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
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

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: Math placement at the F100-level.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

CS F201. Concepts of object-oriented programming and algorithm design
using the Python programming language.

CS F201.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

CS F201, ES F201.

CS F241  Computer Hardware Concepts
4 Credits
Offered Spring
A programmer-centric approach to electrical circuits and microcontroller
interfacing, with applications to smart devices and robotics. Covers bit-
level arithmetic and logic, microcontrollers, battery-powered systems,
sensor and actuator interfacing, and interdevice communication. These
 technologies form the foundation for smart vehicles, devices and
buildings.
Prerequisites: CS F201, ES F201.
Corequisites: CS F241L.
Lecture + Lab + Other: 3 + 3 + 0
Grading System: Letter Grades with option of Plus/Minus

CS F241L  Computer Hardware Concepts Lab
0 Credit
Offered Spring
Laboratory section for CS F241 Computer Hardware Concepts. Activities
may include simulated and physical electronic circuits, microcontroller
programming, digital and analog circuits.
Corequisites: CS F241.
Lecture + Lab + Other: 0 + 0 + 0
Grading System: Non-Graded

CS F254  Unmanned Aircraft Systems (UAS) Design
3 Credits
Offered As Demand Warrants
A multidisciplinary team of students will design, build, test and deliver
an unmanned aircraft system (UAS) in support of university research
mission requirements. Students will learn basic concepts related to
the systems engineering design process. Graded events include team
briefings, written reports, multimedia products and a finished UAS
product.
Prerequisites: AERO F254; ME F254.
Cross-listed with AERO F256, ME F256.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

CS F258  Unmanned Aircraft Systems (UAS) Operations
3 Credits
Offered As Demand Warrants
Covers the use of unmanned aircraft systems (UAS), sensors, and
support infrastructure required to conduct a selected mission set.
Emphasis is on mission analysis, planning, and conduct, including
definition of requirements/constraints, identification of appropriate
assets, flight planning considerations, and data analysis requirements.
Teams coordinate resources for mission and report results.
Cross-listed with AERO F258; GEOS F258; and ME F258.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

CS F301  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
Grading System: Letter Grades with option of Plus/Minus
CS F311  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
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

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: COM F121X, COM F131X or COM F141X; CS F202; WRTG F211X, WRTG F212X, WRTG F213X or WRTG F214X.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

CS F392  Seminar
1-6 Credits
Lecture + Lab + Other: 0 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus
Repeatable for Credit: May be taken unlimited times for up to 6 credits

CS F405  Introduction to Artificial Intelligence
3 Credits
Offered Spring
Examine diverse branches of AI placing AI in the context of computer science. 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.
Prerequisites: CS F311.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

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
Grading System: Letter Grades with option of Plus/Minus

CS F441  System Architecture
3 Credits
Offered Spring
Computer design fundamentals, performance and cost, pipelining, instruction-level parallelism, memory hierarchy design, storage systems, and parallel processing.
Prerequisites: CS F321; CS F241, EE F243, EE F341.
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus

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
Lecture + Lab + Other: 3 + 0 + 0
Grading System: Letter Grades with option of Plus/Minus
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
<th>Offered</th>
<th>Prerequisites</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS F463</td>
<td>Cryptography and Data Security</td>
<td>3</td>
<td>As Demand Warrants</td>
<td>MATH F307; CS F311.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F465</td>
<td>Computer and Network Security</td>
<td>3</td>
<td>As Demand Warrants</td>
<td>CS F472, CS F471 (may be taken concurrently).</td>
<td>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.</td>
</tr>
<tr>
<td>CS F471</td>
<td>Senior Capstone I</td>
<td>3</td>
<td>Fall</td>
<td>CS major; senior standing; CS F311; CS F371.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F472</td>
<td>Senior Capstone II</td>
<td>3</td>
<td>Spring</td>
<td>CS F331; CS F411; CS F441 or EE F443.</td>
<td>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.</td>
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<tr>
<td>CS F480</td>
<td>Topics in Computer Science</td>
<td>3</td>
<td>As Demand Warrants</td>
<td>CS F331; CS F411; CS F441 or EE F443.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F485</td>
<td>Computer Graphics Rendering</td>
<td>3</td>
<td>As Demand Warrants</td>
<td>CS F202; MATH F253X.</td>
<td>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.</td>
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<tr>
<td>CS F486</td>
<td>Computer Graphics Animation and Simulation</td>
<td>3</td>
<td>As Demand Warrants</td>
<td>CS F202; MATH F253X; PHYS F212X.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F487</td>
<td>Computer Graphics Animation and Simulation</td>
<td>3</td>
<td>Fall</td>
<td>CS F202; MATH F253X; PHYS F212X.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F488</td>
<td>Computer Graphics Animation and Simulation</td>
<td>3</td>
<td>Spring</td>
<td>CS F202; MATH F253X; PHYS F212X.</td>
<td>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.</td>
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<tr>
<td>CS F600</td>
<td>Professional Software Development</td>
<td>4</td>
<td>Fall</td>
<td>CS F331; CS F411; CS F441 or EE F443.</td>
<td>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.</td>
</tr>
<tr>
<td>CS F601</td>
<td>Algorithms, Architecture and Languages</td>
<td>4</td>
<td>Spring</td>
<td>CS F331; CS F411; CS F441 or EE F443.</td>
<td>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.</td>
</tr>
</tbody>
</table>

**Lecture + Lab + Other:** 0 + 3 + 0

**Grading System:** Letter Grades with option of Plus/Minus
CS F605  Artificial Intelligence  
3 Credits  
Offered Spring  
Prerequisites: Graduate standing or permission of CS graduate advisor.  
Grading System: Letter Grades with option of Plus/Minus  

CS F658  Unmanned Aircraft Systems (UAS) Operations  
3 Credits  
Offered Spring  
Covers application of unmanned aircraft systems (UAS) to satisfy scientific research or public service missions. Students analyze mission requirements and recommend appropriate UAS vehicles, subsystems, sensors and data analysis tools to accomplish a specified mission. Students design mission profiles, conduct representative missions, produce required data products and present mission results.  
Prerequisites: Graduate standing.  
Cross-listed with AERO F658; EE F658.  
Lecture + Lab + Other: 3 + 0 + 0  
Grading System: Letter Grades with option of Plus/Minus  

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  
Grading System: Letter Grades with option of Plus/Minus  

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  
Grading System: Letter Grades with option of Plus/Minus  
Repeatable for Credit: May be taken 15 times for up to 45 credits  

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  
Grading System: Letter Grades with option of Plus/Minus  
Repeatable for Credit: May be taken 3 times for up to 12 credits  

CS F684  Computer Graphics Fundamentals  
3 Credits  
Offered Fall  
Prerequisites: CS F202; MATH F253X.  
Stacked with CS F484.  
Lecture + Lab + Other: 3 + 0 + 0  
Grading System: Letter Grades with option of Plus/Minus  

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  
Grading System: Letter Grades with option of Plus/Minus  

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  
Grading System: Letter Grades with option of Plus/Minus  

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  
Grading System: Pass/Fail Grades  

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  
Grading System: Pass/Fail Grades
CS F692  Seminar  
1-6 Credits  
Lecture + Lab + Other: 1-6 + 0 + 0  
Grading System: Letter Grades with option of Plus/Minus  
Repeatable for Credit: May be taken unlimited times for up to 6 credits

CS F698  Non-thesis Research/Project  
1-9 Credits  
Lecture + Lab + Other: 0 + 0 + 0  
Grading System: Pass/Fail Grades  
Repeatable for Credit: May be taken unlimited times for up to 99 credits

CS F699  Thesis  
1-9 Credits  
Lecture + Lab + Other: 0 + 0 + 0  
Grading System: Pass/Fail Grades  
Repeatable for Credit: May be taken unlimited times for up to 99 credits