**COMPUTER SCIENCE (CS)**

CS F101  Computers and Society  (m)  
3 Credits  
Offered Fall, Spring and Summer  
Computer literacy for everyone. Overview of computing machines and automatic data processing. Interaction between social institutions and automated decision-making. Introduction to business applications software and electronic mail. Some programming for understanding, not for skill development.  
Prerequisites: Two years of high school mathematics, including at least one year of algebra.  
Lecture + Lab + Other: 3 + 0 + 0

CS F103  Introduction to Computer Programming  
3 Credits  
Offered Fall and Spring  
Computer programming for students without the background for CS F201. Concepts of object-oriented programming and algorithm design using the Python programming language.  
Prerequisites: Math placement at the 100-level.  
Lecture + Lab + Other: 3 + 0 + 0

CS F180  Introduction to Programming and Algorithmic Thinking  
1 Credit  
Offered As Demand Warrants  
Introduction to fundamental concepts across different programming languages including: variables, looping, conditional statements, flow, maintainable code, searching and sorting algorithms. This course is designed as an advance layer over the materials and activities associated with the T3 Alliance grant funded program (T3.alliance.org).  
Lecture + Lab + Other: 1 + 0 + 0

CS F201  Computer Science I  
3 Credits  
Offered Fall and Spring  
The discipline of computer science including problem solving, algorithm development, good programming style, control flow, I/O and elementary data structures. Concepts implemented with extensive programming experience in C++, and a group programming project.  
Prerequisites: One year high school level programming or CS F103; mathematics placement at the F200-level.  
Lecture + Lab + Other: 3 + 0 + 0

CS F202  Computer Science II  
3 Credits  
Offered Fall and Spring  
The discipline of computer science including classes, object-oriented programming, operators, RAII, inheritance, exceptions and generic programming with templates. Concepts implemented with extensive programming experience in C++ and a group programming project.  
Prerequisites: CS F201.  
Lecture + Lab + Other: 3 + 0 + 0

CS F202L  Computer Science II Lab  
0 Credit  
Cross-listed with CS F201, ES F201.

CS F202L  Computer Hardware Concepts Lab  
0 Credit  
Cross-listed with EE F254, ME F254.

CS F210  Data Structures and Algorithms  
3 Credits  
Offered Fall  
Data structures and the algorithms for their manipulation. Algorithmic efficiency and asymptotic notation. Algorithms for searching and sorting. Abstract data types and container data structures: arrays, linked lists, stacks, queues, trees, tables, heaps, balanced search trees, hash tables.  
Prerequisites: CS F202.  
Lecture + Lab + Other: 3 + 0 + 0

CS F210L  Assembly Language Programming  
3 Credits  
Offered Fall  
The low level structure of a modern computer: hardware instruction set architecture, registers, the call stack, pointers, the heap, the page table, and threads. Applications include performance and security.  
Prerequisites: CS F201.  
Lecture + Lab + Other: 3 + 0 + 0

CS F210L  Data Structures and Algorithms Lab  
0 Credit  
Cross-listed with EE F258; GEOS F258; and ME F258.
CS F321  Operating Systems
3 Credits
Offered Spring
The software stack in a modern computer: thread, process, container, kernel, hypervisor and network. Enforcing access control and securing communication between these layers, and designing services to use them effectively.
Prerequisites: CS F301.
Lecture + Lab + Other: 3 + 0 + 0

CS F331  Programming Languages
3 Credits
Offered Spring
Syntax and semantics of widely differing programming languages. Syntax specification, lexical analysis, parsing and interpretation. Comparison of diverse languages such as Python, Haskell, Forth and Prolog.
Prerequisites: CS F311.
Lecture + Lab + Other: 3 + 0 + 0

CS F361  Systems Security and Administration
3 Credits
Offered As Demand Warrants
Advanced systems programming including privileged instructions and system services, authentication technologies, host-based and network-based security issues. Applications to asynchronous I/O, process control and communication, device drivers and file management.
Prerequisites: CS F301.
Lecture + Lab + Other: 3 + 0 + 0

CS F371  Computer Ethics and Technical Communication
3 Credits
Offered Fall
This course explores the social, legal and ethical issues aggravated, transformed or created by computer technology. Additional focus is on technical communication skills needed in the computer industry.
Prerequisites: WRTG F211X, WRTG F212X, WRTG F213X or WRTG F214X; COJO F121X, COJO F131X or COJO F141X; CS F202.
Lecture + Lab + Other: 3 + 0 + 0

CS F372  Software Construction
3 Credits
Offered Spring
Methods for programming and construction of complete computer applications, including refactoring, performance measurement, process documentation, unit testing, version control, integrated development environments, debugging and debuggers, interpreting requirements, and design patterns.
Prerequisites: CS F311.
Lecture + Lab + Other: 3 + 0 + 0

CS F392  Seminar
1-6 Credits
Lecture + Lab + Other: 0 + 0 + 0

CS F405  Introduction to Artificial Intelligence
3 Credits
Offered Spring
Examine diverse branches of AI placing AI in larger context of computer science and software engineering. Knowledge representation formalism and search technology. Programming methodologies; procedural systems such as expert systems and blackboard systems and non-procedural systems such as neural networks. Software engineering aspects of problem selection, knowledge acquisition, verification and validation. Individual projects.
Prerequisites: CS F311.
Lecture + Lab + Other: 3 + 0 + 0

CS F411  Analysis of Algorithms
3 Credits
Offered Fall
Analysis of classic algorithms, their implementation and efficiency. Topics from combinatorics (sets, graphs), algebra (integer arithmetic, primes, polynomial arithmetic, GCD, Diophantine equations, encryption), systems (parsing searching, sorting) and theory (recursion, Turing machines). The complexity classes P, NP and NP complete.
Prerequisites: MATH F307, CS F311.
Lecture + Lab + Other: 3 + 0 + 0

CS F421  Distributed Operating Systems  (W)
3 Credits
Offered As Demand Warrants
Detailed level study of distributed operating system algorithms, functions and associated implementation. Distributed operating system tuning methods and security. Role of distributed operating systems in net-centric computing. Programming, documentation and evaluation of distributed operating system segments as projects.
Prerequisites: CS F321; WRTG F111X; WRTG F211X, WRTG F212X, WRTG F213X or WRTG F214X.
Lecture + Lab + Other: 3 + 0 + 0

CS F425  Database Systems
3 Credits
Offered Fall
Data independence, modeling, relationships and organization. Hierarchical, network and relational data models; canonical schema. Data description languages, SQL, query facilities, functional dependencies, normalization, data integrity and reliability. Review of current database software packages.
Prerequisites: CS F311; CS F321.
Lecture + Lab + Other: 3 + 0 + 0

CS F441  System Architecture
3 Credits
Offered Spring
Computer design fundamentals, performance and cost, pipelining, instruction-level parallelism, memory hierarchy design, storage systems, and vector processing.
Prerequisites: CS F321; EE F341.
Lecture + Lab + Other: 3 + 0 + 0

CS F442  Computer Communication and Networks
3 Credits
Offered As Demand Warrants
Study of computer networks using the ISO/OSI layered model as a framework. Design issues and trade-offs, protocols and selected standards. Emphasis on ISO/OSI Layers 1-4/(Physical, Data Link, Network and Transport Layers), plus medium access sublayers (LAN’s, etc.).
Prerequisites: CS F321.
Lecture + Lab + Other: 3 + 0 + 0
CS F453  Robotics & 3D Printing  
3 Credits  
Offered As Demand Warrants  
Covers self-driving cars, 3D printers, and computer-controlled machine tools as modern applications of a common software core of path planning and motion control. Includes mathematical background in 3D computational geometry, hands-on applications such as designing and fabricating resilient robot parts, and online algorithms for robot driving.  
**Prerequisites:** MATH F253X; CS F311 or equivalent experience programming complex applications in a modern language like C++ or Python.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F460  Introduction to Digital Forensics  
3 Credits  
Offered As Demand Warrants  
Takes a hands-on approach to the forensics examination of computer technology. Focuses on the forensic process, methods, and tools utilized to collect and preserve and examine digital evidence. Course topics include: collection, preservation and examination of evidence from computers including file systems, email and malicious code.  
**Prerequisites:** CS F321.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F462  Intrusion Detection Systems  
3 Credits  
Offered As Demand Warrants  
Focus on IDS theory and practice and its importance; the origin and resolution of common security threats and vulnerabilities; host and network approaches to IDS implementation; and the legal, ethical, and privacy issues associated with IDS use and policies.  
**Prerequisites:** CS F361.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F463  Cryptography and Data Security  
3 Credits  
Offered As Demand Warrants  
Specialized study of cryptography and its application in securing data systems, with an emphasis on applied cryptography. Topics include history of cryptography, encryption, digital signatures, authentication, electronic commerce, key distribution and management, private and public key cryptography, and protocols.  
**Prerequisites:** MATH F307; CS F311.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F465  Computer and Network Security  
3 Credits  
Offered As Demand Warrants  
Analyzes computer software, hardware and network vulnerabilities. Mechanisms to detect and defend against attacks, including authentication, access control and cryptography. Includes code vulnerabilities like buffer overflow, web issues like command injection, network protocol design and storage security. Legal and ethical issues concerning privacy, intellectual property and computer crime.  
**Prerequisites:** CS F202, CS F301 (may be taken concurrently).  
**Stacked with CS F665.**  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F471  Senior Capstone I  
(W)  
3 Credits  
Offered Fall  
Introduction to software engineering and project management principles, techniques, methods and standards for software system development. Additional topics include technical communication, computer ethics and legal issues.  
**Prerequisites:** CS major; senior standing; CS F311; CS F371.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F472  Senior Capstone II  
(O, W)  
3 Credits  
Offered Spring  
Group projects in a real computer industry environment and produce appropriate documentation and reports. Nature, ethics and legal considerations of the computer science profession are discussed with an emphasis on ethics. Additional topics include project management, design methodologies, technical presentation, human-machine interface and programming team interactions.  
**Prerequisites:** CS F372; CS F471.  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F480  Topics in Computer Science  
3 Credits  
Offered As Demand Warrants  
Topics include, but are not limited to; computational linear algebra, cryptography, parallel algorithm development and analysis.  
**Special Notes:** Course may be repeated when topics change.  
**Lecture + Lab + Other:** 0 + 3 + 0

CS F484  Computer Graphics Fundamentals  
3 Credits  
Offered Fall  
**Prerequisites:** CS F202; MATH F253X.  
**Stacked with CS F684.**  
**Lecture + Lab + Other:** 3 + 0 + 0

CS F485  Computer Graphics Rendering  
3 Credits  
Offered As Demand Warrants  
Designing graphics engines for realtime rendering of computer generated imagery; physically based approaches to shading and shadows; artistic approaches to shading and nonphotorealistic rendering; algorithms for rendering an image including ray tracing, deferred rendering, and global illumination; image space algorithms for simulation of camera effects.  
**Prerequisites:** CS F202; MATH F253X.  
**Stacked with CS F685.**  
**Lecture + Lab + Other:** 3 + 0 + 0
CS F486  Computer Graphics Animation and Simulation  
3 Credits  
Offered As Demand Warrants  
Creation of computer graphics animation and simulation of physically based phenomena; designing simulation systems for computer graphics applications; physically based phenomena using particle systems, fluid simulation, and rigid body dynamics; key frame animation, bones, and rigging; and other related topics.  
Prerequisites: CS F202; MATH F253X; PHYS F212X.  
Stacked with CS F686.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F600  Professional Software Development  
4 Credits  
Offered Fall  
Participate in a group project to explore the technical, social and ethical aspects of software development. Topics include: requirements engineering, enterprise-level data storage, software architecture, security, software testing, legal issues, computer ethics, risk management and project management.  
Prerequisites: CS F472.  
Lecture + Lab + Other: 4 + 0 + 0  

CS F601  Algorithms, Architecture and Languages  
4 Credits  
Offered Spring  
Current research on, and cross-cutting interrelationships between computer algorithms, machine architecture and languages. Covers asymptotic performance analysis including NP-completeness, modern parallel hardware including multicore, and grammars and parsing from regular expressions to BNF.  
Prerequisites: CS F331; CS F411; CS F441 or EE F443.  
Lecture + Lab + Other: 4 + 0 + 0  

CS F605  Artificial Intelligence  
3 Credits  
Offered Spring  
Prerequisites: Graduate standing or permission of CS graduate advisor.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F611  Complexity of Algorithms  
3 Credits  
Offered As Demand Warrants  
Theoretical analysis of various algorithms: topics include sorting, searching, selection, polynomial evaluation, NP completeness, decidability.  
Prerequisites: CS F411.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F621  Advanced Systems Programming  
3 Credits  
Offered As Demand Warrants  
Multiprogramming and multiprocessing systems. File and program security. Scheduling optimization and system tuning, I/O processing, archiving and system recovery, and initialization. Study of current systems.  
Prerequisites: CS F311 and CS F321.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F631  Programming Language Implementation  
3 Credits  
Offered As Demand Warrants  
Formal treatment of programming language translation and compiler design. Parsing context-free languages, translation specifications, machine independent code, NBF, scanners, symbol tables, parsers and recursive descent. Programming of compiler or interpreter segments as projects.  
Prerequisites: CS F331.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F641  Advanced Systems Architecture  
3 Credits  
Offered As Demand Warrants  
A study of advanced single processor systems. Detailed study of multiprocessor architectures, such as vector architectures, massively parallel processors and shared-memory multi-processors.  
Prerequisites: CS F441 or permission of Computer Science graduate advisor.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F642  Advanced Computer Networks  
3 Credits  
Offered As Demand Warrants  
A study of networks of interacting computers. The problems, rationales and possible solutions for both distributed processing and distributed databases will be examined. Major national and international protocols will be presented.  
Prerequisites: Graduate standing or permission of Computer Science graduate advisor.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F658  Unmanned Aircraft Systems (UAS) Operations  
3 Credits  
Offered Spring  
This course covers the application of unmanned aircraft systems (UAS) to satisfy real-world scientific research or public service missions. Students will analyze mission requirements and recommend appropriate UAS vehicles, subsystems, sensors and data analysis tools needed to accomplish a specified mission. Students will design the UAS package, conduct a representative UAS mission, produce required data products and present their mission results to the user. Emphasis is on mission planning considerations, UAS/sensor capabilities, flight planning and data collection requirements.  
Prerequisites: Graduate standing.  
Cross-listed with EE F658.  
Lecture + Lab + Other: 3 + 0 + 0  

CS F665  Computer and Network Security  
3 Credits  
Offered As Demand Warrants  
Analyzes computer software, hardware and network vulnerabilities. Mechanisms to detect and defend against attacks, including authentication, access control and cryptography. Includes code vulnerabilities like buffer overflow, web issues like command injection, network protocol design and storage security. Legal and ethical issues concerning privacy, intellectual property and computer crime.  
Stacked with CS F465.  
Lecture + Lab + Other: 3 + 0 + 0
CS F671  Advanced Software Engineering
3 Credits
Offered As Demand Warrants
Advanced software development as an engineering discipline. Includes
investigation of current tools, standards, foundation and trends
in software engineering from component-ware, software system
composition, e-systems, software architecture and CASE tools.
Prerequisites: CS F471.
Lecture + Lab + Other: 3 + 0 + 0

CS F680  Topics in Computer Science
1-4 Credits
Offered As Demand Warrants
Example topics include, but are not limited to, software requirements
engineering, cryptography, parallel algorithm development and analysis.
May be repeated for credit with change of topic.
Prerequisites: Varies with each topic.
Recommended: Varies with each topic.
Lecture + Lab + Other: 1-4 + 0 + 0

CS F681  Topics in Computer Graphics
3 Credits
Offered Fall
Hardware, software and techniques used in computer graphics taken
from topics such as refresh, storage, raster scan technology, volume
rendering, particle systems, shading, image processing, computer aided
design, video effects, animation and virtual environments.
Prerequisites: CS F202 and MATH F253X.
Lecture + Lab + Other: 3 + 0 + 0

CS F684  Computer Graphics Fundamentals
3 Credits
Offered Fall
Creation of computer-generated images using 3D graphics hardware.
Mathematics and data structures in 3D graphics. Sprites, Tiles,
Typography, and Vector Graphics in 2D graphics. Color, lighting, textures,
hidden surface removal. Loading and saving scene graphs; Using
physically based and nonphotorealistic shading. Software design
principles to create interactive applications.
Prerequisites: CS F202; MATH F253X.
Stacked with CS F484.
Lecture + Lab + Other: 3 + 0 + 0

CS F685  Computer Graphics Rendering
3 Credits
Offered As Demand Warrants
Designing graphics engines for realtime rendering of computer generated
imagery; physically based approaches to shading and shadows; artistic
approaches to shading and nonphotorealistic rendering; algorithms for
rendering an image including ray tracing, deferred rendering, and global
illumination; image space algorithms for simulation of camera effects.
Prerequisites: CS F202; MATH F253X.
Stacked with CS F485.
Lecture + Lab + Other: 3 + 0 + 0

CS F686  Computer Graphics Animation and Simulation
3 Credits
Offered As Demand Warrants
Creation of computer graphics animation and simulation of physically
based phenomena; designing simulation systems for computer graphics
applications; physically based phenomena using particle systems, fluid
simulation, and rigid body dynamics; key frame animation, bones, and
rigging; and other related topics.
Prerequisites: CS F202 and PHYS F212X.
Stacked with CS F486.
Lecture + Lab + Other: 3 + 0 + 0

CS F690  Graduate Seminar and Project
3 Credits
Offered Fall
First semester of two-semester seminar in which students will work
on and present the results of major programming or literature survey
projects in computer science. Written and oral reports will be required.
Prerequisites: 12 credits in graduate computer science courses; or
permission of Computer Science graduate advisor.
Lecture + Lab + Other: 3 + 0 + 0

CS F691  Graduate Seminar and Project
3 Credits
Offered Spring
Second semester of a two-semester seminar in which students will work
on and present the results of major programming or literature survey
projects in computer science. Written and oral reports will be required.
Prerequisites: CS F690; 12 credits in graduate computer science courses;
or permission of Computer Science advisor.
Lecture + Lab + Other: 3 + 0 + 0

CS F692  Seminar
1-6 Credits
Lecture + Lab + Other: 1-6 + 0 + 0

CS F698  Non-thesis Research/Project
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0

CS F699  Thesis
1-9 Credits
Lecture + Lab + Other: 0 + 0 + 0