

COMPUTER SCIENCE (COMP)

COMP 1101 Analytical Inquiry I (4 Credits)

Students explore the use of mathematics and computer programming in creating animations. Students create animations on their laptop computers using animation software. This course counts toward the Analytical Inquiry: The Natural and Physical World requirement.

COMP 1201 Introduction to Computer Science I (2 Credits)

This course introduces the discipline of computer science and how it applies the natural and physical world and society. Topics include the history of computing, computer hardware components, the internet, ethics, and uses computation as a means to analyze, process, model, and understand our world. Ideally taken concurrently with COMP 1351.

COMP 1202 Introduction to Computer Science II (2 Credits)

This course continues the introduction of the discipline of computer science by exploring major areas within it. Topics covered include examples from data structures, algorithms, databases, programming languages, parallel computing, artificial intelligence, robotics, cyber-security, data science, gaming, and ethics. Prerequisite: COMP 1201.

COMP 1203 Introduction to Computer Science III (2 Credits)

This course introduces testing and software development in computer science. Topics covered include using debuggers, version control systems, unit testing and general testing, Unified Modeling Language (UML), computing ethics, and software development in a team setting. Prerequisite: COMP 1202.

COMP 1351 Introduction to Programming I (3 Credits)

This course is an introduction to fundamental aspects of computer programming. Topics covered include variables, conditional statements, iteration, functions, basic data structures, objects, file input/output and interactions. Satisfies 3 credits of Analytical Inquiry: Natural and Physical World.

COMP 1352 Introduction to Programming II (3 Credits)

This course continues to introduce more advanced programming topics using the Python programming language. Topics include classes, types, inheritance, methods/functions, testing, graphical-user interfaces, threads, data manipulation, functional programming, and recursion. Prerequisite: COMP 1351.

COMP 1353 Introduction to Data Structures & Algorithms I (3 Credits)

This course introduces data structures used in computation, including their behavior, usage, implementation, and the analysis of their space usage. In addition, the algorithms used for access, manipulation, and updating the data structures is covered. Data structures and algorithms addressed include contiguous and linked lists, stacks, queues, hash tables, heaps, trees, self-balancing trees, graphs, and graph traversal. Introductory runtime analysis is used to prove time and space requirements for data structures and their performance while being used. Prerequisite: COMP 1352.

COMP 1601 Computer Science Pathways (1 Credit)

This course is designed to help first year computer science and game development students succeed in a very challenging major. Topics and activities may include academic success strategies; personal inventory exercises; interviewing computer science alumni; exploring ethical concerns within the profession; seminars by industry and academic experts; establishing the relationships between computing and other disciplines; critical and creative thinking activities; disseminating information on the dual degree programs, the honors program requirements, the honor code, and computer science department program structures; and readings from and discussions about computing related articles and publications.

COMP 1671 Introduction to Computer Science I (4 Credits)

Characteristics of modern computers and their applications; analysis and solution of problems; structure programming techniques; introduction to classes, abstract data types and object-oriented programming. This course counts toward the Analytical Inquiry: The Natural and Physical World requirement. Prerequisite: high school algebra.

COMP 1672 Introduction to Computer Science II (4 Credits)

Advanced programming techniques; arrays, recursion, dynamic data structures, algorithm abstraction, object-oriented programming including inheritance and virtual functions. Prerequisite: COMP 1671.

COMP 1991 Independent Study (1 Credit)

COMP 2300 Discrete Structures in Computer Science (4 Credits)

Number systems and basic number theory, propositional and predicate logic, proof techniques, mathematical induction, sets, counting and discrete probability, case studies with applications from computer science, such as data representation, algorithm analysis and correctness, and system design. Prerequisites: COMP 1672 or COMP 1352.

COMP 2355 Intro to Systems Programming (4 Credits)

The prerequisites for this class are a good understanding of imperative and object-oriented programming in Java. The prerequisites for this class include a good understanding of basic programming constructs, such as branches (if, switch), loops (for, while, do), exceptions (throw, catch), functions, objects, classes, packages, primitive types (int, float, boolean), arrays, arithmetic expressions and boolean operations. Computer organization is a parallel prerequisite; if possible, students should register for both this course and COMP 2691. You must have a good understanding of basic data structures such as arrays, lists, sets, trees, graphs and hash-tables. This is a class on systems programming with focus on the C programming language and UNIX APIs. There will be programming assignments designed to make you use various Debian GNU/Linux system APIs. Programming assignments involve writing code in C or C++. Prerequisite: COMP 2673.

COMP 2361 Systems I (4 Credits)

This course introduces low-level computer systems and programming. Topics covered include Linux, the C programming language, pointers, dynamic memory management, number systems, instruction set architectures, debugging, and caching. Prerequisites: COMP 1353.

COMP 2362 Systems II (4 Credits)

This course introduces computer operating systems and parallel programming. Topics covered include processes, process forks, threads, race conditions, synchronization, scheduling, memory systems, resource sharing, and sockets. Prerequisite: COMP 2361.

COMP 2370 Introduction to Data Structures & Algorithms II (4 Credits)

This course introduces the performance analysis of algorithms, including proof techniques; data structures and their physical storage representation, including space and performance analysis; recursive techniques; stacks, queues, lists, trees, sets, graphs; sorting and searching algorithms. Prerequisites: MATH 2200 or COMP 2300; COMP 2673.

COMP 2381 Object-Oriented Software Development (4 Credits)

Some problems are most naturally modeled by a hierarchy of objects and the relationships between those objects. This course introduces object-oriented design and development as a problem solving technique. Topics covered include the Java programming language, including classes, methods, fields, inheritance, interfaces, polymorphism, generics, static typing, design patterns, and the Java Collections Framework. Prerequisite: COMP 1353.

COMP 2673 Introduction to Computer Science III (4 Credits)

An introduction to several advanced topics in computer science. Topics vary from year to year and may include any of the following: theory of computing, cryptography, databases, computer graphics, graph theory, game theory, fractals, mathematical programming, wavelets, file compression, computational biology, genetic algorithms, neural networks, simulation and queuing theory, randomized algorithms, parallel computing, complexity analysis, numerical methods. Prerequisite: COMP 1672 or COMP 1771.

COMP 2691 Introduction to Computer Organization (4 Credits)

This course covers basic topics in Computer Organization and is a required course in the BS in Computer Science, BS in Game Development, and BS in Computer Engineering degrees. Topics include: instruction set architectures, integer and floating point arithmetic, processors, memory systems, and topics in storage and Input/Output. Prerequisite: COMP 1672.

COMP 2701 Topics in Computer Science (1-5 Credits)**COMP 2821 Introductory Game Design (4 Credits)**

Learn fundamental game design practices through the creation of paper and physical game prototypes using a play-centric design process. Topics include the formal elements, dramatic elements, and system dynamics of games, with an emphasis on playtesting, game analysis, and group game projects. Prerequisites: COMP 1352 or COMP 1672 or EDPX 2100.

COMP 2901 Computing and Society (4 Credits)

This course is designed to explore the social implications of computing practices, organization and experience. These topics and other issues are correlated with examples from the older and modern history of technology and science. Some formal experience with computing is assumed, but students who have a good familiarity with ordinary computing practice should be ready. Students are also expected to contribute their expertise in one or more of the areas of their special interest. Cross listed with DMST 3901.

COMP 3000 Seminar: The Real World (1 Credit)

Series of lectures by alumni and others on surviving culture shock when leaving the University and entering the job world. Open to all students regardless of major. Cross listed with MATH 3000.

COMP 3100 Human-Computer Interaction (4 Credits)

Introduces students in computer science and other disciplines to principles of and research methods in human-computer interaction (HCI). HCI is an interdisciplinary area concerned with the study of interaction between humans and interactive computing systems. Research in HCI looks at cognitive and social phenomena surrounding human use of computers with the goal of understanding their impact and creating guidelines for the design and evaluation of software, interfaces, physical products, and services in industry. No prerequisites are required to take the course and students from all disciplines are welcome. Cross listed with COMP 4100.

COMP 3200 Discrete Structures (4 Credits)

Discrete mathematical structures and non-numerical algorithms; graph theory, elements of probability, propositional calculus, Boolean algebras; emphasis on applications to computer science. Cross-listed as MATH 3200. Prerequisites: (COMP 2300 or MATH 2200) and (COMP 2673 or COMP 1353).

COMP 3351 Programming Languages (4 Credits)

Learn the fundamentals of programming languages through functional programming through an in-depth understanding of syntax and semantics around program structures and how programming languages are parsed and interpreted. Understand recursion as a fundamental problem-solving paradigm and the important role that higher order types and kinds play in eliminating errors and simplifying software development. Prerequisites: COMP 2370 and ((COMP 2355, COMP 2691) or COMP 2362).

COMP 3352 Elements of Compiler Design (4 Credits)

Techniques required to design and implement a compiler; topics include lexical analysis, grammars and parsers, type-checking, storage allocation and code generation. Prerequisite: COMP 3351.

COMP 3353 Compiler Construction (4 Credits)

Design and implementation of a major piece of software relevant to compilers. Prerequisite: COMP 3352.

COMP 3361 Operating Systems I (4 Credits)

Operating systems functions and concepts; processes, process communication, synchronization; processor allocation, memory management in multiprogramming, time sharing systems. Prerequisites: for undergraduates: (COMP 2355 and COMP 2691) or COMP 2361; COMP 2370; for graduate students: COMP 3003, 3004, and 3005.

COMP 3371 Data Structures & Algorithms (4 Credits)

Design and analysis of algorithms and data structures; asymptotic complexity, recurrence relations, lower bounds; algorithm design techniques such as incremental, divide-and-conquer, dynamic programming, iterative improvement, greedy algorithms; randomized data structures and algorithms. Prerequisites: COMP 2370 or equivalent and COMP 3200.

COMP 3372 Advanced Algorithms (4 Credits)

Advanced techniques for the design and analysis of algorithms and data structures; amortized complexity, self-adjusting data structures; randomized, online, and string algorithms; NP-completeness, approximation and exact exponential algorithms; flow networks.

COMP 3381 Software Engineering I (4 Credits)

An introduction to software engineering. Topics include software processes, requirements, design, development, validation and verification and project management. Cross-listed with COMP 4381. Prerequisites: COMP 3351; COMP 3361 or COMP 2362; or instructor permission.

COMP 3382 Software Engineering II (4 Credits)

Continuation of COMP 3381. Topics include component-based software engineering, model-driven architecture, and service-oriented architecture. Prerequisite: COMP 3381.

COMP 3384 Secure Software Engineering (4 Credits)

This course is concerned with systematic approaches for the design and implementation of secure software. While topics such as cryptography, networking, network protocols and large scale software development are touched upon, this is not a course on those topics. Instead, this course is on identification of potential threats and vulnerabilities early in the design cycle. The emphasis in this course is on methodologies and paradigms for identifying and avoiding security vulnerabilities, formally establishing the absence of vulnerabilities, and ways to avoid security holes in new software. There are programming assignments designed to make students practice and experience secure software design and development. Prerequisites: COMP 2362 or COMP 3361.

COMP 3400 Advanced Unix Tools (4 Credits)

Design principles for tools used in a UNIX environment. Students gain experience building tools by studying the public domain versions of standard UNIX tools and tool-building facilities. Prerequisites: COMP 2400 and knowledge of C and csh (or another shell), and familiarity with UNIX.

COMP 3410 World Wide Web Programming (4 Credits)

The World Wide Web (WWW, or web for short) has revolutionized how people communicate with one another and is one of the major technological advances in making the Internet visible around the world. Most people think of the web when they think of the Internet, but in fact the web is a method of organizing and accessing information on top of the Internet. Conceptually the web has a simple design, but it relies heavily on the underlying technology of the Internet. Students will learn what the web is, how it was designed, how it currently works, and how to develop apps on top of it through HTML, CSS and Javascript. Prerequisite: COMP 2673 or COMP 1353.

COMP 3411 Web Programming II (4 Credits)

In this course you will learn how to develop a full-stack web application that is capable of serving dynamic content from a database. Furthermore, you will learn the core design concepts and principles that will enable you to develop scalable and easy to maintain webapplications - a set of skills that will serve you well in both your personal and professional projects in the future. Prerequisite: COMP 3410.

COMP 3412 Web Projects: Web Development III (4 Credits)

In this course you will learn how to develop, as a group, a full-stack web application that is capable of serving dynamic content from a database. We will use the MongoDB, ExpressJS, Angular, and Node.js (MEAN) software stack to work on a real-life problem presented to us by an external product owner. In the class we will use the Scrum framework for Agile development to work, as a software team, through several sprints of development. You will be peer reviewing each other throughout the course, and the product owner will also be reviewing your product through end-of-sprint demos as features are completed. The goal for this class is for it to be a fun, collaborative, and educational environment that demonstrates what it is like to work as a real software team. Prerequisite: COMP 3411.

COMP 3421 Database Organization & Management I (4 Credits)

An introductory class in database management systems covering both relational and non-relational databases with an emphasis on relational. Topics include database design, ER modeling, relational algebra, SQL, scripting, and embedded SQL. Each student will design, load, query and update a nontrivial database using a relational database management system (RDBMS). In addition, an introduction to a NoSQL database will be included. Graduate students will read one or two relevant technical papers and write a summary report. Prerequisites: for undergraduates: COMP 1353 or COMP 2673; for graduates: COMP 3005.

COMP 3424 NoSQL Databases (4 Credits)

In this course, students learn what NoSQL databases are, learn to identify the differences between them, and gain a fundamental understanding between SQL, relational databases, and NoSQL databases. Students further explore which type of NoSQL database is the correct one given a use-cases, examining types, methods of communicating with it, contrasts to other NoSQL databases, performance and scalability. Prerequisites: for undergraduates, COMP 2355 or COMP 2361; for graduates: COMP 3005.

COMP 3431 Data Mining (4 Credits)

Data Mining is the process of extracting useful information implicitly hidden in large databases. Various techniques from statistics and artificial intelligence are used here to discover hidden patterns in massive collections of data. This course is an introduction to these techniques and their underlying mathematical principles. Topics covered include: basic data analysis, frequent pattern mining, clustering, classification, and model assessment. Prerequisites: COMP 2370.

COMP 3432 Machine Learning (4 Credits)

This course will give an overview of machine learning techniques, their strengths and weaknesses, and the problems they are designed to solve. This will include the broad differences between supervised, unsupervised and reinforcement learning and associated learning problems such as classification and regression. Techniques covered, at the discretion of the instructor, may include approaches such as linear and logistic regression, neural networks, support vector machines, kNN, decision trees, random forests, Naive Bayes, EM, k-Means, and PCA. After taking the course, students will have a working knowledge of these approaches and experience applying them to learning problems. Enforced Prerequisites: COMP 2370; COMP 2355 or COMP 2361.

COMP 3433 Data Visualization (4 Credits)

This course explores visualization techniques and theory. The course covers how to use visualization tools to effectively present data as part of quantitative statements within a publication/report and as an interactive system. Both design principles (color, layout, scale, and psychology of vision) as well as technical visualization tools/languages will be covered. Prerequisites: COMP 1353 and Python Programming.

COMP 3441 Introduction to Probability and Statistics for Data Science (4 Credits)

The course introduces fundamentals of probability for data science. Students survey data visualization methods and summary statistics, develop models for data, and apply statistical techniques to assess the validity of the models. The techniques will include parametric and nonparametric methods for parameter estimation and hypothesis testing for a single sample mean and two sample means, for proportions, and for simple linear regression. Students will acquire sound theoretical footing for the methods where practical, and will apply them to real-world data, primarily using R.

COMP 3455 Shell Scripting and System Tools (4 Credits)

This course covers navigating and utilizing tools in a UNIX environment, including use of common command line utilities, Bash and Python shell scripting, source control via Git, pipes and I/O redirection, networking in Python and OS multi-processing/multi-threading. More emphasis will be placed on using these tools than on how those tools work. Students should have experience with Python prior to taking this course.

COMP 3501 Introduction to Artificial Intelligence (4 Credits)

Introduces a variety of Artificial Intelligence concepts and techniques, relevant to a broad range of applications. Students survey multiple techniques including search, knowledge representation and reasoning, probabilistic inference, machine learning, and natural language processing. Examines concepts of constraint programming, evolutionary computation and non-standard computation. Prerequisites: COMP 2673 or COMP 1353.

COMP 3510 Software for AI Robotics (4 Credits)

This course provides an introduction to the key artificial intelligence issues involved in the development of intelligent robotics. We will examine a variety of algorithms for autonomous mobile robot behavior, exploring issues that include software control architectures, localization, navigation, sensing, planning, and uncertainty. We also introduce the Robot Operating System (ROS) middleware, which is popular in academic, industry, and government research. This course does not assume any prior knowledge of artificial intelligence or robotics. The course will be project focused. In the project assignments you will learn ROS and learn to implement algorithms essential for conducting AI robotics research. Prerequisites: COMP 2300, COMP 2370 and COMP 2355 or COMP 2361 and proficiency in Python and Unix. Cross listed with COMP 4510.

COMP 3591 Computational Geometry (4 Credits)

This class deals with the design and implementation of efficient algorithms for problems defined over geometric objects, such as points, lines, polygons, surfaces, etc. The methods and algorithms covered find applications in many areas, including computer graphics (e.g., hidden surface removal), computer-aided design and manufacturing (e.g., 3D printing), machine learning (e.g., supervised and unsupervised classification), geographic information systems (e.g. terrain visibility), robotics (e.g., motion planning), data mining (e.g., dimensionality reduction), and computer vision (3D reconstruction), to name a few. Fundamental geometric problems such as partitioning, proximity, intersection, convexity, visibility, point location, and motion planning are focused on. Efficient data structures and algorithms for their solutions and design techniques germane to the field, such as divide-and-conquer, plane sweep, randomization, duality, etc. are discussed in detail. Practical methods for the robust implementation of geometric algorithms are also covered. Prerequisites: COMP 2300 and COMP 2370.

COMP 3621 Computer Networking (4 Credits)

An introduction to computer networks with an emphasis on Internet protocols. Topics include: internet design, application layer protocols such as SMTP and HTTP, session layer protocols including TCP and UDP, the internet protocol (IP), link layer technology such as Ethernet, and security issues related to networking. Programming experience of client/server architectures using sockets and TCP/UDP through projects is emphasized. Prerequisites: for undergraduates: (COMP 2355 or COMP 2361) and COMP 2370; for graduates COMP 3004 and COMP 3006. Cross listed with COMP 4621.

COMP 3681 Networking for Games (4 Credits)

Implementing the networking code for multiplayer games is a complex task that requires an understanding of performance, security, game design, and advanced programming concepts. In this course, students are introduced to the networking stack and how this is connected to the Internet, learn how to write protocols for games, and implement several large games using a game engine that demonstrate the kind of networking and protocols required by different genres of games. In addition, tools are introduced that help understand and debug networking code, simplify the creation of protocols, and make the development of networking code easier.

COMP 3701 Topics in Computer Graphics (4 Credits)**COMP 3702 Topics in Database (4 Credits)****COMP 3703 Topics-Artificial Intelligence (4 Credits)****COMP 3704 Advanced Topics: Systems (4 Credits)****COMP 3705 Topics in Computer Science (1-4 Credits)****COMP 3721 Computer Security (4 Credits)**

This course gives students an overview of computer security along with some cryptography. Some network security concepts are also included. Other concepts include coverage of risks and vulnerabilities, policy formation, controls and protection methods, role-based access controls, database security, authentication technologies, host-based and network-based security issues. Prerequisite: COMP 2362 or COMP 3361. Cross listed with COMP 4721.

COMP 3722 Network Security (4 Credits)

Network Security covers tools and techniques employed to protect data during transmission. It spans a broad range of topics including authentication systems, cryptography, key distribution, firewalls, secure protocols and standards, and overlaps with system security concepts as well. This course will provide an introduction to these topics, and supplement them with hands-on experience. Prerequisites: COMP 3721, or permission of instructor.

COMP 3723 Ethical Hacking (4 Credits)

Ethical hacking is the process of probing computer systems for vulnerabilities and exposing their presence through proof-of-concept attacks. The results of such probes are then utilized in making the system more secure. This course will cover the basics of vulnerability research, foot printing targets, discovering systems and configurations on a network, sniffing protocols, firewall hacking, password attacks, privilege escalation, rootkits, social engineering attacks, web attacks, and wireless attacks, among others. Prerequisites: COMP 1203 or COMP 2673 (CS Intro sequence).

COMP 3731 Computer Forensics (4 Credits)

Computer Forensics involves the examination of information contained in digital media with the aim of recovering and analyzing latent evidence. This course will provide students an understanding of the basic concepts in preservation, identification, extraction and validation of forensic evidence in a computer system. The course covers many systems level concepts such as disk partitions, file systems, system artifacts in multiple operating systems, file formats, email transfers, and network layers, among others. Students work extensively on raw images of memory and disks, and in the process, build components commonly seen as features of commercial forensics tools (e.g. file system carver, memory analyzer, file carver, and steganalysis). Prerequisites: COMP 3361; COMP 2355 or 2361 for undergraduates; COMP 3006 for graduates.

COMP 3732 Human-Centered Data Security and Privacy (4 Credits)

With an increasing digital presence, it is critical to understand users' needs and requirements in using technological equipment to secure interactions and adhere to privacy perceptions. Thus, it is essential to analyze the cognitive, social, organizational, commercial, and cultural factors in mind. This course will provide a socio-technical approach for analyzing critical user interaction with devices encountered in everyday life, including web, mobiles, and wearables. This course will help students develop an understanding of technological interactions from the perspectives of multiple stakeholders such as users, developers, system administrators, and others and build tools to protect user data.

COMP 3801 Introduction Computer Graphics (4 Credits)

Fundamentals of 3D rendering including the mathematics behind coordinate systems, projections, clipping, hidden surface removal, shadows, lighting models, shading models, and mapping techniques. Significant use of 3D APIs through shader programming is covered along with the basics of 3D model representation and animations. Satisfies "Advanced Programming" requirements for graduate students. Prerequisites: COMP 2370, MATH 1952 or 1962.

COMP 3821 Game Programming I (4 Credits)

Introduces the fundamentals of digital game programming that are essential as future game programmers or game designers. Students have the opportunity to learn game engine architecture, 2D and 3D linear algebra for graphics, sprites and animations, input handling, finite state machines, particle systems, user interfaces, game audio, and artificial intelligence for games. Prerequisites: COMP 2370 and COMP 2821.

COMP 3822 Game Programming II (4 Credits)

In this course, students learn how to work with a 3D game engine and build 3D games. Topics include algorithms, mathematics for 3D game engines, scene management, animations, 3D shaders, particle systems, physics for games, UIs, terrain systems, and working with higher-level scripting languages on top of the low-level implementation language. Prerequisites: COMP 3821. Suggested corequisite or prerequisite: COMP 3801.

COMP 3831 Game Prototyping (4 Credits)

Introduces game prototyping, where game concepts are created and developed into working prototypes using student-chosen game development tools. Engages in critical awareness of game creation practices through discussions, critiques, demos, and player testing. Students have the opportunity to explore their creativity, to expand their knowledge of game design, and to build a broad portfolio of ideas and working projects that demonstrate both their design and technical skillsets. Required for Game Development majors, though all majors are welcome. Prerequisites: COMP 2821.

COMP 3832 Game Capstone I (4 Credits)

Students design, build, critique, and playtest their game prototypes from Game Prototyping. Both art and programming are developed by the student teams with the instructor acting as a project manager to ensure that goals are met through the 10-week development process through various milestones. In addition to building the game, students alter their game design document to add new features, making corrections to prior design issues, and focus on making the game playable and "fun." Prerequisite: COMP 3821 and COMP 3831.

COMP 3833 Game Capstone II (4 Credits)

Students design, build, critique and playtest their working game from Game Capstone I. Both art and programming are developed by the student teams with the instructor acting as a project manager to ensure that goals are met through the 10-week development process through various milestones. In addition to building the game, students modify their design document and implement changes in their game, create new concept art for the features, build an introduction level into their game, test the game with "Play testers", and focus on creating a game that is "fun" to play. By the end of the quarter, their game is ready for distribution on an appropriate platform. Prerequisite: COMP 3832.

COMP 3904 Internship/Co-Op in Computing (0-10 Credits)

Practical experience in designing, writing and/or maintaining substantial computer programs under supervision of staff of University Computing and Information Resources Center. Prerequisites: COMP 2370 and approval of internship committee (see department office).

COMP 3991 Independent Study (1-10 Credits)

Cannot be arranged for any course that appears in the regular course schedule for that particular year.

COMP 3995 Independent Research (1-10 Credits)