COMP112 Introduction to Programming
The course will provide an introduction to a modern, high-level programming language including a discussion of input/output, basic control structures, types, functions, and classes. The lectures will also discuss a variety of algorithms as well as program design issues.

The second meeting time for each section is a computer lab.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: None

COMP113 Bioinformatics Programming
This course is an introduction to bioinformatics and programming for students with interest in the life sciences. It introduces problem areas and conceptual frameworks in bioinformatics. The course assumes little or no prior programming experience and will introduce the fundamental concepts and mechanisms of computer programs and examples (e.g., sequence matching and manipulation, database access, output parsing, dynamic programming) frequently encountered in the field of bioinformatics.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-BIOL
Identical With: MB&B265, BIOL265, CIS265
Prereq: [MB&B181 or BIOL181]

COMP114 How to Talk to Machines
In this course, students will learn how to program in a number of different styles. We start with programming state-transition machines, the kind of programming one might use to instruct a robot how to interact with the world around it. We will move on to programming von Neumann machines, which form the core of most computing systems today, and so along the way we will learn what is "in the box." We will end with an introduction to high-level programming, learning the fundamentals of programming in a language such as Python or Java.

The goal of the course is to understand not just programming, but how computers are designed, and how those designs are reflected in the way we program them. Along the way, we will pay special attention to the commonalities of the various styles, ultimately learning that much of what a high-level language provides is a way to more easily express computational algorithms that are ultimately implemented on a state transition machine. After passing this course, students will have a working knowledge of basic programming, and COMP 114 satisfies the Mathematics major "elementary knowledge of algorithms and computer programming" requirement.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: None

COMP115 How to Design Programs
In this course, students will learn to systematically design programs, going from a problem statement to a well-organized solution in a step-by-step fashion. We will apply these program design skills to many applications within computer science and in other disciplines. Students will develop their mathematical skills, because we will use a symbolic view of computation that explains the process of running a program as simple manipulations of its text. Students will also develop their technical reading and writing skills, such as understanding complex problem descriptions and precisely articulating the design of solutions. No prior experience with programming or computer science is expected.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: None

COMP131 Can Machines Think? (Logic and Computation)
This course will address the question of machine reasoning and its scope through the perspective of computation and logic. We will start by studying the elements of mathematical logic and will learn how to code in the ML programming language so we can approach the issues of automated deduction from both a technical and philosophical perspective. The course will also include extensive readings on consciousness and on the capabilities and limits of computation. Students will be required to write several detailed essays on the issues discussed in class and in the readings.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: None

COMP132 Computing, Privacy, and Security
This course will discuss both technical and ethical issues related to computing. On the technical side, the material will cover topics such as networking and cryptography. The technical material will be learned in the service of discussing social and ethical issues such as privacy, security, and intellectual property. Neither list is exhaustive, and each list is likely to be modified according to the interests of the instructor, interests of the students, and current events.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: None

COMP211 Computer Science I
This is the first course in a two-course sequence (COMP211-212) that is the gateway to the computer science major. It is intended for prospective computer science majors and others who want an in-depth understanding of programming and computer science. Topics to be covered in COMP211-212 include an introduction to the fundamental ideas of programming in imperative and functional languages, correctness and cost specifications, and proof techniques for verifying specifications.
Specifics such as choice of programming language, which topics are covered in which semesters, etc., will vary according to the tastes of the faculty offering the courses.
Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP112 OR COMP113 OR COMP115

COMP212 Computer Science II
This is the second course in a two-course sequence (COMP211-212) that is the gateway to the computer science major. It is intended for prospective computer science majors and others who want an in-depth understanding of programming and computer science. Topics to be covered in COMP211-212 include an introduction to the fundamental ideas of programming in imperative and functional languages, correctness and cost specifications, and proof techniques for verifying specifications.
Specifications such as choice of programming language, which topics are covered in which semesters, etc., will vary according to the tastes of the faculty offering the courses.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Prereq:** COMP211  

**COMP260 Special Topics in Computer Science**  
This course is designed for nonmajors who wish to pursue some topic in computer science beyond introduction to programming. Topics will vary according to the instructor.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Identical With:** COMP521  
**Prereq:** COMP211

**COMP266 Bioinformatics**  
This course is an introduction to bioinformatics for students with interest in the life sciences. The course is similar to BIOL265 but only meets in the second half of the semester (with BIOL265) and is designed for students with programming background, ideally in Python. The course introduces problem areas and conceptual frameworks in bioinformatics and discusses programming approaches used in bioinformatics such as sequence matching and manipulation algorithms using dynamic programming, clustering analysis of gene expression data, analysis of genetic nets using Object Oriented Programming, and sequence analysis using Hidden Markov Models, Regular Expressions, and information theory.

**Offering:** Crosslisting  
**Grading:** A-F  
**Credits:** 0.50  
**Gen Ed Area:** NSM-BIOL  
**Identical With:** MB&B266, CIS266, BIOL266  
**Prereq:** [MB&B181 OR BIOL181]

**COMP301 Automata Theory and Formal Languages**  
This course is an introduction to formalisms studied in computer science and mathematical models of computing machines. The language formalisms discussed will include regular, context-free, recursive, and recursively enumerable languages. The machine models discussed include finite-state automata, pushdown automata, and Turing machines.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Identical With:** COMP500  
**Prereq:** COMP211 AND COMP212 AND MATH228

**COMP312 Algorithms and Complexity**  
The course will cover the design and analysis of efficient algorithms. Basic topics will include greedy algorithms, divide-and-conquer algorithms, dynamic programming, and graph algorithms. Some advanced topics in algorithms may be selected from other areas of computer science.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Identical With:** COMP510  
**Prereq:** COMP212 AND MATH228

**COMP321 Design of Programming Languages**  
This course is an introduction to concepts in programming languages. Topics include parameter passing, type checking and inference, control mechanisms, data abstraction, module systems, and concurrency. Basic ideas in functional, object-oriented, and logic programming languages will be discussed.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Identical With:** COMP521  
**Prereq:** COMP212 AND MATH228

**COMP327 Evolutionary and Ecological Bioinformatics**  
Bioinformatic analysis of gene sequences and gene expression patterns has added enormously to our understanding of ecology and evolution. For example, through bioinformatic analysis of gene sequences, we can now reconstruct the evolutionary history of physiology, even though no traces of physiology exist in the fossil record. We can determine the adaptive history of one gene and all the gene’s descendants. We can now construct the evolutionary tree of all of life. Bioinformatics is particularly promising for analysis of the ecology and biodiversity of microbial communities, since well over 99 percent of microorganisms cannot be cultured; our only knowledge of these organisms is through analysis of their gene sequences and gene expression patterns. For example, even when we cannot culture most of a microbial community, we can determine which metabolic pathways are of greatest significance through analysis of community-level gene expression. All these research programs are made accessible not only by breakthroughs in molecular technology but also by innovation in the design of computer algorithms. This course, team-taught by an evolutionary biologist and a computer scientist, will present how bioinformatics is revolutionizing evolutionary and ecological investigation and will present the design and construction of bioinformatic computer algorithms underlying the revolution in biology. Students will learn algorithms for reconstructing phylogeny, for sequence alignment, and for analysis of genomes, and students will have an opportunity to create their own algorithms.

**Offering:** Crosslisting  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-BIOL  
**Identical With:** COMP527, BIOL527, BIOL327, CIS327  
**Prereq:** [BIOL182 or MB&B182] OR [BIOL196 or MB&B196] OR COMP112 OR COMP211

**COMP331 Computer Structure and Organization**  
The purpose of the course is to introduce and discuss the structure and operation of digital computers. Topics will include the logic of circuits, microarchitectures, microprogramming, conventional machine architectures, and an introduction to software/hardware interface issues. Assembly language programming will be used to demonstrate some of the basic concepts.

**Offering:** Host  
**Grading:** A-F  
**Credits:** 1.00  
**Gen Ed Area:** NSM-MATH  
**Identical With:** COMP531  
**Prereq:** COMP212

**COMP332 Computer Networks**  
This course will provide an introduction to the fundamentals of computer networks. Computer networks have become embedded in our everyday lives, from the Internet to cellular phones to cloud networking, enabling applications such as email, texting, web browsing, on-demand video, video conferencing, peer-to-peer file sharing, social networking, cloud computing, and more. This course will delve into the infrastructure and protocols that have allowed computer networks to achieve their current ubiquity. While the primary focus of the course will be on the Internet’s architecture, protocols, and applications, we
will also touch on other types of computer networks. Programming assignments will be done using Python; prior knowledge of Python is not required.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212 and MATH228

COMP342 Software Engineering
This course provides an introduction to the processes and tools of software engineering: the design, development, testing, and maintenance of large software systems. The course is based on the Berkeley MOOC "Software Engineering as a Service" and uses on-line material from the MOOC to provide some of the course content.

The first part of the course will cover developing software in teams as well as learning the languages and tools used in the course, including Ruby, Rails, Cucumber, RSpec, Pivotal Tracker, and GitHub.

The second part of the course will continue to present software engineering concepts but will also focus on developing a team service-learning software development project for an external customer.

Offering: Host
Grading: A-F
Credits: 1.50
Gen Ed Area: NSM-MATH
Prereq: COMP211 AND COMP212

COMP350 Computational Media: Videogame Design and Development
This course examines the interplay of art and science in the development of contemporary video games using "game tool" applications to achieve a variety of purposes. It combines a detailed understanding of computational media, including legal and commercial aspects, with hands-on experience in the creative process. There will be discussions with invited industry leaders in various subject areas. Students will have the opportunity to work as part of development teams and create working prototypes to understand the challenges and rewards of producing video games in a professional context.

Offering: Crosslisting
Grading: A-F
Credits: 2.00
Gen Ed Area: NSM-IDEA
Identical With: IDEA250, FILM250, CIS250
Prereq: None

COMP352 Topics in Artificial Intelligence
The content of this course will be artificial intelligence and machine learning. The course will cover search strategies and planning and will build up to basic machine learning principles and techniques. Includes some programming.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Identical With: COMP352
Prereq: MATH228 AND COMP212

COMP356 Computer Graphics
This course covers fundamental algorithms in two- and three-dimensional graphics. The theory and application of the algorithms will be studied, and implementation of the algorithms or applications of them will be an integral part of the course. According to the tastes of the instructor, additional topics such as elementary animation or more advanced techniques may be covered.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212

COMP360 Special Topics in Computer Science
This course covers special topics in computer science. Topics will vary according to the instructor.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212 AND MATH228

COMP360A Special Topics in Computer Science
This course covers special topics in computer science. Topics will vary according to the instructor.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212 AND MATH228

COMP360B Special Topics in Computer Science
This course covers special topics in computer science. Topics will vary according to the instructor.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212 AND MATH228

COMP360C Special Topics in Computer Science
This course covers special topics in computer science. Topics will vary according to the instructor.

Offering: Host
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Prereq: COMP212

COMP401 Individual Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.

Offering: Host
Grading: OPT

COMP402 Individual Tutorial, Undergraduate
Topic to be arranged in consultation with the tutor.

Offering: Host
Grading: OPT

COMP403 Department/Program Project or Essay
Project to be arranged in consultation with the tutor.

Offering: Host
Grading: A-F

COMP404 Department/Program Project or Essay
Project to be arranged in consultation with the tutor.

Offering: Host
Grading: A-F
COMP407 Senior Tutorial (downgraded thesis)  
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor. Only enrolled in through the Honors Coordinator.  
Offering: Host  
Grading: A-F

COMP408 Senior Tutorial (downgraded thesis)  
Downgraded Senior Thesis Tutorial - Project to be arranged in consultation with the tutor. Only enrolled in through the Honors Coordinator.  
Offering: Host  
Grading: A-F

COMP409 Senior Thesis Tutorial  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP410 Senior Thesis Tutorial  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP411 Group Tutorial, Undergraduate  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP412 Group Tutorial, Undergraduate  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP419 Student Forum  
Student-run group tutorial, sponsored by a faculty member and approved by the chair of a department or program.  
Offering: Host  
Grading: Cr/U

COMP420 Student Forum  
Student-run group tutorial, sponsored by a faculty member and approved by the chair of a department or program.  
Offering: Host  
Grading: Cr/U

COMP421 Undergraduate Research, Sciences  
Individual research projects for undergraduate students supervised by faculty members.  
Offering: Host  
Grading: A-F

COMP422 Undergraduate Research, Sciences  
Individual research projects for undergraduate students supervised by faculty members.  
Offering: Host  
Grading: OPT

COMP423 Advanced Research Seminar, Undergraduate  
Advanced research tutorial; project to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP424 Advanced Research Seminar, Undergraduate  
Advanced research tutorial; project to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP469 Education in the Field, Undergraduate  
Students must consult with the department and class dean in advance of undertaking education in the field for approval of the nature of the responsibilities and method of evaluation.  
Offering: Host  
Grading: A-F  
Credits: 1.00  
Gen Ed Area: None  
Prereq: None

COMP491 Teaching Apprentice Tutorial  
The teaching apprentice program offers undergraduate students the opportunity to assist in teaching a faculty member's course for academic credit.  
Offering: Host  
Grading: OPT

COMP492 Teaching Apprentice Tutorial  
The teaching apprentice program offers undergraduate students the opportunity to assist in teaching a faculty member's course for academic credit.  
Offering: Host  
Grading: OPT

COMP500 Automata Theory and Formal Languages  
This course is an introduction to formalisms studied in computer science and mathematical models of computing machines. The language formalisms discussed will include regular, context-free, recursive, and recursively enumerable languages. The machine models discussed include finite-state automata, pushdown automata, and Turing machines.  
Offering: Crosslisting  
Grading: A-F  
Credits: 1.00  
Gen Ed Area: NSM-MATH  
Identical With: COMP301  
Prereq: COMP211 AND COMP212 AND MATH228

COMP501 Individual Tutorial, Graduate  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP502 Individual Tutorial, Graduate  
Topic to be arranged in consultation with the tutor.  
Offering: Host  
Grading: OPT

COMP503 Selected Topics, Graduate Sciences  
Topic to be arranged in consultation with the tutor. A seminar primarily concerned with papers taken from current research publications designed for, and required of, graduate students.  
Offering: Host  
Grading: A-F

COMP504 Selected Topics, Graduate Sciences  
Topic to be arranged in consultation with the tutor. A seminar primarily concerned with papers taken from current research publications designed for, and required of, graduate students.  
Offering: Host  
Grading: A-F

COMP510 Algorithms and Complexity  
The course will cover the design and analysis of efficient algorithms. Basic topics will include greedy algorithms, divide-and-conquer algorithms, dynamic programming, and graph algorithms. Some advanced topics in algorithms may be selected from other areas of computer science.  
Offering: Crosslisting  
Grading: A-F  
Credits: 1.00
COMP511 Group Tutorial, Graduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

COMP512 Group Tutorial, Graduate
Topic to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

COMP521 Design of Programming Languages
This course is an introduction to concepts in programming languages. Topics include parameter passing, type checking and inference, control mechanisms, data abstraction, module systems, and concurrency. Basic ideas in functional, object-oriented, and logic programming languages will be discussed.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Identical With: COMP321
Prereq: COMP212 AND MATH228

COMP527 Evolutionary and Ecological Bioinformatics
Bioinformatic analysis of gene sequences and gene expression patterns has added enormously to our understanding of ecology and evolution. For example, through bioinformatic analysis of gene sequences, we can now reconstruct the evolutionary history of physiology, even though no traces of physiology exist in the fossil record. We can determine the adaptive history of one gene and all the gene's descendants. We can now construct the evolutionary tree of all of life. Bioinformatics is particularly promising for analysis of the ecology and biodiversity of microbial communities, since well over 99 percent of microorganisms cannot be cultured; our only knowledge of these organisms is through analysis of their gene sequences and gene expression patterns. For example, even when we cannot culture most of a microbial community, we can determine which metabolic pathways are of greatest significance through analysis of community-level gene expression. All these research programs are made accessible not only by breakthroughs in molecular technology but also by innovation in the design of computer algorithms. This course, team-taught by an evolutionary biologist and a computer scientist, will present how bioinformatics is revolutionizing evolutionary and ecological investigation and will present the design and construction of bioinformatic computer algorithms underlying the revolution in biology. Students will learn algorithms for reconstructing phylogeny, for sequence alignment, and for analysis of genomes, and students will have an opportunity to create their own algorithms.
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-BIOL
Identical With: BIOLS27, COMP327, BIOL327, CIS327
Prereq: [BIOL182 or MB&B182] OR [BIOL196 or MBB196] OR COMP112 OR COMP211

COMP531 Computer Structure and Organization
The purpose of the course is to introduce and discuss the structure and operation of digital computers. Topics will include the logic of circuits, microarchitectures, microprogramming, conventional machine architectures, and an introduction to software/hardware interface issues. Assembly language programming will be used to demonstrate some of the basic concepts.
Offering: Crosslisting
Grading: A-F
Credits: 1.00