COMPUTING AND INFORMATION SCIENCE

ADMINISTRATION

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INTRODUCTION

Computing and Information Science (CIS) offers courses and programs campuswide in various academic disciplines in which computing is integral. It is home to the Department of Computer Science, the Department of Statistical Science, the major in Information Science, and interdisciplinary programs in computational biology, computational science, and engineering. The faculty members associated with CIS programs hold joint appointments with CIS and another Cornell academic unit.

Computing and Information Science is a rapidly changing area. Please consult the CIS web site, www.cis.cornell.edu/, for the most current news of programs and courses, or visit the CIS undergraduate office in 303 Upson Hall.

ACADEMIC PROGRAMS

Computing and Information Science offers the following academic programs through its corresponding colleges. See the departmental listings for details of the programs.

Computational Biology

The program of study in computational biology is part of the biological sciences major offered through the College of Agriculture and Life Sciences and the College of Arts and Sciences and is coordinated by the Office of Undergraduate Biology. It provides core training in biology and the supporting physical and information sciences. It is designed for students who want to emphasize basic biological science.

The concentration in computational molecular biology is offered by the Department of Computer Science to students enrolled in the College of Arts and Sciences and the College of Engineering. It provides core training in computer science and biology. It is designed for students who want to emphasize computational science.

The concentration in statistical genomics is offered by the Department of Biological Statistics and Computational Biology to students enrolled in the College of Agriculture and Life Sciences. It provides training in statistics, biology, and computer science. It is designed for students who want to emphasize statistics and bioinformatics.

The concentration in mathematical biology is offered by the Department of Mathematics and is open to students enrolled in the College of Arts and Sciences. It provides training in mathematics, biology, and computer science. It is designed for students who want to emphasize mathematics

Computational Science and Engineering

Computational science and engineering is an emerging CIS program. Numerous courses are taught throughout the university. Topics include numerical methods, modeling and simulation, and real-time computing and control. CIS sponsors several "tool-based" short courses for students who anticipate that their studies will have a strong computational component (CIS 401, 402). A course on data structures for computational science (CIS 409) is also offered.

Computer Science

All CIS programs have connections to computer science, the study of computation in all of its forms. The curriculum covers the theory of algorithms and computing and its many applications in science, engineering, and business. Students learn the algorithmic method of thinking and how to bring it to bear on a wide range of problems. They also study the elements of computing and information technology such as system design, problem specification, programming, system analysis and evaluation, and complex modeling. Research areas include programming languages, compilers, computing systems, artificial intelligence, natural language processing, computer graphics, computer vision, databases, networks, bioinformatics, the theory of algorithms, scientific computing, and computational logic.

The Department of Computer Science offers the computer science major to students in the College of Arts and Sciences and the College of Engineering, the computer science minor to students in the College of Engineering, and the Master of Engineering (M.Eng.) degree in computer science to students in the College of Engineering.

Information Science

Information science at Cornell is an interdisciplinary program that studies the design and use of information systems in a social context. It integrates the study of three aspects of digital information systems. First, information science studies computing systems that provide people with information content; this study overlaps with parts of computer science, stressing the design, construction, and use of large information systems such as the World Wide Web and other global information resources. The second aspect of information science examines how people engage these information resources and how they can be integrated into everyday life. This area is also called "human-centered systems" because it is concerned with systems that hundreds of millions of people will use in daily life. The third aspect deals with understanding how information systems are situated in social, economic, and historical contexts. It explores the economic value of information, the legal constraints on systems, their social impact, and the cultural aspects of their construction. These are synergistic topics, and the next generation of scientists, scholars, business leaders, and government workers will need to understand them and how they relate.

Specific topics emphasized in the information science program include information networks; information discovery; knowledge organization; interaction design; interface design and evaluation; collaboration within and across groups, communities, organizations, and society; computational linguistics; computational techniques in the collection, archiving, and analysis of social science data; information privacy; methods of collecting, preserving, and distributing information; information system design; cognition and learning; social informatics; and cultural studies of computation.

The Information Science (IS) major is offered by the College of Agriculture and Life Sciences and the College of Arts and Sciences. Students in the College of Engineering may major in information science, systems, and technology (ISST), which is offered jointly by the Department of Computer Science and the School of Operations Research and Industrial Engineering. For details about the IS and ISST majors, please refer to the respective colleges.

The minor/concentration in information science is available to students in all undergraduate colleges.

Applied Statistics

The Department of Statistical Science offers a Master of Professional Studies (MPS) in applied statistics, with an emerging track in bioinformatics, for students pursuing careers in business, industry, and government. The MPS program has three main components: a two-semester core course, ST 501 and 502, covering a wide range of statistical applications, computing, and consulting; an in-depth statistical analysis MPS project supported by the core course; required course work, including a two-semester course sequence in mathematical probability and statistics, and elective course work selected from offerings in the Department of Statistical Science and other departments at Cornell.

THE INFORMATION SCIENCE CONCENTRATION/MINOR

A concentration/minor in information science is available to students in the Colleges of Agriculture and Life Sciences (CALS); Architecture, Art, and Planning (AAP; available to Architecture and Planning students only); Arts and Sciences; Engineering; Human Ecology; and the Schools of Hotel Administration and Industrial and Labor

Relations (ILR). Because of small differences in regulations between the colleges, the requirements may vary slightly, depending on a student's college and, in a few cases, a student's major. All students interested in pursuing the information science concentration/minor must initiate the process by sending an e-mail message with their name, college, year of study (e.g., second-semester sophomore), expected graduation date, and (intended) major to minor@infosci.cornell.edu. Students are also referred to www.infosci.cornell.edu/ugrad/concentrations.html for the most up-to-date description of the concentration and its requirements.

Information science is an interdisciplinary field covering all aspects of digital information. The program has three main areas: human-centered systems, social systems, and information systems. Human-centered systems studies the relationship between humans and information, drawing from human-computer interaction and cognitive science. Social systems examines information in its economic, legal, political, cultural, and social contexts. Information systems studies the computer science problems of representing, storing, manipulating, and using digital information.

The concentration/minor has been designed to ensure that students have substantial grounding in all three of these areas. To this end, the requirements for the undergraduate concentration/minor are as follows. All courses must be chosen from the course lists below. In addition, a letter grade of C or better is required; S-U courses are not allowed.

Note: Course credits from institutions other than Cornell may not be counted toward the IS minor. Engineering students must use ENGRD 270 or CEE 304. Hotel students must use H ADM 201.

- **Statistics:** one course.
- **Human-centered systems** (human-computer interaction and cognitive science): two courses (for all colleges except Engineering and Hotel); one course (Engineering and Hotel).
- **Social systems** (social, economic, political, cultural, and legal issues): one course.
- **Information systems** (primarily computer science): two courses for all colleges except Hotel. Hotel students need to take one course in this area. Engineering students may not use INFO 130. COM S 211 may not be used by students who are required to take it for their major.
- **Elective:** one additional course from any component area. Hotel students must take three courses in this category, from the following: H ADM 374, 574, and 476 or 575. (Engineering students and all Computer science majors must select a course from human-centered systems or social systems. Communication majors must select a course outside Communication. Students in other majors should check with their advisors to make sure there are no special departmental restrictions or requirements.)

Statistics

An introductory course that provides a working knowledge of basic probability and statistics and their application to analyzing data occurring in the real world.

Engineering students must take one of the following:

- ENGRD 270 Basic Engineering Probability and Statistics
- CEE 304 Uncertainty Analysis in Engineering

Hotel students must take:

- H ADM 201 Hospitality Quantitative Analysis

All other students can meet this requirement with any one of the following:

- MATH 171 Statistical Theory and Application in the Real World
- H ADM 201 Hospitality Quantitative Analysis
- AEM 210 Introductory Statistics
- PAM 210 Introduction to Statistics
- ENGRD 270 Basic Engineering Probability and Statistics
- BTRY 301 Statistical Methods I
- SOC 301 Evaluating Statistical Evidence
- CEE 304 Uncertainty Analysis in Engineering
- ILRST 312 Applied Regression Methods
- ECON 319 Introduction to Statistics and Probability
- PSYCH 350 Statistics and Research Design

Human-Centered Systems

- COGST 101 Introduction to Cognitive Science
- PSYCH 205 Perception
- INFO 214 Cognitive Psychology
- INFO 245 Psychology of Social Computing
- PSYCH 280 Introduction to Social Psychology
- PSYCH 342 Human Perception: Applications to Computer Graphics, Art, and Visual Display
- INFO 345 Human-Computer Interaction Design
- PSYCH 347 Psychology of Visual Communications
- PSYCH 380 Social Cognition
- PSYCH 413 Information Processing: Conscious and Unconscious
- PSYCH 416 Modeling Perception and Cognition
- INFO 440 Advanced Human-Computer Interaction Design
- INFO 445 Seminar in Computer-Mediated Communication
- INFO 450 Language and Technology
- DEA 470 Applied Ergonomic Methods

Social Systems

- S&TS 250 Technology in Society
- INFO 292 Inventing an Information Society
- ECON 301 Microeconomics*
- SOC 304 Social Networks and Social Processes
- ECON 313 Intermediate Microeconomic Theory*
- AEM 322 Technology, Information, and Business Strategy*
- INFO 349 Media Technologies
- INFO 355 Computers: From the 17th Century to the Dot.com Boom
- INFO 356 Computing Cultures
- ECON 368 Game Theory*
- INFO 387 The Automatic Lifestyle: Consumer Culture and Technology
- LAW 410 Limits on and Protection of Creative Expression—Copyright Law and Its Close Neighbors
- S&TS 411 Knowledge, Technology, and Property
- ECON 419 Economic Decisions Under Uncertainty
- COMM 428 Communication Law
- INFO 429 Copyright in the Digital Age
- OR&IE 435 Introduction to Game Theory*
- S&TS 438 Minds, Machines, and Intelligence
- INFO 447 Social and Economic Data
- H ADM 474 Strategic Information Systems*
- ECON 476/477 Decision Theory I and II
- H ADM 489 The Law of the Internet and E-Commerce
- INFO 515 Culture, Law, and Politics of the Internet

*Only one of ECON 301 and 313 can be taken for IS credit. Only one of OR&IE 435 and ECON 368 can be taken for IS credit. Only one of AEM 322 and H ADM 474 may be taken for IS credit.

Information Systems

- INFO 130 Introductory Design and Programming for the Web*
- INFO 172 Computation, Information, and Intelligence
- COM S 211 Computers and Programming*
- INFO 230 Intermediate Design and Programming for the Web*
- CIS 300 Introduction to Computer Game Design
- INFO 330 Data-Driven Web Applications
- LING 424 Computational Linguistics
- INFO 430 Information Retrieval
- INFO 431 Web Information Systems
- COM S 432 Introduction to Database Systems
- COM S 465 Computer Graphics I
- COM S 472 Foundations of Artificial Intelligence
- LING 474 Introduction to Natural Language Processing
- OR&IE 474 Statistical Data Mining
- COM S 478 Machine Learning
- OR&IE 480 Information Technology
- OR&IE 481 Delivering OR Solutions with Information Technology

- OR&IE 483 Application of Operations Research and Game Theory to Information Technology
- COM S 501 Software Engineering
- COM S 513 System Security
- COM S 530 Architecture of Large-Scale Information Systems
- ECE 562 Fundamental Information Theory
- OR&IE 574 Statistical Data Mining
- COM S 578 Empirical Methods in Machine Learning and Data Mining

*INFO 130 may not be taken for information science credit by Engineering students. Computer science majors may not use INFO 130 or 230. COM S 211 may not be taken for information science credit by majors for which it is a required course, e.g., Computer Science (COM S) and Operations Research and Industrial Engineering (OR&IE).

COMPUTING AND INFORMATION SCIENCE (CIS) COURSES

CIS 121(1121) Introduction to MATLAB (also EAS 121[1121])
Fall, spring. 2 credits. Corequisite: MATH 111, 191, or equivalent. No programming experience assumed.
Introduction to elementary computer programming concepts using MATLAB. Topics include problem analysis, development of algorithms, selection, iteration, functions, and arrays. Examples and assignments are chosen to build an appreciation for computational science. The goal is for each student to develop a facility with MATLAB that will be useful in other courses whenever there is a need for computer problem solving or visualization.

CIS 122(1002) Application of FORTRAN in the Earth and Environmental Sciences (also EAS 150[1500])
Spring. 2 credits. Prerequisite: CIS/EAS 121 or equivalent.
For description, see EAS 150.

CIS 165(1610) Computing in the Arts (also ART 175, COM S 165[1610], ENGRI 165[1610], MUSIC 165[1465], PSYCH 165[1650])
Fall. 3 credits.
For description, see COM S 165.

CIS 167(1620) Visual Imaging in the Electronic Age (also ART 170[1700], COM S/ENGRI 167[1620])
Fall. 3 credits. Not offered every year.
For description, see ART 170.

CIS 300(3000) Introduction to Computer Game Design
Fall, spring. 4 credits. Prerequisites: students generally choose one field (art, music, programming, writing), although working in multiple areas is encouraged; artists should have taken ART 251 or have equivalent experience; musicians should have programming experience (COM S 100, COM S/INFO 130 or equivalent) and MUSIC 120; programmers must have completed COM S/ENGRD 211 or CIS 409 and have experience with, or the ability to learn quickly, C++; writers should have programming experience (COM S 100, COM S/INFO 130 or equivalent) and ENGL 280/281 or equivalent experience.
Investigates the theory and practice of developing computer games from a blend of technical, aesthetic, and cultural perspectives. Technical aspects of game architecture include software engineering, artificial intelligence, game physics, computer graphics, and networking. Aesthetic and cultural aspects of design include art and modeling, sound and music, history of games, genre analysis, role of violence, gender issues in games, game balance, and careers in the industry. Programmers, artists, musicians, and writers collaborate to produce an original computer game.

CIS 401(4201) Introduction to Applied Scientific Computing with MATLAB
Fall, usually weeks 2–5. 1 credit. Prerequisite: COM S 100 or equivalent programming experience. S-U grades only.
Introduction to the use of MATLAB as an aid to scientific research. Introduces the basic syntax and features of MATLAB and develops the background necessary for the more specialized courses. Covers basic MATLAB programming and vectorized operations, data input/output, and simple visualization. Emphasizes applied issues such as managing large data sets, simulation, and visualization but also introduces fundamental ideas in scientific computing such as floating point arithmetic and algorithm efficiency. Although the course uses MATLAB, the ideas and concepts covered are common to many computational environments.

CIS 402(4202) Scientific Visualization with MATLAB
Fall, usually weeks 6–10. 1 credit. Prerequisite: COM S 100 or equivalent programming experience. Recommended: CIS 401. S-U grades only.
Survey of the advanced visualization features in MATLAB. Covers MATLAB's "handle graphics" paradigm, specialized graphics routines for vectors and fields, and introduces color mapping, lighting, and new features for controlling object transparency. Although the course is meant to introduce students to the capabilities of the MATLAB system, it also emphasizes the basic goal of visualization: producing an image that effectively communicates a scientific result.

CIS 405(4205) Effective Use of High-Performance Computing
Spring, weeks 1–8. 2 credits. Prerequisite: proficiency in C, C++, Fortran, or Fortran 90. S-U grades only.
Introduction to high-performance computing (HPC) for graduate students or advanced undergraduate students who will use HPC as a tool in their research. Various HPC architectural platforms are described, with a focus on computational clusters. Students learn how to identify and exploit the various types of parallelism in algorithms and legacy applications. Understanding how to measure speedup and efficiency and how various bottlenecks affect them is covered. Parallel programming with MPI, OpenMP, and task-farming techniques, such as the use of web services, is covered in detail. The goal of the course is for students to gain practical HPC experience for use in their specific fields of research.

[CIS 409(4209) Data Structures and Algorithms for Computational Science (also M&AE 409[4090])
Fall. 4 credits. Prerequisite: COM S 211 or equivalent programming experience.
Covers data structures and algorithms with emphasis on those useful for computational science. This course is intended for students outside of the Department of Computer Science whose work involves a significant amount of computing. Topics include basic data structures as well as more advanced areas. Emphasis is placed on the use of abstract data types and on how best to select appropriate data structures.]

CIS 490(4999) Independent Reading and Research
Fall, spring. 1–4 credits.
Independent reading and research for undergraduates.

CIS 504(5040) Applied Systems Engineering (also CEE 504[5040], ECE 512[5120], M&AE 591[5910], OR&IE 512[5120], SYSEN 510[5100])
Fall. 3 credits. Prerequisites: senior or graduate standing in engineering field; concurrent or recent (past two years) enrollment in group-based project with strong system design component approved by course instructor.
For description, see SYSEN 510.

CIS 505(5050) Systems Analysis Architecture, Behavior, and Optimization (also CEE 505[5050], ECE 513[5130], M&AE 592[5920], OR&IE 513[5130], SYSEN 520[5200])
Spring. 3 credits. Prerequisite: Applied Systems Engineering (CEE 504, ECE 512, M&AE 591, OR&IE 512, or SYSEN 510).
For description, see SYSEN 520.

[CIS 565(5640) Computer Animation (also ART 273[2703], COM S 565[5640])
Fall. 4 credits. Prerequisite: none.
For description, see ART 273.]

[CIS 566(5642) Advanced Animation (also ART 372, COM S 566[5642])
Spring. 4 credits. Prerequisite: none.
For description, see ART 372.]

CIS 572(5722) Heuristic Methods for Optimization (also CEE 509[5090], COM S 572[5722], OR&IE 533[5340])
Fall. 3 or 4 credits. Prerequisite: COM S/ENGRD 211 or 322, or CEE/ENGRD 241, or graduate standing, or permission of instructor.
For description, see CEE 509.

CIS 576(5846) Decision Theory I (also ECON 476/676[4460/6760])
Fall. 4 credits. Prerequisite: mathematical sophistication.
For description, see ECON 476.

CIS 577(5847) Decision Theory II (also ECON 477/677[4770/6770])
Spring. 4 credits. Prerequisite: mathematical sophistication.
For description, see ECON 477.

CIS 629(6229) Computation Methods for Nonlinear Systems (also PHYS 682[7682])
Fall. 4 credits. Enrollment may be limited. J. Sethna and C. Myers.
For description, see PHYS 682.

[CIS 673(6724) Integration of Artificial Intelligence and Operations Research (also COM S 673[6724])
Spring. 3 credits.
For description, see COM S 673.]

CIS 750(7726) Evolutionary Computation and Design Automation (also COM S 750[7726], M&AE 650[6500])
Fall. 4 credits. Prerequisite: programming experience or permission of instructor.
For description, see COM S 750.

CIS 790(7999) Independent Research
Fall, spring. Variable credit. Prerequisite: permission of CIS faculty member.
Independent research or master of engineering project.

CIS 797(7970) Topics in CIS/IGERT Seminars
Fall, spring. 1 credit. S-U grades only.
Discusses diverse topics in nonlinear systems. The seminar is oriented to the requirements for the IGERT Program in Nonlinear Systems, a National Science Foundation supported graduate training program. Includes a mixture of student, faculty, and visitor presentations and development of plans for internships and student projects.

COMPUTER SCIENCE

The Department of Computer Science is affiliated with both the College of Arts and Sciences and the College of Engineering. Students in either college may major in computer science. The department is also part of CIS, and its courses are an integral part of its several educational programs.

COM S 099(1109) Fundamental Programming Concepts
Summer. 2 credits. Prerequisite: freshman standing. Credit may not be applied toward engineering degree. S-U grades only.
Designed for students who intend to take COM S 100 but are not adequately prepared for that course. Basic programming concepts and problem analysis are studied. An appropriate high-level programming language is used. Students with previous programming experience and students who do not intend to take COM S 100 should not take this course.

COM S 100H(1113) Introduction to Computer Programming—Honors
Spring. 4 credits.
An accelerated, but thorough, introduction to programming (mostly in Java, with a short segment on MATLAB) taught in a small class environment. The primary emphases are problem solving, modular design, and software development, with the focus on learning how to tackle a variety of ill-defined problems in a structured manner. No prior programming experience is required, although a preparedness to enjoy collaborative work and challenges would be a significant asset. Provides adequate preparation for COM S/ENGRD 211.

COM S 100J(1110) Introduction to Computer Programming
Fall, spring, summer. 4 credits. Assumes basic high school mathematics (no calculus) but no programming experience.
Introduction to computer programming concepts using the Java programming language. Includes a two-week unit on MATLAB. Topics include algorithms, language concepts, object-oriented concepts, procedures and functions, arrays, and strings. Principles of software development, style, and testing are emphasized. Weekly lab sections provide students with guided practice on the computer, with staff present to help. COM S 100J and 100M are equivalent courses; both should not be taken.

COM S 100M(1112) Introduction to Computer Programming
Fall, spring. 4 credits. Corequisite: MATH 111, 191, or equivalent. Assumes student is comfortable with mathematics (at level of one semester of calculus) but has no prior programming experience.
Introduction to computer programming concepts using MATLAB (seven weeks) and Java (seven weeks). Emphasizes techniques of problem analysis and development of algorithms and programs. Topics include iteration, functions, arrays, scientific graphics, and object-oriented concepts. Examples and assignments give the student an appreciation for computational science and engineering. COM S 100M and 100J are equivalent courses, and either one provides adequate preparation for COM S/ENGRD 211.

COM S 100R(1114) Introduction to Computer Programming—Robotics
Fall. 4 credits. Limited to 25 students. Prerequisite: programming experience at level of advanced placement computer science.
Fast-paced introduction to computer science using camera-controlled robots, taught in MATLAB. Emphasis is on modular design of programs and on fundamental algorithms. Extensive laboratory experiments with cameras and robots, including Sony Aibo. Example projects include controlling a robot by pointing a light stick and making a robot recognize simple colored objects. Provides adequate preparation for COM S/ENGRD 211.

COM S 101(1710) Introduction to Cognitive Science (also COGST 101[1010], LING 170[1700], PHIL 191[1910], PSYCH 102[1020])
Fall, summer. 3 credits.
For description, see COGST 101.

COM S 113(2000) Introduction to C
Fall, spring, usually weeks 1–4. 1 credit. Prerequisite: COM S 100 or equivalent programming experience. Credit granted for both COM S 113 and 213 only if 113 taken first. S-U grades only.
Brief introduction to the C programming language and standard libraries. Unix accounts are made available for students wishing to use that system for projects, but familiarity with Unix is not required. (Projects may be done using any modern implementation of C.) COM S 213 (C++ Programming) includes much of the material covered in 113. Students planning to take COM S 213 normally do not need to take 113.

COM S 114(2006) Unix Tools
Fall, usually weeks 5–8. 1 credit. Prerequisite: COM S 100 or equivalent programming experience. Recommended: knowledge of at least one programming language. S-U grades only.
Introduction to Unix, emphasizing tools for file management, communication, process control, managing the Unix environment, and rudimentary shell scripts. Projects assume no previous knowledge of Unix or expertise in any particular language.

COM S 130(1300) Introductory Design and Programming for the Web (also INFO 130[1300])
Fall. 3 credits. Prerequisite: none. No computer background necessary.
The World Wide Web is both a technology and a pervasive and powerful resource in our society and culture. To build functional and effective web sites, students need technical and design skills as well as analytical skills for understanding who is using the web, in what ways they are using it, and for what purposes. In this course, students develop skills in all three of these areas through the use of technologies such as XHTML, Cascading Stylesheets, and PHP. Students study how web sites are deployed and used, usability issues on the web, user-centered design, and methods for visual layout and information architecture. Through the web, this course provides an introduction to the interdisciplinary field of information science. No computer background necessary.

COM S 165(1610) Computing in the Arts (also ART 175, CIS 165[1610], ENGRI 165[1610], MUSIC 165[1465], PSYCH 165[1650])
Fall. 3 credits. Recommended: good comfort level with computers and some of the arts.
Over the centuries, artists in a wide variety of media have employed many approaches to the creative process, ranging from the philosophical to the mechanical to the virtual. This course unravels some of the mysteries going on inside software used for art and music. It looks at ways of breaking things apart and sampling and ways of putting things together and resynthesizing, and explores ideas for creation. This course does not teach software packages for creating art and music. The course complements ART 171+ and MUSIC 120+.

COM S 167(1620) Visual Imaging in the Electronic Age (also ART 170[1700], CIS/ENGRI 167[1620])
Fall. 3 credits.
For description, see ART 170.

COM S 172(1700) Computation, Information, and Intelligence (also COGST 172, ENGRI 172[1700], INFO 172[1700])
Fall. 3 credits. Prerequisites: some knowledge of differentiation; permission of instructor for students who have completed equivalent of COM S 100.
Introduction to computer science using methods and examples from the field of artificial intelligence. Topics include game playing, search techniques, learning theory, compute-intensive methods, data mining, information retrieval, the web, natural language processing, machine translation, and the Turing test. This is not a programming course; rather, "pencil and paper" problem sets are assigned. Some calculus is required.

COM S 201(2710) Cognitive Science in Context Laboratory (also COGST 201, PSYCH 201[2010])
Spring. 4 credits. Limited to 24 students. Recommended: concurrent or prior registration in PSYCH 102, COGST/COM S 101, LING 170, or PHIL 191. Knowledge of programming languages not assumed.
For description, see COGST 201.

COM S 211(2110) Computers and Programming (also ENGRD 211[2110])
Fall, spring, summer. 3 credits. Prerequisite: COM S 100 or equivalent course in Java or C++.
Intermediate programming in a high-level language and introduction to computer

science. Topics include program structure and organization, object-oriented programming (classes, objects, types, sub-typing), graphical user interfaces, algorithm analysis (asymptotic complexity, big "O" notation), recursion, data structures (lists, trees, stacks, queues, heaps, search trees, hash tables, graphs), simple graph algorithms. Java is the principal programming language.

COM S 212(2111) Java Practicum
Fall, spring. 1 credit. Pre- or corequisite: COM S/ENGRD 211. Letter grades only.
Project course that introduces students to the ways of software engineering using the Java programming language. The course requires the design and implementation of several large programs.

COM S 214(2008) Advanced UNIX Programming and Tools
Spring, usually weeks 5–8. 1 credit. Prerequisite: COM S 114 or equivalent. S-U grades only.
Focuses on Unix as a programming environment for people with a basic knowledge of Unix and experience programming in at least one language. Projects cover advanced shell scripts (sh, ksh, csh), Makefiles, programming and debugging tools for C and other languages, and more modern scripting languages such as Perl and Python. Students with little or no experience with Unix should take COM S 114 first.

COM S 215(2004) Introduction to C#
Fall, spring, usually weeks 5–8. 1 credit. Prerequisite: COM S/ENGRD 211 or equivalent experience. S-U grades only.
Introduces students to building applications in the .NET environment using the C# language.

COM S 230(2300) Intermediate Design and Programming for the Web (also INFO 230[2300])
Spring. 3 credits. Prerequisite: COM S 130 or equivalent knowledge.
Web programming requires the cooperation of two machines: the one in front of the viewer (client) and the one delivering the content (server). COM S 130 concentrates almost exclusively on the client side. The main emphasis in COM S 230 is learning about server side processing. Students begin by looking at interactions with databases, learning about querying both on paper and via SQL, and then, through a succession of projects, learn how to apply this understanding to the creation of an interactive data-driven site via the use of an integrated web site development tool such as ColdFusion. Also considered are techniques to enhance security, privacy, and reliability and ways of incorporating other programs. Toward the end of the course, students are shown how these development tools are working. Design issues are emphasized. A major component of the course is the creation of a substantial web site.

COM S 280(2800) Discrete Structures
Fall, spring. 3 credits. Pre- or corequisite: COM S 100 or permission of instructor.
Covers the mathematics that underlies most of computer science. Topics include mathematical induction; logical proof; propositional and predicate calculus; combinatorics and discrete mathematics; basic probability theory; basic number theory; sets, functions, and relations; partially ordered sets; and graphs. These topics are discussed in the context of applications to many areas of computer science, including game playing, the RSA cryptosystem, data mining, load balancing in distributed systems, properties of the Internet and World Wide Web, and web searching.

COM S 305(3050) Creative Problem-Solving in Computer Science
Spring. 3 credits. Prerequisites: COM S 211 and 280.
Computer science is full of open-ended, vaguely specified problems; this course is about solving them. Examples draw from several sources, including the ACM programming competitions and a collection of "favorites" that interviewers like to pose to potential CS hires. Emphasis is on developing general problem-solving heuristics and teamwork. The course is discussion-based, with students working in groups, presenting solutions to the class, and critiquing the solutions of others. Grading rewards creativity and unusual thinking. Even an unsuccessful attempt to solve a problem can receive full credit if it is interesting, insightful, and clearly presented.

COM S 312(3110) Data Structures and Functional Programming
Fall, spring. 4 credits. Prerequisite: COM S 211 and 212 or equivalent programming experience. Should not be taken concurrently with COM S 314 or 316.
Advanced programming course that emphasizes functional programming techniques and data structures. Programming topics include recursive and higher-order procedures, models of programming language evaluation and compilation, type systems, and polymorphism. Data structures and algorithms covered include graph algorithms, balanced trees, memory heaps, and garbage collection. Also covers techniques for analyzing program performance and correctness.

COM S 314(3420) Computer Organization (also ECE 314[3140])
Spring. 4 credits. Prerequisite: COM S 211 or ENGRD 230. Should not be taken concurrently with COM S 312.
Basic computer organization. Topics include performance metrics, data formats, instruction sets, addressing modes, computer arithmetic, datapath design, memory hierarchies including caches and virtual memory, I/O devices, and bus-based I/O systems. Students learn assembly language programming and design a simple pipelined processor.

COM S 316(3410) Systems Programming
Fall. 4 credits. Prerequisite: COM S 211 or equivalent programming experience. Should not be taken concurrently with COM S 312.
Introduction to systems programming, computer organization, and the hardware/software interface. Topics include representation of information, machine and assembly languages, processor organization, memory management, input/output mechanisms, and basic network programming. Also covered are techniques for analyzing program performance and optimization

[COM S 321(3510) Numerical Methods in Computational Molecular Biology (also BIOBM 321[3210], ENGRD 321[3510])
Fall. 3 credits. Prerequisites: at least one course in calculus (e.g., MATH 106, 111, or 191) and linear algebra (e.g., MATH 221 or 294 or BTRY 417); COM S 100 or equivalent and some familiarity with iteration, arrays, and procedures; knowledge of discrete probability and random variables at the level of COM S 280. COM S majors and minors may use only one of the following toward their degree: COM S 321, 322, or 421. Offered odd-numbered years; next offered 2007–2008.
Introduction to numerical computing using MATLAB organized around five applications: the analysis of protein shapes, dynamics, protein folding, score functions, and field equations. Students become adept at plotting, linear equation solving, least squares fitting, and cubic spline interpolation. More advanced problem-solving techniques that involve eigenvalue analysis, the solution of ordinary and partial differential equations, linear programming, and nonlinear minimization are also treated. The goal of the course is to develop a practical computational expertise with MATLAB and to build mathematical intuition for the problems of molecular biology.]

COM S 322(3220) Introduction to Scientific Computation (also ENGRD 322[3220])
Spring, summer. 3 credits. Prerequisites: COM S 100 and MATH 221 or 294, knowledge of discrete probability and random variables at the level of COM S 280. COM S majors and minors may use only one of the following toward their degree: COM S 321, 322, or 421.
Introduction to elementary numerical analysis and scientific computation. Topics include interpolation, quadrature, linear and nonlinear equation solving, least-squares fitting, and ordinary differential equations. The MATLAB computing environment is used. Vectorization, efficiency, reliability, and stability are stressed. Includes special lectures on computational statistics.

[COM S 324(3740) Computational Linguistics (also COGST 424[4240], LING 424[4424])
Fall or spring. 4 credits. Prerequisites: LING 203. Recommended: COM S 114. Labs involve work in Unix environment.
For description, see LING 424.]

COM S 330(3300) Data-Driven Web Applications (also INFO 330[3300])
Fall. 3 credits. Prerequisite: COM S/ENGRD 211. COM S majors may use only one of the following toward their degree: COM S/INFO 330 or COM S 433.
Introduces students to modern database systems and three-tier application development with a focus on building web-based applications using database systems. Concepts covered include the relational model, relational query languages, data modeling, normalization, database tuning, three-tier architectures, Internet data formats and query languages, server- and client-side technologies, and an introduction to web services. Students build a database–backed web site.

COM S 381(3810) Introduction to Theory of Computing
Fall, summer. 3 credits. Prerequisite: COM S 280 or permission of instructor. Credit not granted for both COM S 381 and 481; corrective transfers between COM S 381 and 481 (in either direction) encouraged during first few weeks of instruction.
Introduction to the modern theory of computing: automata theory, formal languages, and effective computability.

[COM S 400(4150) The Science of Programming

Fall. 3 credits. Prerequisite: COM S 211. Covers the practical development of correct programs based on the conscious application of principles that are derived from a mathematical notion of program correctness. In addition, related ideas in algorithmic problem solving are explored.]

COM S 411(4110) Programming Languages and Logics

Fall. 4 credits. Prerequisite: COM S 312 or permission of instructor. Not offered every year.

Introduction to the theory, design, and implementation of programming languages. Topics include operational semantics, type systems, higher-order function, scope, lambda calculus, laziness, exceptions, side effects, continuations, objects, and modules. Also discussed are logic programming, concurrency, and distributed and persistent programming.

COM S 412(4120) Introduction to Compilers

Spring. 3 credits. Prerequisites: COM S 312 or permission of instructor and COM S 314 or 316. Corequisite: COM S 413.

Introduction to the specification and implementation of modern compilers. Topics include lexical scanning, parsing, type checking, code generation and translation, an introduction to optimization, and the implementation of modern programming languages. The course entails a substantial compiler implementation project.

COM S 413(4121) Practicum in Compilers

Spring. 2 credits. Corequisite: COM S 412. Compiler implementation project related to COM S 412.

COM S 414(4410) Operating Systems

Fall, spring, summer. 3 credits. Prerequisite: COM S 314 or 316. Corequisite: COM S 415 in spring only.

Introduction to the logical design of systems programs, with emphasis on multiprogrammed operating systems. Topics include process synchronization, deadlock, memory management, input-output methods, information sharing, protection and security, and file systems. The impact of network and distributed computing environments on operating systems is also discussed.

COM S 415(4411) Practicum in Operating Systems

Fall, spring. 2 credits. Corequisite: COM S 414.

Studies the practical aspects of operating systems through the design and implementation of an operating system kernel that supports multiprogramming, virtual memory, and various input-output devices. All the programming for the project is in a high-level language.

COM S 416(4420) Computer Architecture (also ECE 475[4750])

Fall. 4 credits. Prerequisites: ENGRD 230 and COM S/ECE 314.

For description, see ECE 475.

COM S 419(4450) Computer Networks

Spring. 4 credits. Pre- or corequisite: COM S 414 or permission of instructor.

Introduction to computer networks with an emphasis on fundamentals. Detailed introduction to networking protocols for reliable data transfer, flow control, congestion control, naming and addressing, routing, and security. Fundamentals of layered protocols and techniques for protocol design and implementation. Course material is supplemented by network measurement projects, protocol simulations, and a substantial protocol implementation project running over sockets that requires use of C or C++.

COM S 421(4210) Numerical Analysis

Fall. 4 credits. Prerequisites: MATH 221 or 294 or equivalent, one additional mathematics course numbered 300 or above, and knowledge of programming. COM S majors and minors may use only one of the following toward their degree: COM S 321, 322, or 421.

Modern algorithms for systems of linear equations, systems of nonlinear equations, numerical optimization, and numerical solution of differential equations. Some discussion of methods suitable for parallel computation. This course requires more mathematical sophistication than COM S 322.

COM S 426(4520) Introduction to Bioinformatics

Spring. 4 credits. Prerequisites: COM S/ENGRD 211, COM S 280.

Overview of the goals, tools, and techniques used in bioinformatics, a field that applies ideas from computer science, mathematical modeling, and statistics in order to make sense of the huge datasets that typify modern biology. Topics include a brief introduction to molecular biology, DNA sequencing, sequence alignment and multiple alignment, similarity searches and their statistics, phylogeny, gene regulation and motif finding, gene finding, and genome rearrangements. Much of the course is devoted to an in-depth study of the algorithms behind popular computational tools such as Smith-Waterman, BLAST, CLUSTALW, Genscan, and MEME.

COM S 428(4510) Introduction to Computational Biophysics

Fall. 3 credits. Prerequisite: COM S 100, CHEM 211 or equivalent, MATH 221, 293, or 294, PHYS 112 or 213, or permission of instructor. Recommended: BIOBM 330.

Teaches the techniques used to simulate on the computer the structure, dynamics, and function of biological molecules. Computer models of water/proteins/membranes using mechanical force fields are considered. Optimization methods (conjugate gradient and Newton Raphson minimization) are explained in the context of structure optimization. Stochastic sampling (Metropolis algorithm) is used to estimate entropy and partition functions. Enhanced sampling approaches such as multi-tempering to estimate free energies are discussed. Continuum approximation to dielectric and the numerical solution of the Poisson Boltzmann equation are explored.

COM S 430(4300) Information Retrieval (also INFO 430[4300])

Fall. 3 credits. Prerequisite: COM S 211 or equivalent.

Studies the methods used to search for and discover information in large-scale systems. The emphasis is on information retrieval applied to textual materials, but there is some discussion of other formats. The course includes techniques for searching, browsing, and filtering information and the use of classification systems and thesauruses. The techniques are illustrated with examples from web searching and digital libraries.

COM S 431(4302) Web Information Systems (also INFO 431[4302])

Spring. 3 credits. Prerequisites: COM S 211 and some familiarity with web site technology.

Examines the architecture of web information systems such as distributed digital libraries and electronic publishing systems. Many of the topics presented are the subject of current research and development at Cornell, other universities, and in standards organizations such as the World Wide Web Consortium. Course content mixes exploration of current tools for building web information systems such XML, XSLT, and RDF with broader concepts such as techniques for knowledge representation and description, object models for content representation, and legal and economic impacts of web information. A theme that runs throughout the course is the relationship between traditional information environments, exemplified by libraries, and the distributed information environment of the web.

COM S 432(4320) Introduction to Database Systems

Fall. 3 credits. Prerequisites: COM S 312 (or COM S 211, 212, and permission of instructor).

Introduction to modern database systems. Concepts covered include storage structures, access methods, query languages, query processing and optimization, transaction management, recovery, database design, XML, and XQuery. The course focuses on the design and internals of modern database systems.

COM S 433(4321) Practicum in Database Systems

Fall. 2 credits. Prerequisite: COM S 432 or coregistration in COM S 432. COM S majors may use only one of the following toward their degree: COM S/INFO 330 or COM S 433.

Students build part of a real database system in C++.

COM S 465(4620) Computer Graphics I (also ARCH 374[3704])

Fall. 4 credits. Prerequisite: COM S/ENGRD 211. May not be taken after COM S 417.

Introduction to the principles of computer graphics in two and three dimensions. Topics include digital images, filtering and anti-aliasing, 2-D and 3-D affine geometry, ray tracing, perspective and 3-D viewing, the graphics pipeline, curves and surfaces, and human visual perception. Homework assignments require programming.

COM S 467(4630) Computer Graphics II

Spring. 3 credits. Prerequisite: COM S 465.

Covers the principles of computer graphics including advanced topics such as the modern graphics hardware pipeline, transformations, materials and shading models, advanced texturing, shadow algorithms, hierarchical acceleration structures, global illumination, animation, and 3D surface modeling.

COM S 468(4631) Computer Graphics Practicum

Spring. 2 credits. Prerequisite: COM S 465. Corequisite: COM S 467.

Provides COM S 467 students with hands-on experience in computer graphics programming on modern graphics hardware with a final 3D game project. Programming assignments cover 3D transformations, modeling, shading, rendering, animation, and user interfaces. The

course uses Java, OpenGL, and Cg for code development.

COM S 472(4700) Foundations of Artificial Intelligence
Fall. 3 credits. Prerequisites: COM S/ENGRD 211 and COM S 280 (or equivalent).
Challenging introduction to the major subareas and current research directions in artificial intelligence. Topics include knowledge representation, heuristic search, problem solving, natural-language processing, game-playing, logic and deduction, planning, and machine learning.

COM S 473(4701) Practicum in Artificial Intelligence
Fall. 2 credits. Corequisite: COM S 472.
Project portion of COM S 472. Topics include knowledge representation systems, search procedures, game-playing, automated reasoning, concept learning, reinforcement learning, neural nets, genetic algorithms, planning, and truth maintenance.

COM S 474(4740) Introduction to Natural Language Processing (also COGST 474, LING 474[4474])
Fall or spring. 4 credits. Prerequisite: COM S 211.
Computationally oriented introduction to natural language processing, the goal of which is to enable computers to use human languages as input, output, or both. Possible topics include parsing, grammar induction, information retrieval, and machine translation.

COM S 475(4702) Artificial Intelligence: Uncertainty and Multi-Agent Systems
Spring. 4 credits. Prerequisites: COM S/ ENGRD 211 and COM S 280 or equivalent.
A key issue in the design of intelligent system is how to deal with uncertain or incomplete information, as obtained, for example, through (noisy) sensory input. The first half of this course focuses on how to represent and reason with uncertain information. The second half covers the study and design of multi-agent systems. Topics include Bayesian networks, dynamic Bayesian networks, belief propagation, Markov random fields, exact and approximate probabilistic inference methods, Markov Chain Monte Carlo methods, connections to statistical physics and information science, adversarial reasoning and planning in multi-agent systems, and game theoretic notions underlying multi-agent systems. This course complements COM S 472, but is given as a self-contained unit.

COM S 478(4780) Machine Learning
Spring. 4 credits. Prerequisites: COM S 280, 312, and basic knowledge of linear algebra and probability theory.
Machine learning is concerned with the question of how to make computers learn from experience. The ability to learn is not only central to most aspects of intelligent behavior, but machine learning techniques have become key components of many software systems. For example, machine learning techniques are used to create spam filters, to analyze customer purchase data, and to explore new domains of science. This course introduces the fundamental set of techniques and algorithms that constitute machine learning as of today, including classification methods like decision trees and support vector machines, parametric Bayesian learning and hidden Markov models, as well as unsupervised learning and reinforcement learning. The course discusses algorithms and methods and provides an introduction to the theory of machine learning.

COM S 480[4870] Introduction to Cryptology (also MATH 335[3350])
Fall, spring. 3 credits. Prerequisites: COM S 100 and MATH 222 or 294. Students who take this course may not also receive credit for MATH 336.
For description, see MATH 335.

COM S 482(4820) Introduction to Analysis of Algorithms
Spring, summer. 4 credits. Prerequisites: COM S 280 and 312.
Develops techniques used in the design and analysis of algorithms, with an emphasis on problems arising in computing applications. Example applications are drawn from systems and networks, artificial intelligence, computer vision, data mining, and computational biology. This course covers four major algorithm design techniques (greedy algorithms, divide-and-conquer, dynamic programming, and network flow), computational complexity focusing on NP-completeness, and algorithmic techniques for intractable problems (including identification of structured special cases, approximation algorithms, and local search heuristics).

[COM S 483(4812) Quantum Computation (also PHYS 481/681[4481/7681])
Spring. 2 credits. Prerequisite: familiarity with theory of vector spaces over complex numbers. Not offered every year; next offered 2007–2008.
For description, see PHYS 481.]

COM S 485(4850) Mathematical Foundations for the Information Age
Spring. 4 credits. Prerequisites: COM S 381 or 481.
Covers the mathematical foundations underlying modeling and searching of the WWW and other complex networks, discovering trends, data mining, and making recommendations based on user behavior. Topics include random graphs, tail bounds, branching processes, spectral analysis, clustering, learning mixtures of distributions, extracting information from large, high dimensional, and noisy data, VC dimension, latent semantic indexing, and collaborative filtering.

COM S 486(4860) Applied Logic (also MATH 486[4860])
Fall or spring. 4 credits. Prerequisites: MATH 222 or 294, COM S 280 or equivalent (e.g., MATH 332, 432, 434, 481), and some additional course in mathematics or theoretical computer science.
Propositional and predicate logic, compactness and completeness by tableaux, natural deduction, and resolution. Equational logic. Herbrand Universes and unification. Rewrite rules and equational logic, Knuth-Bendix method, and the congruence-closure algorithm and lambda-calculus reduction strategies. Topics in Prolog, LISP, ML, or Nuprl. Applications to expert systems and program verification.

COM S 490(4999) Independent Reading and Research
Fall, spring. 1–4 credits.
Independent reading and research for undergraduates.

COM S 501(5150) Software Engineering
Spring. 4 credits. Prerequisite: COM S 211 or equivalent experience programming in Java or C++.
Introduction to the practical problems of specifying, designing, and building large, reliable software systems. Students work in teams on projects for real clients. This work includes a feasibility study, requirements analysis, object-oriented design, implementation, testing, and delivery to the client. Additional topics covered in lectures include professionalism, project management, and the legal framework for software development.

COM S 513(5430) System Security
Fall. 4 credits. Prerequisites: COM S 414 or 419 and familiarity with JAVA, C, or C# programming languages.
Discusses security and survivability for computers and communications networks. Includes discussions of policy issues (e.g., the national debates on cryptography policy) as well as the discussions of the technical alternatives for implementing the properties that comprise "trustworthiness" in a computing system. Covers mechanisms for authorization and authentication as well as cryptographic protocols.

COM S 514(5410) Intermediate Computer Systems
Spring. 4 credits. Prerequisite: COM S 414 or permission of instructor.
Focuses on practical issues in designing and implementing distributed software. Topics vary depending on instructor. Recent offerings have covered object-oriented software development methodologies and tools, distributed computing, fault-tolerant systems, and network operating systems or databases. Students undertake a substantial software project. Many students obtain additional project credit by co-registering in COM S 490, 515, or 790.

[COM S 516(5420) Parallel Computer Architecture (also ECE 572[5720])
Spring. 4 credits. Prerequisite: ECE 475.
For description, see ECE 572.]

COM S 530(5300) The Architecture of Large-Scale Information Systems (also INFO 530[5300])
Spring. 4 credits. Prerequisite: COM S/ INFO 330 or COM S 432.
Deals with the architecture of large-scale information systems, with special emphasis on Internet-based systems. Topics include three-tier architectures, edge caches, distributed transaction management, web services, workflows, performance scalability, and high-availability architectures. The course includes a substantial project in the context of three-tier architectures, involving web servers, application servers, and database systems. Students study and use technologies such as Web Services, .Net, J2EE, ASPs, Servlets, XML, and SOAP.

[COM S 565(5640) Computer Animation (also ART 273[2703], CIS 565[5640])
Fall. 4 credits. Prerequisite: none.
For description, see ART 273.]

[CIS 566(5642) Advanced Animation (also ART 372[3702], COM S 566[5642])
Spring. 4 credits. Prerequisites: none.
For description, see ART 372.]

COM S 572(5722) Heuristic Methods for Optimization (also CEE 509[5090], CIS 572[5722], OR&IE 533[5340])
Fall. 3 or 4 credits. Prerequisites: COM S/ENGRD 211 or 322 or CEE/ENGRD 241, or graduate standing, or permission of instructor.
For description, see CEE 509.

COM S 578(5780) Empirical Methods in Machine Learning and Data Mining
Fall. 4 credits. Prerequisites: COM S 280 and 312 or equivalent.
This implementation-oriented course presents a broad introduction to current algorithms and approaches in machine learning, knowledge discovery, and data mining and their application to real-world learning and decision-making tasks. The course also covers experimental methods for comparing learning algorithms, for understanding and explaining their differences, and for exploring the conditions under which each is most appropriate.

COM S 611(6110) Advanced Programming Languages
Fall. 4 credits. Prerequisite: graduate standing or permission of instructor.
Study of programming paradigms: functional, imperative, concurrent, and logic programming. Models of programming languages, including the lambda calculus. Type systems, polymorphism, modules, and other object-oriented constructs. Program transformations, programming logic, and applications to programming methodology.

COM S 612(6120) Compiler Design for High-Performance Architectures
Spring. 4 credits. Prerequisites: COM S 314 and 412 or permission of instructor.
Compiler design for pipelined and parallel architectures. Program analysis: data and control dependencies, dataflow analysis, efficient solution of dataflow equations, dependence tests, solution of Diophantine equations. Architecture and code generation for instruction-level parallel (ILP) processors: pipelined, VLIW and superscalar architectures, code reorganization and software pipelining. Architecture and code generation for multi-processors: shared- and distributed-memory architectures, latency tolerance and avoidance, loop transformations to enhance parallelism and locality of reference.

COM S 614(6410) Advanced Systems
Fall or spring. 4 credits. Prerequisite: COM S 414 or permission of instructor.
Advanced course in systems, emphasizing contemporary research in distributed systems. Topics may include communication protocols, consistency in distributed systems, fault-tolerance, knowledge and knowledge-based protocols, performance, scheduling, concurrency control, and authentication and security issues.

COM S 615(6460) Peer-to-Peer Systems
Spring. 4 credits. Recommended: COM S 614.
Peer-to-peer (P2P) is a new paradigm for distributed computing. P2P systems lack centralized servers and rely on self-organization and peer-to-peer resource sharing to accomplish their tasks. This course examines the peer-to-peer paradigm and peer-to-peer systems, and it discusses existing and new applications. Students are expected to perform an in-depth study of an existing approach or to develop new peer-to-peer systems and applications as part of the course project.

COM S 619(6450) Advanced Computer Networks
Fall. 4 credits. Prerequisite: COM S 419 or permission of instructor.
Examines advanced computer network topics such as overlay and P2P networking, reliable multicast, mobility, voice over IP, header compression, security, and extreme networking environments (fast, slow, big, long). The emphasis is on both research and the latest standards. A project with research content is required.

COM S 621(6210) Matrix Computations
Fall. 4 credits. Prerequisites: MATH 411 and 431 or permission of instructor.
Stable and efficient algorithms for linear equations, least squares, and eigenvalue problems. Direct and iterative methods are considered. The MATLAB system is used extensively.

COM S 622(6220) Numerical Optimization and Nonlinear Algebraic Equations
Spring. 4 credits. Prerequisite: COM S 621. Offered odd-numbered years.
Modern algorithms for the numerical solution of multidimensional optimization problems and simultaneous nonlinear algebraic equations. Emphasis is on efficient, stable, and reliable numerical techniques with strong global convergence properties: quasi-Newton methods, modified Newton algorithms, and trust-region procedures. Special topics may include large-scale optimization, quadratic programming, and numerical approximation.

[COM S 624(6240) Numerical Solution of Differential Equations
Spring. 4 credits. Prerequisites: exposure to numerical analysis (e.g., COM S 421 or 621) and differential equations, and knowledge of MATLAB. Offered even-numbered years; next offered 2007–2008.
Finite difference methods for the solution of ordinary and partial differential equations. A fast-moving course that begins with a three-week survey of numerical methods for ODEs, then moves on to Fourier analysis and methods for PDEs, especially parabolic and hyperbolic equations. Other topics include numerical stability, finite element methods, Hamiltonian problems, and computational issues such as mesh generation and sparse matrix computation for PDES.]

COM S 626(6510) Computational Molecular Biology
Spring. 4 credits. Prerequisites: familiarity with linear programming, numerical solutions of ordinary differential equations, and nonlinear optimization methods.
Problems and algorithms in computational molecular biology. Topics include sequences (alignment, scoring functions, complexity of searches and alignment, secondary structure prediction, families, and function), the protein folding problem (lattice models, lattice searches, the HP model, chemical potentials, statistical potentials, funnels, complexity and model verification, global optimization, homology, threading), and the dynamics of complex biosystems (the Molecular Dynamics method, long-range forces, statistics of flexible systems, reduced models).

COM S 628(6522) Biological Sequence Analysis
Fall. 4 credits. Prerequisite: none.
Typically concentrates on one topic in biological sequence analysis, providing an in-depth analysis of the algorithmic and statistical challenges in that area. The selected topics vary from year to year.

COM S 630(6300) Human Language Technology (also INFO 630[6300])
Spring. 4 credits. Prerequisites: basic knowledge of linear algebra and probability theory; basic programming skills.
Information retrieval has evolved from the problem of locating books in a library to a multitude of tasks ubiquitous in business, science, and personal life. Modern information systems automatically compose newspapers, extract facts from the web, and analyze usage patterns. This course covers the necessary techniques for representing, organizing, and accessing digital information that is in textual or semistructured form. Topics combine information retrieval, natural language processing, and machine learning, with links to work in databases and data mining.

COM S 632(6320) Database Management Systems
Spring. 4 credits. Prerequisite: COM S 432 or graduate standing.
Covers a variety of advanced issues ranging from transaction management to query processing to data mining. Involves extensive paper reading and discussion. Development of a term project with research content is required.

COM S 633(6322) Advanced Database Systems
Spring. 4 credits. Prerequisite: COM S 632 or permission of instructor.
Covers advanced topics in database systems and data mining. The exact set of topics changes with each offering of the course.

[COM S 664(6670) Machine Vision
Fall. 4 credits. Prerequisites: undergraduate-level understanding of algorithms and MATH 221 or equivalent.
Introduction to computer vision, with an emphasis on discrete optimization algorithms and on applications in medical imaging. Topics include edge detection, image segmentation, stereopsis, motion and optical flow, active contours, and the Hausdorff distance. Students are required to implement several of the algorithms covered in the course and complete a final project.]

COM S 665(6620) Advanced Interactive Graphics
Fall or spring. 4 credits. Prerequisites: COM S 465 and 467 or equivalent and undergraduate-level understanding of algorithms, probability and statistics, vector calculus, and programming.
Covers advanced topics in realistic rendering with a focus on interactive techniques. Topics include light transport and global illumination, Monte-Carlo rendering, rendering using the modern graphics pipeline, rendering with complex scenes, shadow algorithms, perception for rendering, and image-based rendering.

[COM S 667(6630) Physically Based Rendering
Fall or spring. 4 credits. Prerequisites: COM S 465 and 467 or equivalent and undergraduate-level understanding of algorithms, programming, and vector calculus.

Advanced course in realistic image synthesis, focusing on the computation of physically accurate images. Topics include radiometry; light transport and global illumination; rendering with participating media; advanced models for material properties; and physical measurement of light sources, images, and materials.]

COM S 671(6762) Introduction to Automated Reasoning

Fall or spring. 4 credits. Prerequisite: COM S 611 and graduate standing or permission of instructor. Not offered every year.

Topics in modern logic needed to understand and use automated reasoning systems such as HOL, Nuprl, and PVS. Special emphasis is on type theory and logic and on tactic-oriented theorem proving.

COM S 672(6700) Advanced Artificial Intelligence

Spring. 4 credits. Prerequisites: COM S 472 or permission of instructor.

Artificial intelligence (AI) provides many computational challenges. This course covers a variety of areas in AI, including knowledge representation, automated reasoning, learning, game-playing, and planning, with an emphasis on computational issues. Specific topics include stochastic reasoning and search procedures, properties of problem encodings, issues of syntax and semantics in knowledge representation, constraint satisfaction methods and search procedures, and critically constrained problems and their relation to phase-transition phenomena. In addition, connections between artificial intelligence and other fields, such as statistical physics, operations research, and cognitive science are explored.

[COM S 673(6724) Integration of Artificial Intelligence and Operations Research (also CIS 673[6724])

Spring. 3 credits.

Covers topics on the integration of artificial intelligence (AI) and operations research (OR) techniques for solving combinatorial problems as they appear in AI and OR applications. Application domains include AI planning, scheduling, combinatorial auctions, market mechanisms, and combinatorial designs.]

COM S 674(6740) Natural Language Processing

Spring. 3 credits. Prerequisites: COM S 472 or permission of instructor. COM S 474 is *not* a prerequisite.

Presents a graduate-level introduction to natural language processing, the primary concern of which is the study of human language use from a computational perspective. Covers syntactic analysis, semantic interpretation, and discourse processing, examining both symbolic and statistical approaches. Possible topics include information extraction, natural language generation, memory models, ambiguity resolution, finite-state methods, mildly context-sensitive formalisms, deductive approaches to interpretation, machine translation, and machine learning of natural language.

[COM S 676(6764) Reasoning about Knowledge

Fall. 4 credits. Prerequisites: mathematical maturity and acquaintance with propositional logic.

Knowledge plays a crucial role in distributed systems, game theory, and artificial intelligence. Material examines formalizing reasoning about knowledge and the extent to which knowledge is applicable to those areas. Issues include common knowledge, knowledge-based programs, applying knowledge to analyzing distributed systems, attainable states of knowledge, modeling resource-bounded reasoning, and connections to game theory.]

[COM S 677(6766) Reasoning about Uncertainty

Fall. 4 credits. Prerequisites: mathematical maturity and acquaintance with propositional logic.

Examines formalizing reasoning about and representing uncertainty, using formal logical approaches as a basis. Topics: logics of probability, combining knowledge and probability, probability and adversaries, conditional logics of normality, Bayesian networks, qualitative approaches to uncertainty, going from statistical information to degrees of belief, and decision theory.]

COM S 678(6780) Advanced Topics in Machine Learning

Spring. 4 credits. Prerequisites: COM S 478 or equivalent, or COM S 578 or equivalent, or permission of instructor. Not offered every year.

Extends and complements COM S 478 and 578, giving in-depth coverage of new and advanced methods in machine learning. In particular, we connect to open research questions in machine learning, giving starting points for future work. The content of the course reflects an equal balance between learning theory and practical machine learning, making an emphasis on approaches with practical relevance. Topics include support vector machines, clustering, Bayes nets, boosting, model selection, learning orderings, and inductive transfer.

COM S 681(6820) Analysis of Algorithms

Fall. 4 credits. Prerequisite: COM S 482 or graduate standing.

Methodology for developing efficient algorithms, primarily for graph theoretic problems. Understanding of the inherent complexity of natural problems via polynomial-time algorithms, randomized algorithms, NP-completeness, and randomized reducibilities. Also covers topics such as parallel algorithms and efficient data structures.

[COM S 682(6810) Theory of Computing

Spring. 4 credits. Prerequisite: (COM S 381 or 481) and (COM S 482 or 681) or permission of instructor. Not offered every year; next offered 2007–2008.

Advanced treatment of theory of computation, computational-complexity theory, and other topics in computing theory.]

COM S 683(6822) Advanced Design and Analysis of Algorithms

Spring. 4 credits. Prerequisite: COM S 681 or permission of instructor.

An advanced study of current topics in the design of discrete algorithms. Topics may include randomization, approximation algorithms, online algorithms, learning theory, spectral methods, and techniques from the theory of metric spaces. The course will emphasize algorithmic problems in a range of areas including networks, electronic markets, and large datasets.

[COM S 684(6840) Algorithmic Game Theory

Fall or spring. 4 credits. Prerequisite: background in algorithms and graphs at level of COM S 482. No prior knowledge of game theory or economics assumed.

Algorithmic game theory combines algorithmic thinking with game-theoretic or, more generally, economic concepts. This course focuses on problems arising from, and motivated by, the Internet and other decentralized computer networks. The most defining characteristic of the Internet is that it was not designed by a single central entity, but emerged from the complex interaction of many economic agents, such as network operators, service providers, designers, and users, in varying degrees of collaboration and competition. The course focuses on some of the many questions at the interface between algorithms and game theory that arise from this point of view. Topics include Nash equilibrium and general equilibrium, the price of anarchy, market equilibrium, social choice theory, mechanism design, and multicast pricing.]

[COM S 685(6850) The Structure of Information Networks (also INFO 685[6850])

Fall or spring. 4 credits. Prerequisite: COM S 482.

Information networks such as the World Wide Web are characterized by the interplay between heterogeneous content and a complex underlying link structure. This course covers recent research on algorithms for analyzing such networks and models that abstract their basic properties. Topics include combinatorial and probabilistic techniques for link analysis, centralized and decentralized search algorithms, generative models for networks, and connections with work in the areas of social networks and citation analysis.]

COM S 686(6860) Logics of Programs

Spring. 4 credits. Prerequisites: COM S 481, 682, and MATH 481 or MATH/COM S 486.

COM S 709(7090) Computer Science Colloquium

Fall, spring. 1 credit. For staff, visitors, and graduate students interested in computer science. S-U grades only.

Weekly meeting for the discussion and study of important topics in the field.

COM S 711(7191) Seminar in Advanced Programming Languages

Fall, spring. 3 credits.

COM S 713(7491) Seminar in Systems and Methodology

Fall, spring. 4 credits. Prerequisites: graduate course employing formal reasoning (e.g., COM S 611, 613, 671), logic course, or permission of instructor. Not offered every year.

Discussion of contemporary issues in the design and analysis of computing systems. Emphasis is on the proper use of rigor, models, and formalism.

COM S 714(7410) Topics in Systems

Fall or spring. 3 credits. Prerequisite: permission of instructor.

COM S 715(7192) Seminar in Programming Refinement Logics

Fall, spring. 4 credits. Prerequisite: permission of instructor.

Topics in programming logics, possibly including type theory, constructive logic, decision procedures, heuristic methods,

extraction of code from proofs, and the design of proof-development and problem-solving systems.

COM S 717(7430) Topics in Parallel Architectures
Fall. 4 credits. Prerequisite: COM S 612 or permission of instructor. Not offered every year.
Covers topics in parallel computers. Material includes: architectures of parallel computers, parallelizing compilers, operating systems for parallel computers, and languages (functional and logic-programming languages) designed for parallel computation.

COM S 718(7690) Computer Graphics Seminar
Fall, spring. 3 credits.

COM S 719(7190) Seminar in Programming Languages
Fall, spring. 4 credits. Prerequisite: COM S 611 or permission of instructor. S-U grades only.

COM S 721(7210) Topics in Numerical Analysis
Fall, spring. 4 credits. Prerequisite: COM S 621 or 622 or permission of instructor. Not offered every year.
Topics are chosen at instructor's discretion.

COM S 726(7590) Problems and Perspectives in Computational Molecular Biology
Fall, spring. 1 credit. Open to all from life sciences, computational sciences, and physical sciences. S-U grades only.
Weekly seminar series discussing timely topics in computational molecular biology. Addresses methodological approaches to sequence and structure analysis, function prediction, study of evolutionary relationships, and analysis of large biological systems. Statistical and deterministic computational approaches are covered, and specific and detailed biological examples are discussed. In each topic, one or two representative papers are selected that made significant advances in this field. The lectures are given by faculty and students. We try to bridge these disciplines by pairing students and faculty from complementary backgrounds.

COM S 732(7320) Topics in Database Systems
Fall, spring. 4 credits. S-U grades only.

COM S 733(7390) Database Seminar
Spring. 1 credit. Prerequisite: COM S 633 or permission of instructor. S–U grades only.

COM S 750(7726) Evolutionary Computation and Design Automation (also CIS 750[7726], M&AE 650[6500])
Fall. 4 credits. Prerequisite: programming experience or permission of instructor.
Seminar course in evolutionary algorithms and their application to optimization and open-ended computational design. Genetic algorithms, genetic programming, co-evolution, arms races and cooperation, developmental representations, learning, and symbiosis are covered. Topics include artificial life, evolutionary robotics, and applications in a variety of domains in science and engineering. Suitable for students interested in computational techniques for addressing open-ended design problems and in computational models of evolutionary discovery.

COM S 754(7490) Systems Research Seminar
Fall, spring. 1 credit. S-U grades only.

COM S 764(7670) Visual Object Recognition
Spring. 3 credits.
This course covers recent advances in object recognition in computer vision, set in the context of classical methods. The readings are primarily recently published research results. The course format is a mixture of lectures, student presentations, and discussion. The final project consists of both an implementation and a paper. While the course has no formal prerequisites, a degree of mathematical and algorithmic sophistication is required. Familiarity with computer vision or machine learning techniques would be helpful.

COM S 772(7790) Seminar in Artificial Intelligence
Fall, spring. 4 credits. Prerequisite: permission of instructor. S-U grades only.

COM S 775(7794) Seminar in Natural Language Understanding
Fall, spring. 2 credits.
Informal weekly seminar in which current topics in natural language understanding and computational linguistics are discussed.

COM S 785(7850) Seminar on Information Networks
Fall. 4 credits. Prerequisites: COM S 485 or 685 or permission of instructor.
Covers current research on algorithms and models for analyzing large-scale networks, with connections to work in information systems and the social sciences. The course is based on the presentation and discussion of recent research papers.

COM S 786(7860) Introduction to Kleene Algebra
Spring. 4 credits. Prerequisite: COM S 481. Recommended: COM S 482 or 681, COM S 682, elementary logic (MATH 481 or 681), algebra (MATH 432).
Kleene algebra is an algebraic system that axiomatically captures the properties of a natural class of structures arising in logic and computer science. It has appeared in various guises in relational algebra, semantics and logics of programs, automata and formal language theory, and the design and analysis of algorithms. This course reviews the history of the development of Kleene algebra and Kleene algebra with tests (Kleene/Boolean algebra); studies models, compare axiomatizations, and derive completeness, expressiveness, and complexity results; and discusses discuss various applications in program schematology, program verification, compiler optimization, and programming language semantics and logic.

COM S 789(7890) Seminar in Theory of Algorithms and Computing
Fall, spring. 4 credits. Prerequisite: permission of instructor. S-U grades only.

COM S 790(7999) Independent Research
Fall, spring. Prerequisite: permission of a computer science advisor.
Independent research or master of engineering project.

COM S 990(9999) Thesis Research
Fall, spring. Prerequisite: permission of a computer science advisor. S-U grades only.
Doctoral research.

INFORMATION SCIENCE (INFO)

INFO 130(1300) Introductory Design and Programming for the Web (also COM S 130[1300])
Fall. 3 credits.
For description, see COM S 130.

INFO 172(1700) Computation, Information, and Intelligence (also COGST 172, COM S 172[1700], ENGRI 172[1700])
Fall. 3 credits. Prerequisites: some knowledge of differentiation; permission of instructor for students who have completed equivalent of COM S 100.
For description, see COM S 172.

INFO 204(2040) Networks (also ECON 204[2040], SOC 204[2120])
Spring. 4 credits.
For description, see ECON 204.

INFO 214(2140) Cognitive Psychology (also COGST/PSYCH 214[2140])
Fall. 3 credits. Limited to 175 students. Prerequisite: sophomore standing. Graduate students, see INFO/PSYCH 614, or COGST 501.
For description, see PSYCH 214.

INFO 230(2300) Intermediate Design and Programming for the Web (also COM S 230[2300])
Spring. 3 credits. Prerequisite: COM S/INFO 130 or equivalent knowledge.
For description, see COM S 230.

INFO 245(2450) Psychology of Social Computing (also COMM 245[2450])
Fall. 3 credits.
For description, see COMM 245.

INFO 292(2921) Inventing an Information Society (also AM ST 292[2980], ECE/ENGRG 298[2980], HIST 292[2920], S&TS 292[2921])
Spring. 3 credits; may not be taken for credit after ECE/ENGRG 198.
For description, see ENGRG 298.

INFO 295(2950) Mathematical Methods for Information Science
Fall. 4 credits. Corequisite: MATH 231 or equivalent.
Teaches basic mathematical methods for information science. Topics include graph theory, discrete probability, Bayesian methods, finite automata, Markov models, and hidden Markov models. Uses examples and applications from various areas of information science such as the structure of the web, genomics, natural language processing, and signal processing.

INFO 330(3300) Data-Driven Web Applications (also COM S 330[3300])
Fall. 3 credits. Prerequisite: COM S/ENGRD 211.
For description, see COM S 330.

INFO 345(3450) Human-Computer Interaction Design (also COMM 345[3450])
Spring. 3 credits.
For description, see COMM 345.

INFO 349(3491) Media Technologies (also COMM 349[3490], S&TS 349[3491])
Spring. 3 credits.
For description, see S&TS 349.

INFO 355(3551) Computers: From the 17th Century to the Dot.com Boom (also S&TS 355[3551])
Fall. 4 credits.
For description, see S&TS 355.

[INFO 356(3561) Computing Cultures (also S&TS 356[3561])
Spring. 4 credits. Prerequisites: none. Not offered 2006–2007; next offered 2007–2008.
For description, see S&TS 356.]

INFO 372(3720) Explorations in Artificial Intelligence
Spring. 3 credits. Prerequisites: MATH 111 or equivalent, an information science approved statistics course, and COM S 211 or permission of instructor.
How do computers solve tasks as diverse as playing chess or backgammon, control autonomous space missions such as NASA's Deep Space One, plan the route for a driverless car as in the Darpa Grand Challenge race, perform content-based selection of music programs, or solve Sudoku, the latest puzzle craze? This course introduces students to a range of computational modeling approaches and solution strategies using examples from AI and Information Science. We cover different formalisms such as logical representations, constraint-based languages, mathematical programming, and multi-agent approaches (including adversarial games). Emphasis is on modeling, not on algorithms, but efficiency issues (complexity) are highlighted as part of the modeling approaches. Students also learn about the tradeoffs in modeling choices.

[INFO 387(3871) The Automatic Lifestyle: Consumer Culture and Technology (also S&TS 387[3871])
Spring. 4 credits. Not offered 2006–2007; next offered 2007–2008.
For description, see S&TS 387.]

[INFO 429(4290) Copyright in the Digital Age (also COMM 429[4290])
Fall. 3 credits. Not offered 2006–2007; next offered 2007–2008.
For description, see COMM 429.]

INFO 430(4300) Information Retrieval (also COM S 430[4300])
Fall. 3 credits. Prerequisite: COM S/ENGRD 211 or equivalent.
For description, see COM S 430.

INFO 431(4302) Web Information Systems (also COM S 431[4302])
Spring. 3 credits. Prerequisites: COM S 211 and some familiarity with web site technology.
For description, see COM S 431.

INFO 435(4350) Seminar on Applications of Information Science (also INFO 635[6390])
Spring. 3 credits. Prerequisites: background in computing, data structures, and programming at level of COM S 211 or equivalent, and experience using information systems. Undergraduates and master's students should register for INFO 435; Ph.D. students should register for INFO 635.
This course brings together the interdisciplinary themes of information science—technological, sociological, legal, economic, and political—through a series of case studies of applications and areas of current research. The case studies are explored through reading and discussion of recent articles on aspects of information science, both social and technical. Several of the case studies center on current work at Cornell, e.g., arXiv, the Legal Information Institute, the NSDL, etc. Others build on the Information Science seminar series.

INFO 440(4400) Advanced Human-Computer Interaction Design (also COMM 440[4400])
Fall. 3 credits. Prerequisites: COMM/INFO 245.
For description, see COMM 440.

INFO 445(4450) Seminar in Computer-Mediated Communication (also COMM 445[4450])
Fall. 3 credits. Prerequisite: COMM/INFO 245.
For description, see COMM 445.

INFO 447(4470) Social and Economic Data (also ILRLE 447[4470])
Spring. 4 credits. Prerequisites: one semester of calculus, IS statistics requirement, and one upper-level social science course, or permission of instructor.
Social and economic data drive decisions in public and private organizations, and quality decisions require quality data. This course focuses on data quality—conceptual fit, sampling and nonsampling error, timeliness, geographic detail, and dissemination—as well as legal and ethical issues in the data manufacturing process. Major emphasis is placed on public use microdata files of the U.S. Census Bureau and their role in the allocation of federal funds. These files include the Census of Population and Housing, Current Population Survey, American Housing Survey, Consumer Expenditure Survey, and American Community Survey. The course is appropriate for upper-level undergraduate, professional master's and doctoral students who will be users of data products, from the public and private sectors; and/or producers of data products for their organizations, working with existing data products from public and proprietary sources, as well as administrative or survey data collected by their organization.

INFO 450(4500) Language and Technology (also COMM 450[4500])
Spring. 3 credits. Prerequisite: COMM 240 or 245 or permission of instructor
For description, see COMM 450.

INFO 490(4900) Independent Reading and Research
Fall, spring. 1–4 credits.
Independent reading and research for undergraduates.

INFO 491(4910) Teaching in Information Science, Systems, and Technology
Fall, spring. Variable credit.
Involves working as a T.A. in a course in the information science, systems, and technology major.

INFO 515(5150) Culture, Law, and Politics of the Internet
Fall. 4 credits.
Explores the culture, law, and politics of the Internet. Highlighted issues include: net neutrality, free speech, Internet governance, domain naming, intellectual property, DMCA compliance, privacy and security, and the development of institutional as well as national policy for the Internet.

INFO 530(5300) The Architecture of Large-Scale Information Systems (also COM S 530[5300])
Spring. 4 credits. Prerequisite: COM S/INFO 330 or COM S 432.
For description, see COM S 530.

INFO 614(6140) Cognitive Psychology (also COGST 614[6140], PSYCH 614[6140])
Fall. 5 credits.
For description, see PSYCH 614.

INFO 630(6300) Human Language Technology (also COM S 630[6300])
Spring. 4 credits. Prerequisites: basic knowledge of linear algebra and probability theory; basic programming skills.
For description, see COM S 630.

INFO 634(6341) Information Technology in Sociocultural Context (also S&TS 634[6341])
Spring. 4 credits. Prerequisite: permission of instructor.
For description, see S&TS 634.

INFO 635(6390) Seminar on Applications of Information Science (also INFO 435[4390])
Spring. 3 credits. Prerequisites: background in computing, data structures, and programming at level of COM S 211 or equivalent, and experience using information systems. Undergraduates and master's students should register for INFO 435; Ph.D. students should register for INFO 635.
For description, see INFO 435.

INFO 640(6400) Human-Computer Interaction Design (also COMM 640[6400])
Fall. 3 credits. Prerequisite: graduate standing or permission of instructor.
For description, see COMM 640.

INFO 645(6450) Seminar in Computer-Mediated Communication (also COMM 645[6450])
Spring. 3 credits. Prerequisite: graduate standing or permission of instructor.
For description, see COMM 645.

INFO 648(6648) Speech Synthesis by Rule (also LING 648[6648])
Spring. 4 credits. Prerequisite: LING 401, 419, or permission of instructor.
For description, see LING 648.

INFO 650(6500) Language and Technology (also COMM 650[6500])
Spring. 3 credits.
For description, see COMM 650.

INFO 651(6002) Critical Technical Practices
Fall or spring. 4 credits. Prerequisites: graduate-level training in human-computer interaction, science and technology studies, visual studies, communication, or equivalent, or permission of instructor.
This course studies media research practices that incorporate cultural criticism into technology design. Topics include tangible media, ubiquitous computing, and critical design. Content draws on computer science, human-computer interaction, interactive art, cultural studies, and interaction design.

[INFO 685(6850) The Structure of Information Networks (also COM S 685[6850])
Fall or spring. 4 credits. Prerequisite: COM S 482.
For description, see COM S 685.]

INFO 709(7090) IS Colloquium
Fall, spring. 1 credit.
For staff, visitors, and graduate students interested in information science

INFO 747(7400) Social and Economic Data (GR-RDC) (also ILRLE 740[7400])
Spring. 4 credits. Prerequisite: Ph.D. and research master's students.
Teaches all the basics required to acquire and transform raw information into social and economic data. Covers legal, statistical, computing, and social science aspects of the data "production" process are covered. Major emphasis is placed on U.S. Census data that are accessible from the Census Bureau's Research Data Center network. This version of the course has been specially prepared for graduate students who are planning to use RDC-based data or are seriously considering it. RDC-based data products covered include the new Longitudinal Employer-Household Dynamics (LEHD) micro data; the Longitudinal Business Database (LBD) and its predecessor the Longitudinal Research Database (LRD); internal versions of the Survey of Income and Program Participation (SIPP), Current Population Survey (CPS), American Community Survey (ACS), American Housing Survey (AHS), the 1990 and 2000 Decennial Census of Population and Housing; the Employer Business Register (BR and SSEL); the Censuses and Annual Surveys of Manufactures, Mining, Services, Retail Trade, Wholesale Trade, Construction, Transportation, Communications, and Utilities; Business Expenditures Survey; Characteristics of Business Owners; and others. Students are introduced to the new NSF-sponsored Virtual Research Data Center. Core topics include: basic statistical principles of populations and sampling frames; acquiring data via samples, censuses, administrative records, and transaction logging; law, economics and statistics of data privacy and confidentiality protection; data linking and integration techniques (probabilistic record linking; multivariate statistical matching); data imputation techniques; and analytic methods for complex linked data sets.

INFO 790(7900) Independent Research
Fall, spring. Variable credit. Prerequisite: permission of an information science faculty member.
Independent research for M.Eng. students and pre–A exam Ph.D. students.

INFO 990(9900) Thesis Research
Fall, spring. Variable credit. Prerequisite: permission of an information science faculty member.
Thesis research for post–A exam Ph.D. students.

FACULTY ROSTER

Computing and Information Science (CIS)
Abowd, John, Information Science Program; School of Industrial and Labor Relations
Apanasovich, Tatiyana, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Arms, William, Dept. of Computer Science; Information Science Program
Bailey, Graeme, Dept. of Computer Science; Computing in the Arts Program
Bala, Kavita, Dept. of Computer Science; Program of Computer Graphics
Berger, Toby, Dept. of Statistical Science; School of Electrical and Computer Engineering
Birman, Kenneth, Dept. of Computer Science
Blume, Lawrence, Information Science Program; Dept. of Economics
Bunge, John, Dept. of Statistical Science; School of Industrial and Labor Relations
Burtscher, Martin, Computer Science Field; School of Electrical and Computer Engineering
Bustamante, Carlos, Computational Biology Program; Dept. of Biological Statistics and Computational Biology
Cardie, Claire, Dept. of Computer Science; Information Science Program
Caruana, Rich, Dept. of Computer Science
Clark, Andrew, Computational Biology Program; Dept. of Molecular Biology and Genetics
Constable, Robert, Dept. of Computer Science
DiCiccio, Thomas, Dept. of Statistical Science; School of Industrial and Labor Relations
Durrett, Richard, Dept. of Statistical Science; Dept. of Mathematics
Dynkin, Eugene, Dept. of Statistical Science; Dept. of Mathematics
Easley, David, Information Science Program; Dept. of Economics
Edelman, Shimon, Information Science Program; Dept. of Psychology
Elber, Ron, Dept. of Computer Science; Computational Biology Program
Ellner, Stephen, Computational Biology Program; Dept. of Ecology and Evolutionary Biology
Ernste, Kevin, Computing in the Arts Program; Dept. of Music
Fan, K-Y Daisy, Dept. of Computer Science
Fine, Terrence, Dept. of Statistical Science; School of Electrical and Computer Engineering
Francis, Paul, Dept. of Computer Science
Friedman, Eric, Computer Science Field; Information Science Program; School of Operations Research and Industrial Engineering
Gay, Geri, Information Science Program; Dept. of Communication
Gehrke, Johannes, Dept. of Computer Science
Gillespie, Tarleton, Information Science Program; Dept. of Communication
Ginsparg, Paul, Information Science Program; Dept. of Physics
Gomes, Carla, Dept. of Computer Science; Dept. of Applied Economics and Management
Greenberg, Donald, Dept. of Computer Science; Program of Computer Graphics; Johnson Graduate School of Management; Dept. of Architecture
Gries, David, Dept. of Computer Science; College of Engineering
Guckenheimer, John, Computational Biology Program; Computational Science and Engineering Program; Dept. of Mathematics
Guo, Xin, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Haas, Zygmunt, Computer Science Field; School of Electrical and Computer Engineering
Halpern, Joseph, Dept. of Computer Science; Information Science Program
Hancock, Jeff, Information Science Program; Dept. of Communication
Hartmanis, Juris, Dept. of Computer Science
Hemami, Sheila, Computer Science Field; School of Electrical and Computer Engineering
Hong, Yongmiao, Dept. of Statistical Science; Dept. of Economics
Hopcroft, John, Dept. of Computer Science
Huttenlocher, Daniel, Dept. of Computer Science; Information Science Program; Johnson Graduate School of Management
Hwang, J. T. Gene, Dept. of Statistical Science; Dept. of Mathematics
Ingraffea, Anthony, Computational Science and Engineering Program; Dept. of Civil and Environmental Engineering
Joachims, Thorsten, Dept. of Computer Science; Information Science Program
Kedem, Klara, Dept. of Computer Science; Computational Biology Program
Keich, Uri, Dept. of Computer Science; Computational Biology Program
Kesten, Harry, Dept. of Statistical Science; Dept. of Mathematics
Kiefer, Nicholas, Dept. of Statistical Science; Dept. of Mathematics
Kleinberg, Jon, Dept. of Computer Science; Computational Biology Program; Information Science Program
Kleinberg, Robert, Dept. of Computer Science
Kozen, Dexter, Dept. of Computer Science
Lawler, Gregory, Dept. of Statistical Science; Dept. of Mathematics
Lee, Lillian, Dept. of Computer Science; Information Science Program
Lifka, David, Computational Science and Engineering Program
Linster, Christiane, Computational Biology Program; Dept. of Neurobiology and Behavior
Lipson, Hod, Computing and Information Science Program; School of Mechanical and Aerospace Engineering
Macy, Michael, Information Science Program; Dept. of Sociology
Manohar, Rajit, Computer Science Field; School of Electrical and Computer Engineering
Marschner, Steve, Dept. of Computer Science; Program of Computer Graphics
Martinez, Jose, Computer Science Field; School of Electrical and Computer Engineering
McKee, Sally, Computer Science Field; School of Electrical and Computer Engineering
Merman, N. David, Dept. of Physics
Myers, Andrew, Dept. of Computer Science
Nerode, Anil, Computer Science Field; Dept. of Mathematics
Nussbaum, Michael, Dept. of Statistical Science; Dept. of Mathematics
Pershing, Andrew, Computational Science and Engineering Program; Dept. of Earth and Atmospheric Sciences
Pinch, Trevor, Information Science Program; Dept. of Science and Technology Studies
Pope, Stephen, School of Mechanical and Aerospace Engineering; School of Operations Research and Industrial Engineering
Prentice, Rachel, Information Science Program; Dept. of Science and Technology Studies
Protter, Philip, Dept. of Statistical Science; School of Operations Research and Industrial Engineering

Resnick, Sidney, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Rooth, Mats, Information Science Program; Dept. of Linguistics
Rugina, Radu, Dept. of Computer Science
Ruppert, David, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Samorodnitsky, Gennady, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Schneider, Fred, Dept. of Computer Science
Schwager, Steven, Dept. of Statistical Science; Dept. of Biological Statistics and Computational Biology
Schwartz, David, Dept. of Computer Science
Selman, Bart, Dept. of Computer Science
Sengers, Phoebe, Information Science Program; Dept. of Science and Technology Studies
Shalloway, David, Computational Biology Program; Dept. of Molecular Biology and Genetics
Shmoys, David, Dept. of Computer Science; School of Operations Research and Industrial Engineering
Shoemaker, Christine, School of Civil and Environmental Engineering
Siepel, Adam, Computational Biology Program; Dept. of Biological Statistics and Computational Biology
Sirer, Emin Gun, Dept. of Computer Science
Spector, Buzz, Dept. of Art
Spivey, Michael, Information Science Program; Dept. of Psychology
Strawderman, Robert, Dept. of Statistical Science; Dept. of Biological Statistics and Computational Biology
Tardos, Eva, Dept. of Computer Science; Information Science Program
Teitelbaum, Tim, Dept. of Computer Science
Thurston, William, Computing and Information Science Program; Dept. of Mathematics
Torrance, Kenneth, Program of Computer Graphics; School of Mechanical and Aerospace Engineering
Turnbull, Bruce, Dept. of Statistical Science; School of Operations Research and Industrial Engineering
Van Loan, Charles, Dept. of Computer Science; Computational Science and Engineering Program
Vavasis, Stephen, Dept. of Computer Science; Computational Science and Engineering Program
Velleman, Paul, Dept. of Statistical Science; School of Industrial and Labor Relations
Vidyashankar, Anand, Dept. of Statistical Science; School of Industrial and Labor Relations
Vogelsang, Timothy, Dept. of Statistical Science; Dept. of Economics
Walther, Joe, Information Science Program; Dept. of Communication
Wells, Martin, Dept. of Statistical Science; Computational Biology Program
Wicker, Stephen, Computer Science Field; School of Electrical and Computer Engineering
Williamson, David, Information Science Program; School of Operations Research and Industrial Engineering
Yuan, Connie, Information Science Program; Dept. of Communication
Zabih, Ramin, Dept. of Computer Science