science
A study of the ethical implications of computers in society and the role of Christians as computer science and engineering professionals. Foundational concepts of Western moral philosophy are presented. Major ethical issues, such as privacy, piracy, liability, equity, and whistle-blowing are explored. Professional society codes of conduct are examined and discussed. Legal and ethical issues such as piracy, copyright, and fair use related to media are also addressed. Ethical concerns of computer science and systems analysis and their relationship to one's faith are an integral part of this course.

COS 320   **3 hours**
Algorithm Design
An advanced algorithms and data structures course with emphasis on runtime analysis and correctness proving. Greedy algorithms, dynamic programming, network flow, and graph algorithms are discussed. *Prerequisites: COS 265 and MAT 215.*

COS 321H   **3 hours**
Ethics and Technology
A study of the ethical implications of computing technology in society and the role of Christians as users, people impacted by, and shapers of computing technology. Foundational concepts of Western moral philosophy are presented. Major ethical issues, such as privacy, piracy, liability, equity, and whistle-blowing are explored. Professional society codes of conduct are examined and discussed. Legal and ethical issues such as piracy, copyright, and fair use related to media are also addressed. Ethical concerns of computer science and systems analysis and their relationship to one's faith are an integral part of this course. *This course is intended for students in the Honors Guild but will also meet the COS 311 requirement for majors in computer science and engineering. Meets foundational core computation requirement.*

COS 323   **3 hours**
Computer and Network Security II
A study of operating system, network, and application security. This course is a continuation of COS 232 (Computer and Network Security). Major areas of exploration include software reverse engineering, static and dynamic program analysis, basic cryptanalysis, and related current topics. *Prerequisite: COS 232. Offered Spring semester.*

COS 326   **3 hours**
Data Visualization
This course introduces explanatory and exploratory data visualization, including principles, techniques, and tools, that facilitate understanding and action based on very big data sets. Principles from graphic design, visual perception, and cognitive science are considered. Students employ modern tools and languages to access, analyze, and visualize Internet-scale data. *Participants are encouraged to take MAT 311 and a statistics course before enrolling. Prerequisites: COS 120 or SYS 120; and COS 143.*

COS 331   **3 hours**
Data Communications
A study of the nature and applications of data communications in use today. Fundamental concepts of types, modes, and media of transmission are studied. Communication protocols and their encompassing architectures are analyzed and compared. Practical applications of data communications concepts are demonstrated through networking projects and development of communications software. *Prerequisite: COS 121.*

COS 333   **3 hours**
Missions Computing
Combining computer science and service to the missions community, students travel to an international location during Interterm to undertake software development and systems analysis for a missions partner. Students design, construct, test, document, and deploy a non-trivial software system that meets the partner's requirements. Students experience the local culture and participate in direct ministry as opportunities arise. *Meets foundational core cross-cultural requirement. Prerequisite: COS 121 or COS 143; and instructor permission.*

COS 340   **3 hours**
Software Engineering
A study of the concepts, tools, best practices, and lifecycle phases associated with developing large software systems, in groups, over prolonged durations. Using an agile software development process, students gather requirements, design, and begin construction of a non-trivial software system. *Prerequisite: COS 121. Offered Fall semester.*

COS 343   **3 hours**
Database Systems
A study of the fundamental concepts of how database technologies work. An emphasis on relational databases will be explored, including normalization, advanced SQL queries, indexing, physical data storage, performance and tuning strategies, and concurrency control. Students will be introduced to other database technologies, possibly including object-oriented databases, NoSQL, replication, etc. *Prerequisites: COS 121 and MAT 215.*

COS 350   3 hours
Computer Graphics
An introductory course in computer graphics with an emphasis on 3D image production using a variety of approaches, including ray tracing and raster graphics. Applied linear algebra and basic algorithms for graphics are introduced. *Prerequisite: COS 121.*

COS 351   3 hours
Computer Vision
A study of the fundamental concepts of digital image acquisition, manipulation, enhancement, representation, analysis, and understanding. *Prerequisite: COS 121. Offered Spring semester of even years.*

COS 355   3 hours
Mobile Application Development
A study of the concepts, principles, tools, and constraints related to developing mobile applications, including power-performance tradeoffs, sensor management, location acquisition, and responsive user interface design. Students will develop mobile applications within large software ecosystems (mobile operating system APIs and web services) and as a result gain significant experience using current software development tools, asynchronous programming techniques, and object-oriented design patterns. *Prerequisite: COS 265.*

COS 360   1-4 hours
Independent Study
An individualized, directed study involving a specified topic.

COS 370   1-4 hours
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

COS 380   3 hours
Natural Language Processing
A study of the automation of human communication abilities, covering both textual and vocal aspects. Major topics include language parsing, understanding, representation, enhancement, generation, translation, and speaker/author recognition. *Prerequisite: COS 280.*

COS 381   3 hours
Computer Architecture
A study of the hardware structure of computer systems, including arithmetic/logic units, memory organization, control unit design, pipelining, and instruction set design. A brief introduction to advanced topics, such as out-of-order execution, branch prediction, multi-core systems, and parallel processing cache coherency will prepare the student for graduate level courses in architecture. *Prerequisite: COS 284.*

COS 382   3 hours
Language Structures
A study of the features and implementation issues of programming languages, including a survey of language paradigms. Grammars, syntax, semantics, translation, lexical analysis, and parsing are introduced. *Prerequisite: COS 265.*

COS 393   1-4 hours
Practicum
Supervised learning involving a first-hand field experience or a project. Generally, one hour of credit is awarded for a minimum of 40 hours of practicum experience. *Grade only. Practicum course credit requires a minimum of 320 hours of work experience. Offered primarily during Summer.*

COS 394   1-4 hours
Advanced Project
Students complete an open-ended software development project or laboratory experiment project. The individual project depends on students and faculty interest. Specific learning outcomes vary depending on faculty, student, and project selected. Independent or small group projects are possible. *May be taken by any Computer Science major with instructor permission. May be taken multiple times for credit.*

COS 411   3 hours
Digital Forensics
A study of the concepts, tools, methodologies, and analysis techniques used for host, media, and network forensic investigations. Students will learn how to capture, decipher, reconstruct, and analyze digital data. *Prerequisite: COS 331. Offered Fall semester of even years.*

COS 421   3 hours
Operating Systems
A study of the design considerations of computer operating systems and their interaction with hardware features. Topics covered include process management, storage management, protection and security, file systems, and concurrency. *Prerequisites: COS 265 and COS 284.*

COS 424   3 hours
Surfaces and Modeling
An advanced graphics course with emphasis on curve and surface representation and geometric modeling. Graphics algorithms and data structures are studied. Topics may include curves and surfaces, geometric modeling techniques, implicit surface generation, and topology editing. *Prerequisite: COS 350.*

COS 425   3 hours
Animation
An advanced graphics course with emphasis on techniques for rendering and animation. Mathematics and algorithms are studied. Topics include light and illumination models, ray tracing, methods to enhance realism, and standard animation techniques. A professional software package will be used to create a significant animation. *Prerequisite: COS 350.*

COS 432   3 hours
Software Reverse Engineering and Analysis
A study of defensive programming techniques, platform security, secure software engineering, software reverse engineering, and vulnerability analysis. Students will perform static and dynamic software analysis, identify and analyze malicious software, and apply tools and techniques for identifying software vulnerabilities. *Prerequisite: COS 284. Offered Fall semester of odd years.*

COS 433   3 hours
Missions Computing Senior Project
Combining computer science and service to the missions community, students travel to an international location during Interterm to undertake software development and systems analysis for a missions partner. Students design, construct, test, document, and deploy a non-trivial software system that meets the partner's requirements. Students experience the local culture and participate in direct ministry as opportunities arise. Students share their experience on campus in a formal paper, presentation, and poster. Satisfies the senior project requirement. *Meets foundational core cross-cultural requirement. Prerequisites: senior standing and instructor permission.*

COS 435   3 hours
Theory of Computation
A theoretical treatment of what can be computed and how efficiently computation can be done. Topics include models of computation and automata, deterministic and non-deterministic computations, and formal language theory. *Prerequisite: COS 265.*

COS 436   3 hours
Parallel and Distributed Computing
A study of concepts and models of distributed and parallel computing, including concurrency, synchronization, algorithms, hardware organization, and common programming environments. Implementation of parallel algorithms on multicore CPUs and many-core GPUs. *Prerequisites: COS 265 and COS 284.*

COS 450   1-4 hours
Directed Research
Investigative learning involving closely directed research and the use of such facilities as the library or laboratory. *Independent or small group projects. May be taken by any COS major with instructor approval. May be taken multiple times for credit.*

COS 452   3 hours
Research I
Participation in a research project under faculty direction. *Prerequisite: COS 310 or instructor permission.*

COS 453   3 hours
Research II
Participation in a research project under faculty direction. A formal presentation of results is required. *Prerequisite: COS 452 or instructor permission.*

COS 480   1-4 hours
Seminar
A limited-enrollment course designed especially for upper-class majors with emphasis on directed readings and discussion.

COS 486   3 hours
Game Engine Architecture
An exploration of the architecture and design underlying modern game engines. Systems covered include physics, graphics, human interfaces, and audio. Students implement from scratch a game engine with several games as demos. *Prerequisite: COS 265. COS 350 is strongly recommended.*

COS 490   1-2 hours
Honors
Individualized study or research of an advanced topic within a student's major. *Open to students with at least a 3.00 GPA in the major field.*

COS 491   1 hour
Computer Science Senior Capstone
A survey of topics useful for graduates of the department, but not covered by other courses. The emphasis is on non-technical issues such as making a budget, finding a church, balancing career and family, etc. The course is conducted as a trip off-campus to further strengthen relationships with the department. *Prerequisite: Senior status.*

COS 492   3-4 hours
Senior Project
Designed to exercise each senior's technical analysis, design, and development skills and showcase his/her documentation and presentation skills. The student develops a project through multiple phases of the software lifecycle frequently beginning at the design stage. The project is typically chosen to reflect the student's area of concentration. *Prerequisite: Senior status.*

COS 493   **2 hours**
Engineering Senior Capstone I
The first of a three course culminating experience preparing students for engineering practice through a major design and implementation project. *Prerequisite: Senior status, CEN major. Offered Fall semester.*

COS 494   **3 hours**
Engineering Senior Capstone II
The second in a three course culminating experience preparing students for engineering practice through a major design and implementation project. *Prerequisite: COS 493. Offered January interterm.*

COS 495   **1 hour**
Engineering Senior Capstone III
The third of a three course culminating experience preparing students for engineering practice through a major design and implementation project. It includes the Engineering poster session for assessment of the project. *Prerequisite: COS 494. Offered Spring semester.*

Systems Courses

SYS 101   **3 hours**
Introduction to Systems
This course provides a foundational understanding of systems thinking and the principles involved in designing, developing, and managing complex systems. Students learn how to identify and analyze systems components, their relationships, and system performance. Key topics include systems modeling, quality, systems thinking, and problem solving. Students will also learn about relational database concepts and structured query language (SQL), which are essential for managing data in modern systems. *Meets foundational core computation requirement.*

SYS 120   **4 hours**
Introduction to Problem Solving
An introduction to problem solving strategies applied to problems from numerous domains, resulting in the development of algorithms that are programmed in Python. The basic control structures, functions and parameter passing, and the concept of abstraction are all emphasized. Simple data structures (e.g., lists and dictionaries) and basic file processing are introduced. Incremental construction of large programs is practiced. *Three hours of lecture and two hours of lab per week. Meets foundational core computation requirement.*

SYS 125   **2 hours**
Introduction to Object Oriented Programming
This course is an introduction to object oriented design and programming. Students will apply problem solving strategies to devise OOD descriptions of problems formerly solved via procedural coding methods. Implementation of increasingly complex OOD solutions will be carried out in the Python programming language. *Prerequisite: COS 120 or SYS 120.*

SYS 170   **1-4 hours**
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

SYS 214   **3 hours**
Principles of Human Computer Interaction
This course discusses the analysis, design, development, and evaluation of interfaces allowing humans to interact with computers and the presentation of information in formats designed for human understanding. People-centered design is emphasized through prototyping and information visualization are also discussed.

SYS 270   **1-4 hours**
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

SYS 310   **3 hours**
E-Commerce
Examines the development of and future prospects for electronic commerce. It focuses on the use of electronic transmissions to engage in exchange of products and services. Students will consider the emerging changes in business as well as the new opportunities for entrepreneurship brought on by e-commerce. They will explore the dynamics of technical innovations as well as the organizational and societal consequences of moving commerce electronically. They will also evaluate the operations of a variety of web-based businesses. Guest speakers from industry will lecture regarding the technical, economic, and political/regulatory aspects of e-commerce. *Prerequisites: COS 120 or COS 130 or COS 143 or SYS 120; and COS 102 or SYS 101.*

SYS 330   **3 hours**
Human Relations in Organizations
The necessity of constructive conflict in organizations and the inevitability of destructive personal conflict are the reasons for studying human relations. Five books, some classics like Carnegie's How to Win Friends and Influence People, some near classics like Covey's The Seven Habits of Effective People, and possible future classics like Sande's The Peacemaker, are read and discussed. The goal is to improve understanding of conflict: That constructive conflict is healthy and necessary, how creative conflict can degenerate into destructive personal conflict, the causes of team dysfunction, how to achieve team synergy, and personal techniques for engaging in constructive conflict, avoiding destructive conflict and redeeming it should it happen. The Bible is used as a discussion resource. The pre-supposition of the course is that evangelical Christian culture encourages conflict avoidance within the culture and often without. Some strive to be "meek and mild" like Jesus, an aspiration that belies an incomplete understanding of Jesus' character and behavior. This is a writing course with a strong emphasis on discussion. *Meets foundational core social science requirement.*

SYS 352   **3 hours**
Knowledge Based Systems
Prominent knowledge-based system approaches are introduced including crisp production rule systems and fuzzy logic systems. Principles of knowledge acquisition are taught and applied. Various forms of knowledge representation are experienced, including rules, nets, frames, and predicate logic. Programming is primarily in CLIPS. *Prerequisites: COS 121; and COS 102 or SYS 101.*

SYS 360   **1-4 hours**
Independent Study
An individualized, directed study involving a specified topic.

SYS 370   **1-4 hours**
Selected Topics
A course offered on a subject of interest but not listed as a regular course offering.

SYS 390   **3 hours**
Information Systems Analysis
A study of the knowledge and skills needed to conduct the definition and analysis phases of an information system project. Central concepts are quality management and business process reengineering. Problem definition, information gathering, user experience modeling, data and process modeling, and specification of logical system requirements using a business event methodology are emphasized. Learning is by doing: a major project is begun in this course and completed in SYS 394. *Prerequisites: Junior standing; COS 120 or COS 130 or COS 143 or SYS 120; and COS 102 or SYS 101.*

SYS 393   **1-4 hours**
Practicum
Supervised learning involving a first-hand field experience or a project. Generally, one hour of credit is awarded for a minimum of 40 hours of practicum experience. *Offered primarily during Summer.*

SYS 394   **4 hours**
Information Systems Design
A study of the knowledge and skills needed to conduct the design and construction of an information system project. Central concepts are translating requirements into a physical design, project management, and deployment of information systems architectures. Students will learn and use application technologies empowering modern business systems. Learning is by doing; the major project defined and analyzed in SYS 390 will be designed and built. *Prerequisites: COS 120 or COS 130 or SYS 120; COS 121 or COS 143; and SYS 390.*

SYS 402   **3 hours**
Modeling and Simulation
A study of mathematical modeling and simulation methods, focusing on discrete systems. Simil and pysym are used in hands on exercises. Many applications are surveyed and group term projects are carried out. *Prerequisites: COS 121 or COS 143; MAT 210 or MAT 352; MAT 151.*

SYS 411   **3 hours**
Machine Learning
Classification learning systems of various types are explored. These include statistical pattern recognition, neural networks, genetic algorithms, and methods for inducing decision trees and production rules. Industry standard ML modules are utilized. Group term projects allow development of and experimentation with small ML solutions of interest. *Prerequisites: COS 121; and MAT 210 or MAT 352. COS 265 is strongly recommended.*

SYS 450   **1-4 hours**
Directed Research
Investigative learning involving closely directed research and the use of such facilities as the library or laboratory.

SYS 480   **1-4 hours**
Seminar
A limited-enrollment course designed especially for upper-class majors with emphasis on directed readings and discussion.

SYS 490   **1-2 hours**
Honors
Individualized study or research of an advanced topic within a student's major. *Open to students with at least a 3.00 GPA in the major field.*