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: CIS265, BIOL265, MB&B265
Prereq: [MB&B181 or BIOL181]

COMP114 How to Talk to Machines
How do we tell robots and computers how to do what they do? Getting a handle on this question is the goal of this course. Since telling a device how to do something depends a lot on what that device can do, along the way we will learn a bit about what is “in the box.” We will start with the kind of programming one might use to instruct a robot how to interact with the world around it. That will lead us to the Turing machine, a beautiful mathematical model of a computer. We will adapt that model to something that is closer to how most computer systems today are designed. 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. After passing this course, students will have a basic knowledge of programming and how a computer works. COMP 114 can be used to satisfy the COMP 211 prerequisite and also 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

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 COMP114 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.

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: 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: QAC260
Prereq: COMP112

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: 1.00
Gen Ed Area: NSM-MATH
Identical With: COMP500
Prereq: COMP211 AND 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: BIOL327, COMP527, CIS327, BIOL527
Prereq: [BIOL182 or MB&B182] OR [BIOL196 or MBB196] 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 provides 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

COMP432 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 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:** FILM250, IDEA350
**Prereq:** None

**COMP360 Special Topics in Computer Science: Information Security and Privacy**
This course explores principles and practical applications of computer security and privacy. Some of the topics covered include static and dynamic code analysis, secure authentication, privacy enhancing technologies, usable privacy and security, and web tracking. We will also touch upon theoretical areas, such as basic cryptographic concepts as well as differential privacy. The course has the objective to provide students with the conceptual knowledge and technical skills to identify and resolve privacy and security issues in the design, development, and evaluation of information systems.

**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

**COMP361 Advanced Topics in Computer Science**
Network science is an emerging field that focuses on the analysis of real-world complex systems arising in the social, biological, and physical sciences by abstracting them into networks (or graphs). The size and complexity of real networks has produced a deep change in the way that graphs are approached, and led to the development of new mathematical and computational tools.

This course provides an introduction to network science by walking through modern techniques for modeling, analyzing, and simulating the structures and dynamics of complex networks. Specific topics to be discussed will include: network models and measures, graph algorithms, visualization and simulation, models of dynamic/adaptive networks, network modularity and community detection, and some applications. Python and NetworkX will be used for modeling and analysis of networks, in addition to other computational tools. Students should have a reasonable amount of experience in Python programming or willingness to learn "on the go."

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

**COMP360C Special Topics in Computer Science: Network Science**
This course covers advanced topics in Computer Science. The precise topics will vary with the offering, but will typically have prerequisites beyond COMP 211-212. This course may be repeated for credit.

**Offering:** Host
**Grading:** A-F
**Credits:** 1.00
**Gen Ed Area:** NSM-MATH
**Prereq:** COMP321

**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
**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
Gen Ed Area: NSM-MATH
Identical With: COMP312
Prereq: COMP212 AND MATH228

**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

COMP523 Programming Language Implementation
This course is an introduction to the implementation of programming languages.
Students will learn how to formally describe and implement major components of the implementation pipeline. Topics may include lexical analysis and parsing (checking whether source code is well-formed and converting it to an internal programmatic representation), type-checking and -inference (static program analysis for safety features), interpretation (direct execution of a high-level language program), and compilation (translation to a low-level language such as assembly or bytecode).
Offering: Crosslisting
Grading: A-F
Credits: 1.00
Gen Ed Area: NSM-MATH
Identical With: COMP323
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: BIOL327, COMP327, CIS327, BIOL527
Prereq: [BIOL182 or MBB182] 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
Gen Ed Area: NSM-MATH
Identical With: COMP331
Prereq: COMP212

COMP549 Advanced Research Seminar, Graduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

COMP550 Advanced Research Seminar, Graduate
Advanced research tutorial; project to be arranged in consultation with the tutor.
Offering: Host
Grading: OPT

COMP571 Special Topics in Computer Science
Supervised reading course of varying length. This course may be repeated for credit.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: None
Prereq: None

COMP572 Special Topics in Computer Science
Supervised reading course of varying length. This course may be repeated for credit.
Offering: Host
Grading: OPT
Credits: 1.00
Gen Ed Area: None
Prereq: None