COMPUTER SCIENCE

Undergraduate Degree Programs

We offer several Bachelor of Science degree programs: the Computer Science major and three newer specialized majors: Cybersecurity, Software Engineering, and Information Technology. There also are two interdepartmental majors with their own administrative structure: Bioinformatics and Data Science. There also is a Computational Science track within the Applied Mathematics major managed by the mathematics department. Also, there are two combined majors with mathematics and physics, respectively. We also offer minors in computer science, computer crime and forensics, and information technology. Finally, students can enroll in a streamlined dual-degree BS/MS program.

Undergraduate Programs

- Computer Crime and Forensics Minor (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/computer-crime-forensics-minor/)
- Computer Science (BS) (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/computer-science-bs/)
- Computer Science (BS/MS) (https://catalog.luc.edu/undergraduate/accelerated-bachelors-masters-program/computer-science-bs-ms-dual-degree-programs/)
- Computer Science Minor (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/computer-science-minor/)
- Cybersecurity (BS) (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/cybersecurity-bs/)
- Departmental Honors (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/departmental-honors/)
- Information Technology/Computer Science (BA/MS) (https://catalog.luc.edu/undergraduate/accelerated-bachelors-masters-program/information-technology-computer-science-ba-ms/)
- Information Technology (BS) (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/information-technology-bs/)
- Information Technology (BA/MS) (https://catalog.luc.edu/undergraduate/accelerated-bachelors-masters-program/information-technology-bams/)
- Information Technology (BS/MS) (https://catalog.luc.edu/undergraduate/accelerated-bachelors-masters-program/information-technology-bsms/)
- Information Technology Minor (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/information-technology-minor/)
- Physics with Computer Science (BS) (https://catalog.luc.edu/undergraduate/arts-sciences/physics/physics-computer-science-bs/)
- Software Engineering (BS) (https://catalog.luc.edu/undergraduate/arts-sciences/computer-science/software-engineering-bs/)
- Software Engineering (BS/MS) (https://catalog.luc.edu/undergraduate/accelerated-bachelors-masters-program/software-engineering-bsms/)

Computer Science Department Policies

"Double-Dipping" Rules

Computer Science Qualifiers to the College of Arts & Sciences Double-Dipping Policy for Majors and Minors

April 15, 2016

This document seeks to lay out exceptions and clarifications to College of Arts & Sciences **(CAS)** policies for awarding multiple majors or minors, in so far as they relate to any of the majors and minors administered by the Computer Science Department or that constitute an interdepartmental program in which Computer Science is one of the constituent departments. These include the following majors:

- "Communication Networks and Security" **(CNWS-BS)**
- "Computer Science" **(COMP-BS)**
- "Information Technology" **(ITEC-BS)**
- "Software Engineering" **(SWEN-BS)**
- "Mathematics & Computer Science" **(MCSC-BS)**
- "Physics & Computer Science" **(PCSC-BS)**
- "Bioinformatics" **(BIOI-BS)**

and minors:

- "Computer Science" **(COMP-MINR)**
- "Information Technology" **(ITEC-MINR)**
- "Computer Crime and Forensics" **(CCFR-MINR)**

1. Minors prohibited because of being entirely or almost entirely included in the student's major include "Computer Science" **(COMP-MINR)** and "Information Technology" **(ITEC-MINR)** for any student majoring in "Communication Networks and Security" **(CNWS-BS)**, "Computer Science" **(COMP-BS)**, "Information Technology" **(ITEC-BS)**, "Software Engineering" **(SWEN-BS)**, "Mathematics & Computer Science" **(MCSC-BS)**, or "Physics & Computer Science" **(PCSC-BS)**.
2. The minor in "Computer Crime and Forensics" **(CCFR-MINR)** is permitted with any major since it constitutes a meaningful addition (6 credits) and focuses (restriction of 3–6 elective credits) beyond the general requirements of any major.
3. A minor in one of "Computer Science" **(COMP-MINR)** or "Information Technology" **(ITEC-MINR)** is permitted with a major in "Bioinformatics" **(BIOI-BS)** since it constitutes an addition of at least 3 credits and a restriction of at least 3 elective credits and helps an external audience to recognize the extent of computer science studies, which may not be evident from the "Bioinformatics" degree title.
4. A major in "Mathematics & Computer Science" **(MCSC-BS)** is not meant for a student who completes separate majors in both Mathematics and any of "Communication Networks and Security" **(CNWS-BS)**, "Computer Science" **(COMP-BS)**, "Information Technology" **(ITEC-BS)**, or "Software Engineering" **(SWEN-BS)**, even if extra course work is incorporated.
5. A major in "Physics & Computer Science" **(PCSC-BS)** is not meant for a student who completes separate majors in both Physics and any of "Communication Networks and Security" **(CNWS-BS)**, "Computer Science" **(COMP-BS)**, "Information Technology" **(ITEC-BS)**, or "Software Engineering" (SWEN-BS), even if extra course work is incorporated.
6. Any other combinations of majors will be permitted as long as students respect the general CAS rule that each major should include 21 credit hours not being counted for another major.

Undergraduate Policies and Procedures

Please see Undergraduate Policies and Procedures (https://catalog.luc.edu/undergraduate-academic-standards-regulations/) for

academic policies that supersede those of academic units within the University.

Computer Science (COMP)

COMP 102 Web Design and Multimedia Publishing (3 Credit Hours)
This course introduces foundations of the world wide web technology, HTML, and multimedia publishing techniques. Topics include HTML syntax, CSS, XML, RSS, and various multimedia formats.
Outcomes:
An understanding of the technologies behind web sites and the ability to use them effectively

COMP 104 Computer Animation (3 Credit Hours)
The course introduces techniques for understanding and developing dynamic and interactive media by using sound, motion, images, and text. Relevant software knowledge areas are covered.
Outcomes:
Ability to publish created animated media projects to the web in a process that involves understanding human interface design

COMP 111 History of Computing (3 Credit Hours)
The social and organizational history of humanity is intricately entangled with the history of technology in general and the technology of information in particular. Advances in this area have often been closely involved in social and political transformations. While the contemporary period is often referred to by such names as the Computing and Information Age, this is the culmination of a series of historical transformations that have been centuries in the making. This course will provide a venue for students to learn about history through the evolution of number systems and arithmetic, calculating and computing machines, and advanced communication technology via the internet.
Course equivalencies: X - COMP 111 / HIST 279C

COMP 122 Introduction to Digital Music (3 Credit Hours)
Computers and digital tools have been seeping into the world of music, this course aims to explore this newly formed territory. This course is intended for students who wish to learn more about electronic music, signal processing, and algorithmic music composition.
Knowledge Area: Quantitative Knowledge
Course equivalencies: X-COMP 122/MUSC 122
Outcomes:
Understanding of the physics of musical sound and digital audio, facility with hands-on applications of algorithmic music composition and musicology, and ability to design and render digital instruments

COMP 125 Visual Information Processing (3 Credit Hours)
This course, intended primarily for non-majors, provides an introduction to computer programming using a language well-suited to beginning programmers and practical applications, e.g., Visual Basic.Net. Restricted to Freshman or Sophomore standing OR majors other than COMP-BS AND CSEC-BS AND SWEN-BS.
Knowledge Area: Quantitative Knowledge
Outcomes:
Understanding of computer mechanisms for representing and analyzing numerical and logical information and the power of programmability; practical ability to implement useful computing tools

COMP 141 Introduction to Computing Tools and Techniques (3 Credit Hours)
This course introduces students to the Unix shell environment and essential tools for succeeding in computer science degrees. Students who complete this course will develop fluency in the Unix (Linux) environment, which is essential for solving problems in academic, research, and professional computing disciplines.

COMP 150 Introduction to Computing (3 Credit Hours)
The world overflows with electronic data. This course introduces programming in a simple, powerful language like Python, with selection, repetition, functions, graphical effects, and dynamic interaction with the Internet, plus connections to lower level computer organization and computer implications in the wider world. Restricted to Freshman or Sophomore standing OR majors other than COMP-BS AND CSEC-BS AND SWEN-BS.
Knowledge Area: Quantitative Knowledge
Course equivalencies: ACCOMP 150/COMP 150
Outcomes:
Empowerment to manage and transform masses of data; understanding of technical, societal, and ethical issues involved

COMP 163 Discrete Structures (3 Credit Hours)
Pre-requisites: MATH 117 or placement
This course covers the mathematical foundations of computer science, including such topics as complexity of algorithms, modular arithmetic, induction and proof techniques, graph theory, combinatorics, Boolean algebra, logic circuits, and automata.
Interdisciplinary Option: Bioinformatics
Course equivalencies: COMP211/COMP163
Outcomes:
The student will be prepared for the study of advanced ideas in computer science, from cryptography to databases to algorithms to computer architecture

COMP 170 Introduction to Object-Oriented Programming (3 Credit Hours)
Pre-requisites: MATH 118 or Placement or COMP 125 or COMP 141 or COMP 150 or COMP 180 or permission or SCPS student; Prior experience with a procedural programming language is sufficient to obtain permission to enroll
This programming intensive course with its weekly lab component introduces basic concepts of object-oriented programming in a language such as Java.
Interdisciplinary Option: Bioinformatics
Course equivalencies: COMP170/ISOM/INFS370
Outcomes:
Ability to take a problem, break it into parts, specify algorithms, and express a solution in terms of variables, data types, input/output, repetition, choice, arrays, subprograms, classes, and objects; ability to judge a good program

COMP 171 Scripting Languages (1 Credit Hour)
Scripting languages are rapid prototyping languages that are used extensively. This course covers the principles, syntax and semantics of widely used scripting languages.
Outcomes:
Students will learn how a program can be put together quickly and efficiently to solve problems

COMP 180 Computing and Data Analysis for the Sciences (3 Credit Hours)
Scientific computing emphasizes data analysis and visualization in a scientific context - analyzing data quickly for understanding by the individual, sharing automated workflows with collaborators, and preparing results for later publication. This course will emphasize rapid, interactive, and reproducible collaborative analysis of data for scientific contribution. Students are required to have taken MATH 117: College Algebra as a prerequisite or to have been placed in MATH 118: Precalculus or higher. At the end of this course, students will be well versed in the use of a specific, interactive environment for data analysis (likely Python, R, or MATLAB as indicated in the course notes) for analyzing data and sharing results.
Interdisciplinary Option: Neuroscience

COMP 215 Object Oriented Programming with Mathematics (3 Credit Hours)
Pre-requisites: MATH 132 or MATH 162 or MATH 162A
This is an introductory programming course for students interested in mathematics and scientific computing. Students will program primarily in a general object-oriented language such as Python, with supplementary exercises in a computer algebra system. Examples will be drawn primarily from applications of calculus, elementary number theory, and cryptography.
Course equivalencies: X-COMP215/MATH215
Outcomes:
Students will learn basic scripting and object-oriented programming, with the goal of being able to solve mathematical and scientific problems

COMP 231 Data Structures & Algorithms for Informatics (3 Credit Hours)
Pre-requisites: (MATH/COMP 215 OR COMP 170) AND (COMP 141 OR AMTH-BS OR MATH-BS) Advisory: MATH/COMP 215 preferred
This course introduces data structures and algorithms that are essential for data science and informatics. Here we will focus on identifying the right method for storing data and using the most efficient algorithm for analysis. A subset of data structures and algorithms fundamental to computer science will be covered.
Outcomes:
Students will learn fundamental data structures and algorithms frequently used in informatics and data science; Students will be able to apply this knowledge for data analysis

COMP 250 Introduction to Scientific and Technical Communication (3 Credit Hours)
Pre-requisites: A minimum grade of C- in COMP 125 or COMP 150 or COMP 170 or COMP/MATH 215
This course trains students in writing clear, readable, and well-organized technical communications, including presentations, end-user documentation, internal project documentation, and scientific papers.
Outcomes:
Students will learn to write clear technical documentation

COMP 251 Introduction to Database Systems (3 Credit Hours)
Pre-requisites: COMP 125 or COMP 150 or COMP 170 or COMP 180 or COMP/MATH 215
This course explores ways in which data collections are organized, stored, analyzed, and manipulated. Topics include relational databases, the SQL query language, and the basics of XML and web interfaces to data sets. Applications from a variety of domains illustrate the course's key concepts.
Course equivalencies: COMP 251 / COMP 368
Outcomes:
Students will organize data in ways to emphasize relationships, write simple programs to process, visualize and graphically display data, mine data for patterns, and design web interfaces to data

COMP 264 Introduction to Computer Systems (3 Credit Hours)
Pre-requisites: COMP 141 and (COMP 170 or MATH/COMP 215) and (coreq or prereq of COMP 163 or MATH 201); COMP 163 coreq or prereq and COMP 170 prereq preferred
This course studies the hierarchy of abstractions and implementations that constitute a modern computer system, with a particular focus on issues of interest to programmers, typically including some systems programming instruction.
Outcomes:
Understanding of system issues that affect the performance, correctness, or utility of user-level programs

COMP 266 Digital Electronics Lab (3 Credit Hours)
Combinatorial and sequential logic devices, oscillators and timers, microprocessor components, CPU operation, computer architecture and digital/analog conversion.
Course equivalencies: X-PHYS266/COMP266
Outcomes:
Students will gain a working knowledge of digital electronics design and its application to computers, an understanding of CPU design and operation and the ability to document and report experimental results

COMP 271 Data Structures I (3 Credit Hours)
Pre-requisites: COMP 141 and COMP 170 and (co-requisite or pre-requisite of COMP 163 (preferred) or MATH 201); For Bioinformatics majors, pre-requisite of COMP 141 and COMP 170; For SCPS students, pre-requisite of COMP 170
This course studies basic data structures including array lists, linked lists, stacks, queues, binary trees, and hash tables. Efficiency of data structure operations, study of recursion, applications of data structures, and simple analysis of algorithms are covered.
Interdisciplinary Option: Bioinformatics
Outcomes:
Students learn linear data structures and the performance of their operations, and they learn to solve simple computational problems by designing suitable algorithms and efficient data structures

COMP 272 Data Structures II (3 Credit Hours)
Pre-requisites: COMP 271 and (COMP 163 or MATH 201) and (MATH 131 or MATH 161)
This course studies advanced abstract data types, such as sets, maps, and graphs, and their implementation using arrays and dynamically allocated nodes in an object-oriented language. The course also studies the performance of the data structures built-in operations and related algorithms such as sorting, searching, and traversing.
Outcomes:
Students learn non-linear data structures and runtime performance of their operations, solve computational problems by choosing suitable data structures, and implement algorithms within the object-oriented paradigm

COMP 301 Introduction to Computer Security (3 Credit Hours)
Pre-requisites: COMP 170
This is an introductory course on computer security covering a broad range of topics, including basic security goals, encryption, penetration testing, software exploitation, reverse engineering, packet sniffing, and secure coding. The course teaches both the principles and concepts of computer security as well as some of the tools and technologies. Students will learn to think like an adversary, find and exploit vulnerabilities in computer and network systems, understand cryptography and security goals, and learn about some of the commonly-used tools.

COMP 305 Database Administration (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 251 or COMP 271
Business and scientific institutions increasingly use large commercial data base systems. This course teaches the theory and practice for the definition, security, backup, tuning, and recovery of these systems.
Outcomes:
Students will be able to use theory and pragmatic approaches to define and implement realistic solutions for large database administration environments

COMP 306 Data Mining (3 Credit Hours)
Pre-requisites: (COMP 231 or COMP 251 or COMP 271) and (STAT 103 or STAT 203 or ISSCM 241 or PSYC 304 or instructor permission)
This course covers theory and practice of the analysis (mining) of extremely large datasets. With data growing at exponential rates knowledge gathering and exploration techniques are essential for gaining useful intelligence.
Outcomes:
Students will be able to define and critically analyze data mining approaches for fields such as security, healthcare, science and marketing

COMP 309 Numerical Methods (3 Credit Hours)
Pre-requisites: (COMP 170 or MATH/COMP 215), and [(MATH 212, and MATH 264) or MATH 266]
This course offers an introduction to topics such as error analysis, interpolation and approximation, and the numerical solution of problems involving differentiation, integration, and ordinary and partial differential equations. Students will obtain an understanding of how numerical methods can be used in a variety of areas of mathematics.
Course equivalencies: X-COMP309/MATH309

COMP 310 Operating Systems (3 Credit Hours)
Pre-requisites: COMP 264 and COMP 272
This course introduces principles of operating systems and how they are designed. Various important parts of operating systems such as memory addressing, file structures, processes, and threads are covered.
Outcomes:
Students will learn the different parts of an operating system at a functional level and how they interact with each other

COMP 312 Open Source Software Practicum (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271 or instructor permission
This course will cover the fundamentals of Free and Open Source software development. Topics to be addressed include licensing, Linux, typical software development tools, applications, and techniques for managing remote servers.
This course satisfies the Engaged Learning requirement.
Outcomes:
Students will learn to implement projects involving Free and Open Source software and learn how to participate in open-source projects effectively

COMP 313 Object-Oriented Design (3 Credit Hours)
Pre-requisites: COMP 272
Object-orientation continues to be a dominant approach to software development. This intermediate programming-intensive course studies the use of classes and objects with an emphasis on collaboration among objects.
Outcomes:
A thorough understanding of the principles of object-orientation: abstraction, delegation, inheritance, and polymorphism; exposure to basic design patterns; programming experience in mainstream object-oriented languages such as C++ and Java

COMP 314 Problem Solving Strategies I (1 Credit Hour)
Pre-requisites: COMP 271
Corequisite or This course allows students to sharpen problem-solving skills along with, or as part of, the ACM Programming Team. Groups generally work on old competition problems on alternate weekends, with short follow-ups during the next week.
Course equivalencies: COMP281/COMP314
Outcomes:
Ability to work in small groups, quickly and accurately assessing and solving focused problems involving many sorts of programming knowledge

COMP 315 Problem Solving Strategies II (2 Credit Hours)
Pre-requisites: COMP 314
This course allows students to sharpen problem-solving skills along with, or as part of, the ACM Programming Team. Groups generally work on old competition problems on alternate weekends, with short follow-ups during the next week.
Outcomes:
Ability to lead a small group, quickly and accurately assessing and solving focused problems involving many sorts of programming knowledge

COMP 317 Social, Legal, and Ethical Issues in Computing (3 Credit Hours)
Pre-requisites: Any COMP course and Ethics Core
This course covers social, legal, and ethical issues commonly arising in key areas related to computing technologies.
Interdisciplinary Option: Sociolegal Studies
Outcomes:
Understanding of laws and issues in areas such as privacy, encryption, freedom of speech, copyrights and patents, computer crime, and computer/software reliability and safety; understanding of philosophical perspectives such as utilitarianism versus deontological ethics and basics of the U.S. legal system

COMP 319 Introduction to UNIX (1 Credit Hour)
Pre-requisites: COMP 170 and COMP/MATH 215
An introduction to the UNIX operating system. Topics include files and directories, electronic mail, security, advanced file systems, network utilities, network file sharing, text utilities, shell programming, UNIX internals, UNIX system administration (essentials), the X windowing system, systems programming, and secure shell (SSH).
Course equivalencies: COMP219/COMP319
Outcomes:
After taking this course, students will develop working knowledge of Unix and be able to use modern Unix operating systems such as Linux, OS X, or Solaris

COMP 321 Computational Aspects of Modeling and Simulation (3 Credit Hours)
Pre-requisites: STAT 203 or STAT 335
This course uses SAS and R languages to address statistical modelling and to conduct statistical simulations to assess linear, generalized linear, nonlinear and complex models and experimental designs.
Course equivalencies: X-STAT356/COMP321/STAT321
Outcomes:
Students will gain practical experience and knowledge in real-world statistical situations for which underlying theory is cumbersome or intractable

COMP 322 Software Development for Wireless and Mobile Devices (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
This course will focus on the unique challenges, methods, tools, and technologies for developing software applications for wireless and mobile devices, smart mobile phones, and the growing world of mobile connected devices.
Outcomes:
1) Understand challenges of software design for resource limited devices; 2) Know the architecture of one or more state-of-the-art mobile operating systems; 3) Gain experience designing, developing, testing embedded software

COMP 323 Game Design and Development (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
This course studies design, development, and publication of games and game-based applications. This includes example games and designers, industry practices, and team-based project development.
Outcomes:
Students will acquire an awareness of different game design and development methods, technologies, and techniques suitable for the development of a variety of game based environments

COMP 324 Client-Side Web Development (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
This course covers the design and implementation of the presentation layer of dynamic web applications. Topics include visual design and usability, multi-channel and multi-modal applications, markup of static and dynamic content, and client-side executable content. HTML/CSS/JavaScript are introduced quickly, followed up with the stack of current JavaScript frameworks and libraries used in practice.
Outcomes:
Familiarity with the most common effective tools for creating responsive, dynamic, and interactive web content with client-side tools

COMP 325 Rapid Application Development Methodology (3 Credit Hours)
Pre-requisites: COMP 271 with a grade of C- or above
This course will teach students how to effect rapid application development using a software framework such as the .NET Framework. Particular emphasis will be placed on enhancing object-oriented programming skills using a language such as C#.NET.
Outcomes:
Students will gain enhanced skill in object-oriented programming and development of such applications as database applications, web applications, Microsoft .NET services, Silverlight applications, and WCF Services

COMP 328 Algebraic Coding Theory (3 Credit Hours)
Pre-requisites: MATH 212
Codes with algebraic structure for error control are examined. Block codes including Hamming codes and Reed-Muller codes, BCH codes, and other cyclic codes with algebraic structure and other cyclic codes and their implementation are treated. Other topics may include: convolutional codes, efficiency considerations, and Shannon's fundamental theorem of information theory.
Course equivalencies: X-MATH328/COMP328

COMP 329 Natural Language Processing (3 Credit Hours)
Pre-requisites: (COMP 231 or COMP 271) and (MATH 131 or MATH 161) and (STAT 103 or STAT 203 or ISSCM 241 or PSYC 304 or instructor permission)
This course provides an introduction to the field of natural language processing (NLP). NLP is concerned with computational approaches to analyzing, generating, and understanding human language. This course will introduce the students to the problems, methods, and applications of NLP.
Outcomes:
Students will become familiar with such areas of natural language processing as information retrieval, sentiment analysis, machine translation, document classification, and question answering

COMP 330 Software Engineering (3 Credit Hours)
Pre-requisites: COMP 271
Students learn real-world theory and techniques organizations use to create high-quality software on time. Students work on a large programming team to create plans, review progress, measure quality, and make written and oral analyses of their project.
Outcomes:
Students will experience process based development, understand the dynamics of a professional software organization, and develop skills for implementing software with others

COMP 331 Mathematical Foundations of Cryptography (3 Credit Hours)
Pre-requisites: Theoretical Foundations: MATH 201 or COMP 363; Programming Foundations: COMP125 or COMP150 or COMP170 or COMP 180 or COMP/MATH 215
This course introduces the formal foundations of cryptography and also investigates some well-known standards and protocols, including private and public key cryptosystems, hashing, digital signatures, RSA, DSS, PGP, and related topics.
Course equivalencies: X-COMP331/MATH331
Outcomes:
Students will gain an understanding of cryptosystems widely used to protect data security on the internet, and be able to apply the ideas in new situations as needed

COMP 332 Requirements Engineering (3 Credit Hours)
Pre-requisites: COMP 330
This course aims to equip students with techniques for successful requirements analysis and requirements engineering (RE) of software-intensive systems. Students will learn a systematic process of developing requirements through co-operative problem analysis, representation, and validation.
Outcomes:
Students will learn and apply the current state of the art in requirements engineering and a systematic method for engineering high-quality requirements on realistic large-scale projects

COMP 333 Web Services Programming (3 Credit Hours)
Pre-requisites: COMP 313
Web services are building blocks for enterprise applications that use open data exchange standards and transport protocols to exchange data with calling clients. This course studies the architectures, frameworks, and tools required to develop and compose web services and clients, as well as integrate service-oriented systems with legacy systems.
Outcomes:
An understanding of the design space of software architecture; Proficiency in designing, implementing, deploying and composing systems from web services

COMP 335 Formal Methods in Software Engineering (3 Credit Hours)
Pre-requisites: COMP 313
As embedded and networked systems are becoming ever more ubiquitous, we depend increasingly on the correctness of the software that controls such systems. This course studies the formal specification, verification, and synthesis of software.
Outcomes:
An understanding of the role of formal methods in the construction of software systems; proficiency in representative methods and tools, such as UML and ESC

COMP 336 Markup Languages (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
This course is concerned with XML and its various component frameworks. The core frameworks to be covered include Document Object Model (DOM), Simple API for XML processing (SAX), the XML Path language (XPath), and XSLT.
Outcomes:
After taking this course, students will have working knowledge of XML and its connections to other ideas such as HTML, object models, relational databases, and network services

COMP 337 Concurrent Programming (3 Credit Hours)
Pre-requisites: COMP 313
Many real-world software systems rely on concurrency for performance and modularity. This programming-intensive course covers analysis, design, implementation, and testing of concurrent software systems.
Outcomes:
An in-depth understanding of event-based and thread-based views of concurrency; the ability to develop concurrent software components using suitable languages, frameworks, and design patterns; familiarity with object-oriented modeling and development tools and test-driven development

COMP 338 Server-based Software Development (3 Credit Hours)
Pre-requisites: COMP 313
Server-based web applications and services have become part of everyday life. This programming-intensive course covers analysis, design, implementation, and testing of multi-tiered server-based software systems along with typical tier-specific technologies.
Outcomes:
An understanding of software architecture and integration in the development of multi-tiered server-based software; familiarity with object-oriented modeling and development tools and test-driven development

COMP 339 Distributed Systems (3 Credit Hours)
Pre-requisites: COMP 313 or COMP 363 or COMP 310
This course covers topics in modern distributed systems. This course places special emphasis on scalability (performance), reliability/fault tolerance, and security.
Outcomes:
After taking this course, students should understand the essential ingredients of distributed systems and how to build distributed systems that are resilient to transient network failures and other potential anomalies

COMP 340 Computer Forensics (3 Credit Hours)
Pre-requisites: (COMP 150 or COMP 170 or COMP/MATH 215) and (COMP 264 or COMP 317 or COMP 343)
The course introduces the fundamentals of computer/network/internet forensics, analysis and investigations.
Outcomes:
The student will learn computer software and hardware relevant for analysis, and investigative and evidence-gathering protocols

COMP 341 Human-Computer Interaction (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
Limitations in human-computer interaction are as much due to human factors, cognitive limits, expectations, motivations, and inertia as technological capabilities. Systematic methods will be used to evaluate and improve designs through both qualitative feedback and statistical, hypothesis-driven testing on web pages, GUIs, mobile apps and many non-traditional interfaces.
Outcomes:
Students will be exposed to a wide array of non-traditional computing interfaces, and be able to evaluate, design and develop better human-computer interfaces using research-based, systematic approaches

COMP 342 Introduction to Web Application Development (3 Credit Hours)
Pre-requisites: COMP 170
An introduction to webpage development using JavaScript, jQuery and associated client-side tools.
Course equivalencies: X- DIGH403/CPST342/COMP342
Outcomes:
Students will be able to create webpages using JavaScript and related tools and protocols, and interface a webpage with a database

COMP 343 Computer Networks (3 Credit Hours)
Pre-requisites: COMP 264 or COMP 271 or instructor permission
This course surveys packet-switched computer networks and attendant communication protocols, using the TCP/IP protocol suite on which the Internet is based as the primary model. Some programming may be required.
Outcomes:
Students will understand how the Internet is constructed, how data is routed to its destination, how connections are made, how congestion is handled, and how security can be addressed

COMP 344 Hands-on Approach to Security & Privacy (3 Credit Hours)
Pre-requisites: COMP 301
This course will introduce students to privacy, cybersecurity competitions, and how computers can be compromised and secured.
Outcomes:
Students will start thinking like an adversary, learn how to find exploits in software and computer networks, and how to be a cybersecurity professional

COMP 345 Internet of Things Device and Application Security (3 Credit Hours)
Pre-requisites: COMP 301
It introduces the Internet of Things (IoT) comprising embedded devices and cloud-based resources. The course studies concepts and techniques used in designing and implementing IoT systems providing valuable functionality to consumers and valuable data to organizations. The course discusses methods for addressing related safety, security, reliability, and privacy concerns.
Outcomes:
Ability to design and implement secure software and establish safety, security, reliability, and privacy goals for embedded and IoT-based systems; Ability to visualize and analyze data from an IoT system

COMP 346 Telecommunications (3 Credit Hours)
Pre-requisites: COMP 264 or COMP 271
This course introduces the fundamental concepts of telecommunication networks, including requirements of voice networks, analog versus digital transmission, data link protocols, SONET, ATM, cellular phone systems, and the architecture of the current telephone system.
Outcomes:
Students will understand how modern telephone systems work

COMP 347 Intrusion Detection and Security (3 Credit Hours)
Pre-requisites: COMP 301
This course covers techniques and algorithms for detecting unusual usage patterns that typically signal a break-in, including techniques for detecting evasive or stealthy attacks. Also covered are differences in detecting local versus network intruders. Additional topics: computer viruses, computer security management, computer forensics.
Outcomes:
Students will learn to configure ID systems (eg SNORT) and analyze their output; They will also understand both network-based and host-based monitoring techniques

COMP 348 Network Security (3 Credit Hours)
Pre-requisites: COMP 301
This course involves a discussion of network security through the following areas which lead to an overall security posture: Security Frameworks, Implementation Security, System Best Practices, a Case for Centralized Configuration Management, Network Security Architecture, Standards Adherence, Risk Assessments, Testing and Review and Application Security.
Outcomes:
An understanding of how to secure networks using encryption, authentication, perimeter protection, restricted access policies, intrusion detection/prevention and other security frameworks

COMP 349 Wireless Networking and Security (3 Credit Hours)
Pre-requisites: COMP 301
This course will explore the wireless standards, authentication issues, and common configuration models for commercial versus institutional installations and analyze the security concerns associated with this ad-hoc method of networking.
Outcomes:
Students will gain an understanding of wireless networking, protocols, and standards and security issues

COMP 351 Network Management (3 Credit Hours)
Pre-requisites: COMP 264 or COMP 271
This course introduces the current state of the art in automated management of computer networks, including protocols such as SNMP and its attendant naming conventions, network management systems, and important issues in administrative network configuration.
Outcomes:
Students will become familiar with the SNMP protocol, with how large-scale Network Management Systems operate and are configured, and with advanced network configuration

COMP 352 Computer Vulnerabilities (3 Credit Hours)
Pre-requisites: COMP 264 and COMP 301
This course will introduce students to computer vulnerabilities at the machine-code level, including viruses, browser vulnerabilities, buffer and heap overflows, return-to-libc attacks and others.
Outcomes:
Describe some recent computer software vulnerabilities at the machine-code level and how they can be leveraged into an attack; Run a virus in a virtual-machine sandbox with appropriate monitoring

COMP 353 Database Programming (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 251 or COMP 271
This course introduces relational and object databases to support database creation and application development. Use of commercial database products will give a practical orientation.
Course equivalencies: COMP353/BIOI353
Outcomes:
Students will learn SQL, database design and application development using the latest software tools; Students will also learn techniques for web based data retrieval and manipulation

COMP 358 Big Data Analytics (3 Credit Hours)
In this course, large data sets will be leveraged to solve challenging analytics problems. With more samples, analytics can use more complex learning models to automate more feature combinations for more robust model tuning, selection, and validation. Parallel, distributed processing will be performed with Apache Spark and Hadoop. ((Database experience: COMP 251 OR COMP 305 OR COMP 353) AND (Analytics experience: COMP 300 OR COMP 379 OR STAT 338 OR STAT 308)) OR permission of instructor.
Outcomes:
Python or R will be used with parallel frameworks to perform proper model selection when testing large combinations of features, models, hyperparameters, and ensembles, with additional emphasis on deep learning

COMP 362 Computer Architecture (3 Credit Hours)
This course covers computer design from the level of digital logic and circuit design to high-level computer organization.
Course equivalencies: COMP 260 / COMP 275 / COMP 362
Outcomes:
A basic understanding of how computers work at many levels and how to use various analytical tools and techniques to design computer components

COMP 363 Design and Analysis Computer Algorithms (3 Credit Hours)
Pre-requisites: COMP 272 and (MATH 132 or MATH 162)
Theoretical design and analysis of computer algorithms may be supplemented by small amounts of programming.
Interdisciplinary Option: Bioinformatics
Course equivalencies: X-COMP363/BIOI363
Outcomes:
The ability to design and analyze efficient algorithms; understanding of the necessary models and mathematical tools; understanding of a variety of useful data structures and fundamental algorithms; exposure to the classification of computational problems into different complexity classes

COMP 364 High Performance Computing (3 Credit Hours)
Pre-requisites: COMP 264 and COMP 272
This course covers parallel architectures and parallel models of computation. Algorithms for achieving high performance in various computational contexts are discussed. Models such as shared memory, message passing, and hybrid modes of computing are introduced.
Outcomes:
Students will learn how to engineer solutions to practical problems in multiprocessor architectures and using large physical memories

COMP 366 Microcomputer Design & Interfacing (3 Credit Hours)
Pre-requisites: COMP 271
This course covers computer architecture, CPU logic, data acquisition, signal conditioning, analog/digital conversion and computer interfacing.
Course equivalencies: X-PHYS366/COMP366
Outcomes:
Students will gain a working knowledge of interfacing techniques and design, hands-on experience with professional interfacing hardware and software, and the ability to document and report experimental results

COMP 367 Robotics Software Development (3 Credit Hours)
Pre-requisites: COMP 271; COMP 313 recommended
This course is an introduction to robotics and robotic software development using humanoid robots. The course will use modern robot platforms and provide hands on experience with robotic sensor systems, motion and navigation, robot behavior planning and implementation.
Outcomes:
Students will explore the history of robotics, overview the theory of autonomous robotic systems, and develop complete robot projects

COMP 369 Physical Design and Fabrication (3 Credit Hours)
This course explores the role of products in the economy and how things are made, including: product conceptualization and design, physical design vs. design of things that are not physical, rapid prototyping, 3D printing, 2D conceptualization and sketching, 3D modeling, and design reviews.
Outcomes:
Students will be able to visualize ideas via sketching basic shapes, create 3D models using 3D modeling software, use a 3D Printer, and give constructive feedback in peer review sessions

COMP 370 Software Quality (3 Credit Hours)
Pre-requisites: COMP 330
The course teaches software testing and quality control concepts, principles, and techniques including black box and white box testing, coverage testing, test case development, and regression testing.
Outcomes:
Students will learn how to prevent errors, how to get 'bugs' out of software, and be able to apply this knowledge in other courses and projects

COMP 371 Programming Languages (3 Credit Hours)
Pre-requisites: COMP 264 and COMP 272
There are over two thousand programming languages. This course studies several languages that represent the much smaller number of underlying principles and paradigms.
Outcomes:
An understanding of key principles and paradigms underlying the design and implementation of commonly used programming languages; exposure to formal mechanisms for describing language syntax and semantics; programming experience in several representative languages

COMP 373 Advanced Object-Oriented Programming (3 Credit Hours)
Pre-requisites: COMP 313
Object-orientation continues to be a dominant approach to software development. This advanced programming-intensive course studies object-oriented analysis, design, and implementation from a design patterns perspective.
Outcomes:
Proficiency in the use of object-oriented languages, frameworks, and patterns; advanced understanding of key language mechanisms such as delegation, inheritance, polymorphism, and reflection; familiarity with object-oriented modeling and development tools and test-driven development

COMP 376 Formal Languages & Automata (3 Credit Hours)
Pre-requisites: COMP 163 or MATH 201 or MATH 212 or MATH 266
This course introduces formal language theory, including such topics as finite automata and regular expressions, pushdown automata and context-free grammars, Turing machines, undecidability, and the halting problem.
Course equivalencies: X-COMP376/MATH376
Outcomes:
An understanding of the theoretical underpinnings of computability and complexity in computer science

COMP 377 IT Project Management (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 251 or COMP 271
This course is an introduction to the philosophy and practice of project management. The course involves a student group project to investigate and plan a 'real world' IT project that specifies project objectives, schedules, work breakdown structure and responsibilities, a written interim report, and a final oral and written report.
Outcomes:
Students will learn time management, work-flow management, and team dynamics to design, implement and test large-scale software projects

COMP 378 Artificial Intelligence (3 Credit Hours)
Pre-requisites: COMP 231 or COMP 271
This course introduces artificial intelligence theory and programming.
Outcomes:
Student will learn basic theory of artificial intelligence and be able to build small applications based on it

COMP 379 Machine Learning (3 Credit Hours)
Pre-requisites: (COMP 231 or COMP 271) and (STAT 103 or STAT 203 or ISSCM 241 or PSYC 304 or instructor permission)
Machine learning is the process of making predictions and decisions from data without being explicitly programmed. Topics include a variety of supervised learning methods. Ensemble approaches are used to combine independent models efficiently. Unsupervised and semi-supervised methods demonstrate the power of learning from data without an explicit training goal.
Outcomes:
Students in this course will learn how to apply sophisticated algorithms to large data sets to make inferences for prediction or decision making

COMP 380 Computer Graphics (3 Credit Hours)
Pre-requisites: COMP 271
This course introduces modern theory and practices in 3-D computer graphics, stressing real-time interactive applications using libraries like OpenGL.
Outcomes:
Student will learn how to program real-time interactive applications using libraries like OpenGL

COMP 381 Bioinformatics (3 Credit Hours)
Students will engage in the applications of computer-based tools and database searching to better understand the fields of genetics, genomics, evolutionary biology, and personalized medicine. Students will be introduced to scripting programming languages for analyzing biological data sets.
Interdisciplinary Option: Bioinformatics
Course equivalencies: X-BIOL388/COMP381/BIOI388
Outcomes:
Students will be able to appropriately use computer software and databases to accurately analyze biological data and interpret the results, applying their understanding of genetic processes

COMP 382 Compiler Construction (3 Credit Hours)
Pre-requisites: COMP 264 and 272
This course covers the basics of writing a compiler to translate from a simple high-level language to machine code. Topics include lexical analysis, top-down and LR parsing, syntax-directed translation, and code generation and optimization. Students will write a small compiler.
Outcomes:
Students will learn how a compiler is built

COMP 383 Computational Biology (4 Credit Hours)
Pre-requisites: (COMP 231 or COMP 271) and COMP 381 (Equivalencies: BIOI/BIOL 388)
This course presents an algorithmic focus to problems in computational biology. It is built on earlier courses on algorithms and bioinformatics. Problems and solutions covered in this course include gene hunting, sequence comparison, multiple alignment, gene prediction, trees and sequences, databases, and rapid sequence analysis.
Interdisciplinary Option: Bioinformatics
Course equivalencies: COMP383/BIOI383
Outcomes:
Students will learn, in detail, foundational methods and algorithms in bioinformatics

COMP 386 Computational Neuroscience (3 Credit Hours)
Pre-requisites: C- or better in COMP 150 or COMP 170 or COMP 180
Introduces computational methods to understand neural processing in the brain. Levels of representation from low-level, temporally precise neural circuits to systems-level rate-encoded models, to information-theoretic approaches. Emphasis on sensory systems, primarily vision and audition, most readily demonstrating the need for such computational techniques.
Interdisciplinary Option: Neuroscience
Outcomes:
Appreciation that many aspects of neuroscience cannot be understood without appropriate mathematical or computational frameworks, and ability to adeptly apply these frameworks in the various domains of neuroscience

COMP 388 Topics in Computer Science (1-6 Credit Hours)
This course is used to introduce emerging topics in computer science that do not yet have a regular course number. Content of the course varies.
Outcomes:
Understanding of an emerging area of Computer Science

COMP 390 Broadening Participation in STEM (Computing, Math & Science) (1-3 Credit Hours)
Students will learn about underrepresentation of various population groups in STEM fields (science, technology, engineering, mathematics), as well as some of the reasons and negative effects of this situation. They will learn about techniques and educational materials for ameliorating this situation and will engage in relevant service learning activities.
This course satisfies the Engaged Learning requirement.
Outcomes:
Students gain first-hand experience with broadening STEM participation and seeing how they can make a difference in the lives of other students and contribute to national needs

COMP 391 Internship in Computer Science (1-6 Credit Hours)
Students work outside the classroom applying and extending their computer science skills, typically for at least 150 hours for 3 credits. A memorandum of understanding is required between a student, his or her employer, and the Undergraduate Program Director, followed by final reports from the student and the employer.
This course satisfies the Engaged Learning requirement.
Outcomes:
Application of classroom skills to real-world situations

COMP 392 Metagenomics (3 Credit Hours)
Pre-requisites: BIOL 282
Exploration of next-generation sequencing technologies for assessing microbial diversity in ecological niches.
Interdisciplinary Option: Bioinformatics
This course satisfies the Engaged Learning requirement.
Course equivalencies: X-COMP 384/BIOL 392/COMP 392
Outcomes:
Students will gain hands-on experience with metagenomic methodologies while working in an interdisciplinary, collaborative setting

COMP 395 Professional Development & Career Growth in CompSci/IT (1 Credit Hour)
Pre-requisites: Sophomore standing and any COMP course
This course is designed specifically for students pursuing a degree in computing-related fields, for example, Computer Science, Information Technology, Software Engineering, and Cybersecurity. They will learn about ways to develop themselves professionally, communicate their strengths, expand their contacts, and advance their careers. Students should acquire skills to professionally brand themselves, successfully network in technical circles, perform an effective job/internship search, and conduct themselves well in interviews.

COMP 397 Research Methods in Computer Science (1 Credit Hour)
Supplements CS Seminar by targeting students directly engaging in research and facilitating contributions in ongoing projects. Progress in outside projects tracked through milestones such as abstracts, small fellowship-style proposals, informal updates, and outcome-oriented goal setting. Emphasizes creating lasting impacts through establishing project continuity and presenting posters, papers, and slide shows.
Outcomes:
Regular progress on research projects and final presentations of results for demonstration to department faculty and students, and potential use at professional conferences

COMP 398 Independent Study (1-6 Credit Hours)
The student and a sponsoring faculty member will determine an advanced topic for the student to work on.
This course satisfies the Engaged Learning requirement.
Outcomes:
Knowledge of an advanced topic

COMP 399 Computer Science Seminar (1 Credit Hour)
The department seminar is designed to bring together students interested in understanding and engaging in extracurricular applications of computer science, with a focus on ongoing research. Speakers will include department faculty, research students, and invited outside speakers. Students will be asked to read relevant literature and participate in discussions.
Course equivalencies: COMP 399H / COMP 399
Outcomes:
Students will be exposed to a wide range of topics in computer science, participate in discussions, and provide feedback to assess their general understanding of the presented material