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COLLEGE OF
ARTS & SCIENCES

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of NORTH CAROLINA
at CHAPEL HILL

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KEVIN JEFFAY
Gillian Cell Distinguished Professor

January 10, 2011

Dr. Bobbi Owen
Michael R. McVaugh Distinguished Professor of Dramatic Art
Senior Associate Dean for Undergraduate Education
College of Arts and Science
3011 Steele Bldg, CB 3054
Carolina Campus

Dear Dr. Owen,

On behalf of the Department of Computer Science, I write to request the Administrative Board's consideration and approval of a new Bachelor of Arts Degree in Computer Science.

Background and Motivation for the Degree

The Computer Science department presently offers a Bachelor of Science degree in computer science as well as a minor in computer science. The proposed BA degree will expand computer science education to a broader segment of the UNC undergraduate population and better meet the needs of those students who are in our BS program but have broader interests than the BS degree program intends. It also brings the Computer Science department into parity with the other science departments at UNC-CH by offering both BS and BA degree programs.

Compared to our BS degree, we will require fewer science and math courses for the BA degree. This creates space in the BA program for a student to pursue a broader and richer exposure to the traditional liberal arts, specifically in areas where computing is having an enabling impact. Correspondingly, the BA encourages cross-disciplinary study by allowing a cluster of courses from other departments that teach a computing application area. The goal of the new BA degree program will be to prepare the undergraduate student for a career in either a traditional computing field, or, more likely, for a career in a field where computing is a significant enabling technology. Such fields are growing in number and importance, and include finance, e-commerce, bioinformatics, multimedia communications, networking, security, and gaming (among others).

Degree Requirements

The following are the requirements for the proposed degree. The requirements are shown in contrast to the requirements for the existing BS degree. The BA degree requires no science above and beyond that required by the College, and requires 3 fewer MATH courses and 1 less COMP course. The BA degree also affords more flexibility for the selection of upper-level COMP courses.

Proposed BA Degree	Existing BS Degree
MATH 231, 381 (or STOR 215) STOR 155 or 435	MATH 231, 232, 232, 381 (or STOR 215), 547 STOR 435 PHYS 216 1 of: PHYS 217, CHEM 101/101L, or 102/102L, or BIO 101/101L, 202, or 205
COMP 401 Foundations of Programming COMP 410 Data Structures COMP 411 Machine Organization	COMP 401 Foundations of Programming COMP 410 Data Structures COMP 411 Machine Organization COMP 550 Analysis of Algorithms
1 course from the Systems Group COMP 431 Internet Protocols and services COMP 530 Operating Systems COMP 535 Computer Security COMP 541 Digital Logic 1 course from the Languages Group COMP 520 Compilers COMP 523 Software Engineering COMP 524 Programming Languages 1 course from the Applications Group COMP 426 Advanced WWW Programming COMP 521 Files and Databases COMP 536 Enterprise Computing COMP 575 Computer Graphics COMP 580 Enabling Technologies COMP 585 Serious Games 3 Computing or computing related courses, approved as a group by a Departmental advisor, from COMP and/or related disciplines such as (but not limited to) ECON, BIO, SILS, business, MATH/STOR, PHYS, *etc*.	6 Courses chosen as follows: At least 1 course from the Theory Group COMP 455 MATH 566 At least 1 course from the Systems Group COMP 431 COMP 530 COMP 535 COMP 541 At least 1 course from the Languages Group COMP 520 COMP 523 COMP 524 At least 1 course from the Applications Group COMP 426 COMP 521 COMP 536 COMP 575 COMP 580 COMP 585 At most 1 course from the Interdisciplinary Group Any MATH course numbered greater than 520 STOR 415, 445, or 515 LING 540 INLS 509 or 512

With regard to the final requirement for the BA (the “3 Computing or computing related courses, approved as a group by a Departmental advisor” requirement), the

goal here is to develop thematic triads of courses from COMP and related departments. As the new major evolves, we envision publishing listings of suggested triads.

The BS degree additionally requires a grade of C or better in MATH 231, 232, 233, 381, PHYS 116, and COMP 401, 410, 411. In addition, an average grade of C or better, with no individual grade lower than a C- is required in MATH 547, STOR 435, COMP 550, and the 6 post COMP 410/411 COMP courses.

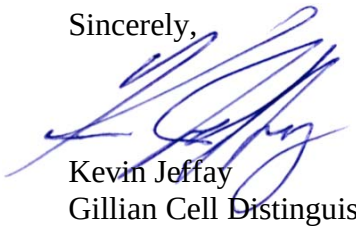
For the BA degree the Department proposes the requirement that an average grade grade of C or better is required in MATH 231, 381, and COMP 401, 410, 411, with no individual grade lower than a C-. The Department appreciates that this is a non-standard request, however, our experience indicates that these requirements are essential for ensuring students who enter the BS degree program complete the BS degree. We have every reason to believe the same will hold for the BA degree.

Changes to the Undergraduate Bulletin

Attached to this letter is document listing the changes to the text of the undergraduate bulletin required by the introduction of the BA degree. The additions proposed to the Department's bulletin entry are listed in italics.

If I can provide any additional information about any of these proposed changes, please do not hesitate to contact me.

Sincerely,



Kevin Jeffay
Gillian Cell Distinguished Professor
Associate Chairman for Academic Affairs

Cc: Anselmo Lastra, Chair, Department of Computer Science

Department of Computer Science

Introduction

The Department of Computer Science offers instruction and performs research in the essential areas of computer science, including software, Web and Internet computing, networking, hardware systems, computer and network security, operating systems, compilers, parallel and distributed computing, theory of computing, and computer graphics. The bachelor of science with a major in computer science is the preferred degree both for graduate study in computer science and for technical careers in software development, computational science, networking, information systems, and electronic commerce. Graduates of the program are well-suited for professional employment in traditional computer and communications industries, as well as in such diverse industries as financial services and consulting practices in which computing and information management are central to the operation of the enterprise. Students who desire a more in-depth knowledge of computing have the option of starting graduate study as an undergraduate and receiving a Bachelor's degree and a Master's degree in as few as five years. *The bachelor of arts degree with a major in computer science is the preferred degree for those whose interests in computing spans the boundaries of multiple disciplines and wish to integrate their study of computing with study in a related discipline. The bachelor of arts degree will prepare the undergraduate student for a career in either a traditional computing field, or a career in a field where computing is a significant enabling technology.*

Majors receive rigorous training in the foundations of computer science and the relevant mathematics, then have ample opportunity to specialize in software systems, programming languages, theoretical computer science, or applications of computing technology in science, applied mathematics, medicine, or business. Students whose interests lie more in the area of digital system design should consider the computer engineering track of the Curriculum in Applied Sciences and Engineering. Students with interests in the cognitive, social, and organizational roles of information should consider the information science major in the School of Information and Library Science. Both programs are described elsewhere in this bulletin.

Majors also have the opportunity to receive practical training as a computing professional through an internship with a company or organization in the computing or information technology fields. Internships typically are paid positions and involve the student working off campus full time for a nine-month period consisting of one academic semester and a summer. During the academic semester of the internship, the student is enrolled in COMP 393 Internship and will be considered a full-time student for administrative purposes. All internships must be approved in advance by the director of undergraduate studies. Students interested in pursuing an internship should contact the director of undergraduate studies at least one year prior to the start of the internship.

Students who wish to use computers vocationally and desire a technical introduction to computing should take one or more of the introductory courses, COMP 110, 116, and 401, and one or two more advanced courses such as COMP 410, 411, and 416. Students can minor in computer science with five courses, as described below.

The department offers COMP 101 for all students who wish to develop the ability to use a personal computer for common applications. COMP 380 Computers and Society is a philosophical and moral reasoning Approaches course that has no programming prerequisite. Many other courses satisfy General Education quantitative requirements.

Programs of Study

~~The degree~~*The department offers both* ~~offered~~ *a* ~~is the~~ bachelor of science *degree* with a major in computer science *as well as a bachelors of arts degree with a major in computer science*. Strong students can also pursue a combined bachelor of science and master of science program of study and receive a Bachelor's degree and a Master's degree in as few as five years. A minor in computer science is also offered.

Majoring in Computer Science: Bachelor of Science

Departmental Requirements

• COMP 401, 410, 411, and 550

• MATH 231, 232, 233, 381 (or STOR 215), and 547

• PHYS 116 and one of BIOL 101/101L, 202, 205; CHEM 101/101L, 102/102L; PHYS 117

• STOR 435

• Six courses from the computer science distribution requirement list (see below), with at least one course in each of the programming languages group, systems group, theory group, and applications group, with no more than one course from the interdisciplinary group. The following courses may be used to satisfy the distribution requirement:

• Theory group (at least one course): COMP 455, MATH 566

• Systems group (at least one course): COMP 431, 530, 535, 541

• Programming languages group (at least one course): COMP 520, 523, 524

• Applications group (at least one course): COMP 426, 521, 536, 575, 580

• Interdisciplinary group (at most one course): BMME 410, 430, 440; INLS 509, 512; LING 540; any MATH course numbered greater than 520; STOR 415, 445, 515. Computing-related courses other than those listed in the interdisciplinary group may be counted as interdisciplinary courses, with the advance approval of the director of undergraduate studies. Note that students are not required to take a course from the interdisciplinary group.

Additional Requirements

• Completion of COMP 401, 410, and 411; MATH 231, 232, 233, 381 (or STOR 215); and PHYS 116 and the second science course (BIOL, CHEM, or PHYS) with a grade of C or better in each course is required for graduation.

• Students must earn a grade point average of 2.0 or higher and receive no grade lower than a C- in the nine required junior/senior courses: COMP 550, MATH 547, STOR 435, and the six required distribution courses.

• B.S. majors in computer science must fulfill all Foundations, Approaches, and Connections requirements.

The following is a suggested plan of study for B.S. majors. The nine required first-year/sophomore courses should be taken no later than the year listed, or students will be unable to declare the computer science major during the nominal major declaration period in the second semester of their sophomore year.

First Year

• ENGL 101, 102 (composition and rhetoric Foundations); foreign language level 2 and 3 (Foundations); first-year seminar or COMP 110; COMP 401; MATH 231, 232 (quantitative reasoning Foundations and quantitative intensive Connections courses)

Sophomore Year

• PHYS 116 and the second science course (BIOL, CHEM, or PHYS) (physical and life sciences Approaches course); MATH 233, 381 (or STOR 215); COMP 410, 411; three additional Approaches and Connections courses

Junior Year

• MATH 547; COMP 550; computer science distribution requirement (four courses); three additional Approaches and Connections courses

Senior Year

• STOR 435; computer science distribution requirement (two courses); Connections and free elective courses (four courses)

Majoring in Computer Science: Bachelor of Arts

Departmental Requirements

• COMP 401, 410, and 411

• MATH 231, 381 (or STOR 215)

• STOR 155 or 435

• One course from the programming languages group: COMP 520, 523, 524

• One course from systems group: COMP 431, 530, 535, 541

• One course from the applications group: COMP 426, 521, 536, 575, 580, 585

• 3 Computing or computing related courses, approved as a group by a Departmental advisor, from COMP and/or related disciplines such as (but not limited to) ECON, BIO, SILS, business, MATH/STOR, PHYS, etc.

Additional Requirements

• Completion of COMP 401, 410, and 411; MATH 231, 381 (or STOR 215); with a grade average of C or better and no grade lower than C- in each course is required for graduation.

• B.A. majors in computer science must fulfill all Foundations, Approaches, and Connections requirements.

The following is a suggested plan of study for B.A. majors. The nine required first-year/sophomore courses should be taken no later than the year listed, or students will be unable to declare the computer science major during the nominal major declaration period in the second semester of their sophomore year.

First Year

• ENGL 101, 102 (composition and rhetoric Foundations); foreign language level 2 and 3 (Foundations); first-year seminar or COMP 110; COMP 401; MATH 231 (quantitative reasoning Foundations and quantitative intensive Connections courses)

Sophomore Year

• An appropriate physical and life sciences Approaches course; MATH 381 (or STOR 215); COMP 410, 411; four additional Approaches and Connections courses

Junior Year

• One programming languages group course; one systems group course, one applications group course; three additional Approaches and Connections courses; four free electives

Senior Year

• Three pre-approved computing or computing-related courses; Connections and free elective courses (four courses); three free electives

Notes on the Suggested Plan of Study

COMP 110 Introduction to Programming is a required prerequisite for COMP 401. Students with no programming experience should begin their program of study with COMP 110. The department assumes (but does not require) that prospective majors will have acquired sufficient knowledge of programming basics prior to enrolling at UNC–Chapel Hill to start with COMP 401. Students who are able to begin with COMP 401 may take it in their first semester and either advance the suggested program of study by one semester (giving themselves an extra free elective in their junior/senior years) or take another appropriate course such as a first-year seminar as an elective in the first year. (In either case, neither COMP 110 nor a first-year seminar is a required course in the major.)

This plan of study further assumes that students will place out of foreign language 1. If this is not the case, then the student should start with foreign language 1 (and have one fewer free elective in the senior year.)

Combined Bachelor's-Master's Degree Program

Students *in the B.S. degree program* with a GPA of 3.2 or better after five semesters of study have the option of applying to the graduate program at UNC to pursue graduate course work leading to the degree of Master of Science. Such students would then complete the requirements for both the Bachelor of Science degree as well as the Master of Science degree. The requirements for the Bachelor's degree must be completed within eight semesters of study. The requirement for the Master's can be completed in as few as two additional semesters, for a total of ten semesters of study.

The requirements for the Master of Science degree can be found in the Graduate Record (http://www.unc.edu/gradrecord/). Generally, the Master's degree requires 30 additional hours of computer science coursework. Up to nine credit hours of computer science coursework taken while an undergraduate can be applied to the Master's degree if the coursework is not also used to satisfy the graduation requirements for the Bachelor's degree.

Students interested in the combined degree program should have completed (or be on track to complete) seven computer science courses at the 400-level or higher by the end of their sixth semester. Students must formally apply for admission to the graduate program and it is expected that the application process would take place in the student's sixth semester. Students applying in their sixth semester of study will be notified of the outcome of their application by the end of their sixth semester.

Students interested in the combined degree program are strongly advised to consult the Director of Undergraduate Studies for the Computer Science department in their sophomore year to discuss eligibility and an appropriate plan of study.

Minoring in Computer Science

A student may minor in computer science by completing five courses within these restrictions:

• COMP 401

• COMP 410 or 411

• Any three additional COMP courses above COMP 400

Students with the appropriate prerequisites (for example, from a mathematics major) may include MATH 381/STOR 215 and MATH 566 in their selection of courses. A grade of C or better is required in at least 12 hours of the minor courses. Including "Topics" courses such as COMP 590 requires approval of the undergraduate studies committee in the computer science department. Alternatives to these requirements must be approved by the undergraduate studies committee. No course may be counted for both the computer science minor and any major.

Honors in Computer Science

Students are eligible for graduation with honors if they complete the following requirements:

• Accumulation of a 3.2 or better cumulative grade point average

• Accumulation of a 3.2 or better grade point average from among the set of COMP, MATH, PHYS, and STOR courses taken to fulfill the graduation requirements for the major

• Successful completion of an honors independent study or research project, which requires completion of two sections of COMP 396, the construction of a written honors thesis, and an oral presentation of the thesis.

Students interested in pursuing honors in computer science are encouraged to contact the director of undergraduate studies to arrange an independent study or research project. Graduation with highest honors in computer science is possible for those students who accumulate grade point average of 3.6 or higher both overall and in the major and write an honors thesis that is acceptable for graduation with highest honors.

Special Opportunities in Computer Science

Departmental Involvement

Undergraduates participate in many department and university activities. Department-organized activities, such as the annual ACM programming contest, give students the chance to test their skills and knowledge against their peers at other universities.

Experiential Education

When arranged in advance with a supervising faculty member, COMP 392 can be used to get credit for appropriate work experience in the summer. COMP 392 satisfies the experiential education requirement. Another possibility is through study abroad (see below).

Internships in Industry

As described above, computer science majors have the opportunity to intern with a company for an extended period of up to nine months (one academic semester plus one summer) while remaining a full-time student. In addition, more traditional summer-only internships are also routinely available.

Laboratory Teaching Internships and Assistantships

In addition to their classroom experiences, undergraduates may enhance their learning experience as lab assistants or teaching assistants for computer science courses. They can gain valuable work experience as assistants on the department's computer services staff. The department also encourages students to pursue internships and summer co-op experiences. Carolina's proximity to Research Triangle Park means that computer science majors have many internship and postgraduation opportunities available in their own backyard.

Study Abroad

Study abroad opportunities with priority for computer science students are offered through University College London (UCL) and the National University of Singapore (NUS) School of Computing.

UCL can accept UNC–Chapel Hill students for either a spring semester or year-long exchange. Many courses satisfying the computer science B.S. requirements can be completed at UCL. UCL is located in the heart of London and is just a few blocks away from UNC–Chapel Hill's European Study Center in Winston House.

NUS can accept UNC-Chapel Hill students for fall or spring semester, or a year-long exchange. This exchange allows Carolina students to enroll directly into the NUS School of Computing and choose their courses from among the full offering. Students may also be able to take other courses at NUS outside of the School of Computing on a case by case basis. Study abroad at NUS is eligible for the Phillips Ambassadors Scholarship. Please see phillips.studyabroad.unc.edu for more information.

Application for both programs is through the University's Study Abroad Office. Application to the UCL programs and the NUS fall and year-long programs takes place early in the spring of each year. Application for the NUS spring program takes place early in the fall of each year. Applicants for exchange participation must have completed at least one year of study at UNC–Chapel Hill and must have declared a computer science or pre-computer science major. Study abroad satisfies the experiential education requirement of the undergraduate curriculum.

Undergraduate Awards

The department awards two yearly prizes to computer science majors. In conjunction with SAS Institute, the department annually presents the Charles H. Dunham Scholarship The Dunham scholarship includes a cash award to the student and a summer internship at SAS. The

department also annually presents the Stephen F. Weiss Award for Outstanding Achievement in Computer Science which includes a cash prize.

Undergraduate Research

Undergraduate students can participate in nationally recognized research programs or use the department's facilities to pursue self-directed research with a faculty member. The department has built peaks of excellence in several areas, including computer graphics, distributed and collaborative systems, hardware design, medical imaging, networking, and parallel computing. Much of its research is accessible to undergraduates and focuses on solving real-world problems.

Facilities

The department maintains a number of computer servers to support programming projects in advanced COMP courses. Within Sitterson Hall and the Brooks Computer Science Building, computer science majors have access to additional facilities, including projection facilities for pair programming and research computing equipment for students engaged in supervised research projects.

Graduate School and Career Opportunities

The computer science *B.S. degree* program provides an excellent preparation for students interested in advanced study in computing in graduate school. The department's graduates are competitive nationally for admission to the top graduate schools, including UNC–Chapel Hill's graduate program. As described above, a combined B.S.-M.S. degree program in computer science is also an option.

Graduates typically have a wide range of career opportunities as computing professionals in such diverse fields as software development, information systems management, electronic commerce, education, and financial transaction processing. In addition, computer science majors have consistently ranked at or near the top of recent surveys of starting salary offers.

Contact Information

For the latest information about the B.S. *or B.A.* degree with a major in computer science, and for additional details about requirements, courses, advising, and other relevant information, please see www.cs.unc.edu/bachelors, or contact the Director of Undergraduate Studies, CB# 3175, Sitterson Hall, (919) 962-1700.

COMP

050 First-Year Seminar: Computers Make It Possible (3). The goal of this seminar is to teach students how computers have affected society and how those uses have changed computers.

051 First-Year Seminar: Technology and Entrepreneurship: Propitious Partners (3). This course will look at the fundamental technologies important to an entrepreneurial endeavor. The course will include case studies and the design of technology in a new venture.

056 First-Year Seminar: The World Wide Web: What, How, and Why (3). This seminar will explore, use, and ponder the World Wide Web.

060 First-Year Seminar: Robotics with LEGO® (3). Required preparation, knowledge of elementary computer programming. The goal of this seminar is to give students a feel for the physical aspects of computing.

061 First-Year Seminar: 3D Animation with Computers—Your Cinematic Debut (3). This course is designed to combine some math, physical science, and computer graphics with the fun and creative aspects of movie making.

065 First-Year Seminar: Folding, from Paper to Proteins (3). Explore the art of origami, the science of protein, and the mathematics of robotics through lectures, discussions, and projects involving artistic folding, mathematical puzzles, scientific exploration, and research.

066 First-Year Seminar: Random Thoughts (3). Explore in depth notions of randomness and its antithesis, structure. Students will collectively conduct several classic experiments to explore the nature of randomness. Computer programming skills helpful, but not required.

070 First-Year Seminar: Computability, Unsolvability, and Consciousness (3). The course will introduce Turing machines, which have a finite control, can move back and forth on a one dimensional tape, and can read and write on the tape. The students will construct Turing machines to convince themselves that Turing machines are in principle as powerful as any other computer.

071 First-Year Seminar: Problem Solving and the World Wide Web (3). This is not a course in computer programming and credit may be earned for both this course and COMP 110 Introduction to Programming. Coregistration in ENGL 101 or 102 is required.

072 First-Year Seminar: Introduction to Computers (3). Required preparation, previous programming experience. We will explore the process of design and the nature of computers by designing, building, and programming LEGO® robots.

080 First-Year Seminar: Enabling Technology—Computers Helping People (3). Service-learning course exploring issues around computers and people with disabilities. Students work with users and experts to develop ideas and content for new technologies. No previous computer experience required.

101 Computers: Power Tools for the Mind (3). The nature of computers, their capabilities, and limitations. How computers work; popular applications; problem-solving skills; algorithms and programming; potential use and abuse in society. Lectures, weekly readings, and laboratory assignments.

102 Computer-Mediated Communication and Collaboration (3). An introduction to computing and computers as a way to communicate and collaborate. This course will teach communication and collaboration tools that facilitate effective content development and delivery.

110 Introduction to Programming (3). Introduction to computer use. Approaches to problem solving; algorithms and their design; fundamental programming skills. Students can receive credit for only one of COMP 110, 116, or 121.

116 Introduction to Scientific Programming (3). Prerequisite, MATH 231. An introduction to programming for computationally oriented scientists. Fundamental programming skills, using MATLAB and another imperative programming language (such as C). Problem analysis and algorithm design, with examples drawn from simple numerical and discrete problems. Students can receive credit for only one of COMP 110, 116, or 121.

121 Introduction to Functional Programming (3). An introduction to programming in the functional programming style, e.g., using a dialect of LISP. A brief introduction to an imperative language such as Pascal. A first course for prospective majors or students with some programming background. Students can receive credit for only one of COMP 110, 116, or 121.

180 Enabling Technologies (3). We will investigate ways computer technology can be used to mitigate the effects of disabilities and the sometimes surprising response of those we intended to help.

185 Serious Games (3). Concepts of computer game development and their application beyond entertainment to fields such as education, health, and business. Course includes team development of a game. Excludes COMP majors.

371 Language and Computers (LING 301) (3). See LING 301 for description.

380 Computers and Society (3). Cultural, social, philosophical, technological, and economic effects of information technology on individuals, groups, and society. Risks and controversies. Ethics of technology and computer use.

381 Computers and Technology for Society (3). Overview of the impact of computers and technology on society's institutions, beliefs, values, tastes, activities, ideals, paradigms, and processes. Programming knowledge assumed, permitting topics beyond COMP 380.

392 Practicum (1–3). Permission of the director of undergraduate studies. Computer science majors only. Work experience in nonelementary computer science. Pass or fail grade depends on a substantial written report by student and evaluation by employer. Pass/Fail. May be repeated for up to six credits.

393 Internship (3). Permission of the director of undergraduate studies. Computer science majors only. Practical extension of computer science knowledge through industrial work experience.

396 Independent Study in Computer Science (1–3). Permission of the director of undergraduate studies. Computer science majors only. For advanced majors in computer science who wish to conduct an independent study or research project with a faculty supervisor. May be taken repeatedly for up to a total of six credit hours.

401 Foundation of Programming (4). A first formal course in computer programming required. Advanced programming: Program specifications, preconditions, postconditions, loop invariants. Linear data structures, searching, and sorting. Algorithm paradigms and analysis.

410 Data Structures (3). Prerequisite, COMP 401. The analysis of data structures and their associated algorithms. Abstract data types, lists, stacks, queues, trees, and graphs. Sorting, searching, hashing.

411 Computer Organization (3). Prerequisite, COMP 401. Digital logic, circuit components. Data representation, computer architecture and implementation, assembly language programming.

416 Introduction to WWW Programming (3). Prerequisites, COMP 401 and 410. Client-side programming in Java for the World Wide Web. Introduction to TCP/IP, HTTP, and Web architecture. Emphasis on applet programming and component programming using threads, simple client-server applications, and XML.

426 Advanced WWW Programming (3). Prerequisite, COMP 416. Server-side programming in Java for the World Wide Web. Emphasis on servlet programming and distributed component programming using APIs for object serialization, remote method invocation, database connectivity, and XML generation.

431 Internet Services and Protocols (3). Prerequisites, COMP 410 and 411. Application-level protocols HTTP, SMTP, FTP, transport protocols TCP and UDP, and the network-level protocol IP. Internet architecture, naming, addressing, routing, and DNS. Sockets programming. Physical-layer technologies. Ethernet, ATM, and wireless.

455 Models of Languages and Computation (3). Prerequisites, COMP 110 or 401, and MATH 381. Introduction to the theory of computation. Finite automata, regular languages, pushdown automata, context-free languages, and Turing machines. Undecidable problems.

486 Applications of Natural Language Processing (INLS 512) (3). See INLS 512 for description.

487 Information Retrieval (INLS 509) (3). See INLS 509 for description.

520 Compilers (3). Prerequisites, COMP 410 and 411. Design and construction of compilers. Theory and pragmatics of lexical, syntactic, and semantic analysis. Interpretation. Code generation for a modern architecture. Run-time environments. Includes a large compiler implementation project.

521 Files and Databases (3). Prerequisites, COMP 410 and 411 and MATH 381. Placement of data on secondary storage. File organization. Database history, practice, major models, system structure and design.

523 Software Engineering Laboratory (4). Prerequisites, COMP 410 and 411. Organization and scheduling of software engineering projects, structured programming, and design. Each team designs, codes, and debugs program components and synthesizes them into a tested, documented program product.

524 Programming Language Concepts (3). Prerequisite, COMP 410. Concepts of high-level programming and their realization in specific languages. Data types, scope, control structures, procedural abstraction, classes, concurrency. Run-time implementation.

530 Operating Systems (3). Prerequisites, COMP 410 and 411. Types of operating systems. Concurrent programming. Management of storage, processes, devices. Scheduling, protection. Case study. Students implement significant components of a small operating system.

535 Introduction to Computer Security (3). Prerequisites, COMP 410 and MATH 381. Principles of securing the creation, storage, and transmission of data and ensuring its integrity, confidentiality and availability. Topics include access control, cryptography and cryptographic protocols, network security, and online privacy.

536 Enterprise Computing (3). Prerequisite, COMP 426. Equivalent experience for students lacking the prerequisite. Designing and building enterprise systems. Basic principles, design considerations, and technologies for large multiserver systems. Requirements include a project in which teams design and build a substantial system.

541 Digital Logic and Computer Design (4). Prerequisite, COMP 411. This course is an introduction to digital logic as well as the structure and electronic design of modern processors. Students will implement a working computer during the laboratory sessions.

550 Algorithms and Analysis (3). Prerequisites, COMP 410 and MATH 381. Formal specification and verification of programs. Techniques of algorithm analysis. Problem-solving paradigms. Survey of selected algorithms.

555 Bioalgorithms (3). Prerequisites, COMP 410 and MATH 381. Computational methods and algorithmic principles underlying bioinformatics and computational biology. Topics include graph algorithms, divide-and-conquer, dynamic programming, and greedy algorithms plus basic topics in molecular biology, genetics, and proteomics.

575 Introduction to Computer Graphics (3). Prerequisites, COMP 410 and MATH 547. Hardware, software, and algorithms for computer graphics. Scan conversion, 2-D and 3-D transformations, object hierarchies. Hidden surface removal, clipping, shading, and antialiasing. Not for graduate computer science credit.

580 Enabling Technologies (3). Prerequisite, COMP 410. We will investigate ways computer technology can be used to mitigate the effects of disabilities and the sometimes surprising response of those we intended to help.

585 Serious Games (3). Concepts of computer game development and their application beyond entertainment to fields such as education, health, and business. Course includes team development of a game.

590 Topics in Computer Science (1–21). Permission of the instructor. This course has variable content and may be taken multiple times for credit.

631 Computer Networks (3). Required preparation, a first course in operating systems, a first course in networking (e.g., COMP 431 and 530), and knowledge of probability and statistics. Topics in computer networks, including link layer protocols, switching, IP, TCP, and congestion control. Additional topics may include peer-to-peer infrastructures, network security, and multimedia applications.

633 Parallel and Distributed Computing (3). Required preparation, a first course in operating systems and a first course in algorithms (e.g., COMP 530 and 550). Principles and practices of parallel and distributed computing. Models of computation. Concurrent programming languages and systems. Architectures. Algorithms and applications. Practicum.

651 Computational Geometry (3). Required preparation, a first course in algorithms (e.g., 550). Design and analysis of algorithms and data structures for geometric problems. Applications in graphics, CAD/CAM, robotics, GIS, and molecular biology.

662 Scientific Computation II (ENVR 662, MATH 662) (3). Prerequisite, MATH 661. Theory and practical issues arising in linear algebra problems derived from physical applications, e.g. discretization of ODEs and PDEs; linear systems; linear least squares; eigenvalue problems; singular value decomposition.

665 Images, Graphics, and Vision (3). Required preparation, a first course in data structures and a first course in discrete mathematics (e.g., COMP 410 and MATH 383). Display devices and procedures. Scan conversion. Matrix algebra supporting viewing transformations in computer graphics. Basic differential geometry. Coordinate systems, Fourier analysis, FDFT algorithm. Human visual system, psychophysics, scale in vision.