College of Computer and Information Science

Graduate Guidebook

1. MESSAGE FROM THE DEAN

The College of Computer and Information Science is one of the leading research units at Northeastern University, with 28 faculty, approximately 150 Master's students (both full- and part-time), 55 PhD students, and $2.8 million in external research funding.

We offer an excellent environment for graduate education, with many exciting research projects, a wide spectrum of courses, and modern computing facilities. Our Master's program offers both thesis and non-thesis options, with the requirement of an in-depth study of at least one subfield of computer science. Our PhD program gives students the opportunity to publish journal papers and to give presentations at prestigious conferences.

Computer science is a vital discipline for the economies of New England and the United States. Not only is it important in its own right, it is becoming increasingly vital for the success and advancement of other sciences, manufacturing, and the arts. Donald Knuth has said that computer science is a field that attracts a different kind of thinker: one who thinks algorithmically, who can rapidly change levels of abstraction, thinking both “in the large” and “in the small”. The College welcomes such thinkers; we offer you an exciting, challenging, and rewarding experience.

2. THE FACULTY

Dean of the College

Larry A. Finkelstein, PhD, Birmingham (England). Symbolic problems in algebra, group theory algorithms and applications, fast algorithms for signal processing.

Associate Dean and Director of the Graduate Program

Agnes H. Chan, PhD, Ohio State. Wireless security and cryptography.

Associate Dean and Director of the Undergraduate Program

Richard A. Rasala, PhD, Harvard. Computer aided instruction, algorithm animation, graphics, multi-media, software engineering.

Trustee Professor

Matthias Felleisen, PhD, Indiana University. Programming Languages.

Professors

Javed A. Aslam, PhD, MIT. Machine learning and information retrieval.

Gene Cooperman, PhD, Brown. Symbolic algebra, group theory algorithms and applications, large software systems, aspects of artificial intelligence.

Harriet J. Fell, PhD, MIT. Interactive graphics systems, raster graphics algorithms, digital typography, cryptography.

David Kaeli, (*joint appointment with ECE*), PhD, Rutgers University, computer architecture, code optimization and software engineering.

Karl J. Lieberherr, PhD, ETH (Zurich). Tools for object-oriented design and programming.

Viera K. Proulx, PhD, Columbia. Parallel processing, distributed computer systems and architectures, educational software.

Rajmohan Rajaraman, PhD, University of Texas. Algorithms, distributed systems, combinatorial optimization.

Mitchell Wand, PhD, MIT. The semantics of programming languages, program verification and construction, algebra and logic.

Patrick S. P. Wang, PhD, Oregon State. Artificial intelligence, pattern recognition, programming languages, automata.

Associate Professors

Kenneth P. Baclawski, PhD, Harvard. Distributed and object-oriented database systems, high performance concurrency control methods, data semantics and view integration.

John Casey, BA, Boston College. Exploring the possibilities of cooperation among numbers of computers on common tasks.

William Clinger, PhD, MIT. Semantics and implementation of programming languages.

Robert P. Futrelle, PhD, MIT. Artificial Intelligence and the construction of an intelligent "scientists' assistant". Natural language and diagram understanding. Representation and reasoning about biological knowledge.

Carole D. Hafner, PhD, Michigan. Natural language processing, computational models of legal reasoning, legal information systems.

Michael Lipton, (*joint appointment with Philosophy & Religion*) PhD, MIT. Logic.

Panagiotis Manolios, PhD, University of Texas. Program Verification.

Mirek Riedewald, PhD, UC Santa Barbara, Database Management.

Guevara Noubir, PhD, Swiss Federal Institute of Technology, Lausanne. Wireless networks, security, real-time systems.

Olin Shivers, PhD, Yale. Programming Languages.

Ravi Sundaram, PhD, MIT. Network algorithms.

Assistant Professors

Timothy Bickmore, PhD, MIT. Human Computer Interaction, Information Science.

Peter Desnoyers, PhD, UMass Amherst. Operating Systems.

Alan Mislove, PhD, Rice University. Social networks, distributed systems, and network measurement tools.

Riccardo Pucella, PhD, Cornell University. Security in fault tolerant systems, modeling and reasoning about evidence.

Emannuele Viola, PhD, Harvard. Complexity Theory, Pseudorandom Generator.

Marty Vona, PhD, MIT. Robotics and Graphics.

Professor Emeritus

Betty J. Salzberg, PhD, Michigan. Database implementation issues: external sorting, access methods, concurrency and recovery.

Ronald J. Williams, PhD, University of California. Connectionist networks, cognition, machine learning.

3. COMPUTING FACILITIES

The College of Computer and Information Science provides computing resources for both undergraduate and graduate courses in the College, for individual student projects, and for faculty research. These facilities are constantly being upgraded to keep pace with developments in the computer industry.

The College has three laboratories for student computation, housing a mix of UNIX and WindowsXP workstations. All faculty and supported graduate students have their own workstations. Our computing facilities are connected via a layer-3 switched ethernet 10/100/1000BT network. Wireless networking is available in our facility. Our research and teaching environments are serviced by a cadre of dedicated data servers including a Network Appliance F820 and six Sun Fire 280R servers.

4. MASTER OF SCIENCE PROGRAM

The College of Computer and Information Science offers students the opportunity to pursue studies in the broad field of computer science. The program is designed for men and women who are seeking to prepare themselves for organizations that design, develop, market, or utilize computing systems. A fundamental goal of the College is to help students develop the ability to recognize and solve problems arising in the use of modern digital computers in business and engineering as well as in educational and research environments. In developing the skills necessary to achieve this goal, the student has the opportunity to assimilate ideas and concepts from theoretical studies and from in-depth, hands-on design and programming of both large time-sharing systems and single-user microcomputers. To enhance students' classroom learning experience, the Master of Science program provides a Cooperative Education option, upon which students are given the opportunity to participate in at least a 6 month or longer work experience with industries.

ADMISSIONS REQUIREMENTS

Applicants must submit an official application, official transcripts from all colleges/universities attended, a personal statement, official scores of the GRE General Test, and three letters of recommendation. International students must also submit official scores of the TOEFL examination. Acceptance into the College of Computer and Information Science is granted upon recommendation of the College Graduate Committee after a review of the completed application.

Candidates must have completed the undergraduate material listed below.

- Experience in some high level procedural language, e.g. C, C++, Java, Scheme, ML
- Data Structures
- Computer Organization
- One year of college calculus
- Discrete Mathematics

Industrial experience in these areas may be an acceptable substitute for formal coursework. Students may be accepted provisionally while completing these deficiencies, and may take graduate courses concurrently as their preparation allows.

ACADEMIC REQUIREMENTS

Thirty-two semester hours are required for the Master of Science in Computer Science. These must include:

- eight semester hours of core courses, CS 5010 Program Design Paradigm, together with the associated recitation lab CS 5011, and CS 5800 Algorithms,

- four semester hours of core system courses: CS 5500 Managing Software Development or CS 5600 Computer Systems, and

- twenty semester hours of electives, eight of which must come from the same concentration area. These electives may include readings, project, or a thesis.

- A student must enroll in CS 5010/CS 5011 during their first semester in the program, unless s/he has received special permission from the Graduate Director of the College.

- During the course of studies, every student must obtain a minimum grade point average of 3.000 among the core courses and a minimum overall average of 3.000.

ACADEMIC PROBATION

A student whose overall GPA (grade point average) and/or whose GPA based on the three required core courses falls below 3.00 will be automatically placed on academic probation and will be notified by the College. Once on probation, a student has the following two academic semesters (summer excluded) to achieve a 3.00 GPA. If at the end of those two semesters, the student's GPA is still unsatisfactory, the student will be dismissed from the graduate program.

TIME AND TIME LIMITATION

The Graduate School of the College of Computer and Information Science offers courses during the fall and spring semesters. A few summer courses may be offered. With careful planning and approval of an academic adviser, full-time students may be able to complete the MS program in three semesters. Normally, full-time students complete the program in two years. Part-time students usually elect one or two courses per academic semester and can complete the MS degree in two or three years.

Course credits earned in the program of graduate study or accepted by transfer are valid for a maximum of seven years unless an extension is granted by the Graduate Committee of the College of Computer and Information Science. Students should petition, in writing, to the Director of the Graduate School for such extensions.

TRANSFER CREDIT

A maximum of 9 semester hours of credit obtained at another institution may be accepted towards the degree, provided the credits consist of work taken at the graduate level for graduate credit, carry grades of 3.000 or better, have been earned at an accredited institution, and have not been used toward any other degree. Transfer credit will be offered only for courses that match a course offered at Northeastern University and that have been approved by the

Graduate Committee. However, *no* transfer credit will be given for courses listed as Interdisciplinary Courses.

APPROVED COURSES

MS Core

CS 5010/CS 5011 Program Design Paradigm

CS 5800 Algorithms

System Core

CS 5500 Managing Software Development

CS 5600 Computer Systems

PhD Core

CS 7400 Intensive Principles of Programming Languages

CS 7600 Intensive Computer Systems

CS 7800 Advanced Algorithms

CS 7805 Theory of Computation

CONCENTRATIONS

Artificial Intelligence

CS 5100 Foundations of Artificial Intelligence

CS 6140 Machine Learning

CS 6110 Knowledge-based Systems

CS 6120 Natural Language Processing

CS 7180 Special Topics in Artificial Intelligence

CS 7170 Seminar in Artificial Intelligence

Computer Human Interaction

CS 5340 Computer Human Interaction

CS 6350 Empirical Research Methods

Database Management

CS 5200 Introduction to Database Management Systems

CS 6220 Data Mining Techniques

CS 7280 Special Topics in Database Management

CS 7270 Seminar in Database Systems

Graphics

CS 5310 Computer Graphics

CS 5320 Digital Image Processing

CS 5330 Pattern Recognition and Computer Vision

CS 7380 Special Topics in Graphics/Image Processing

CS 7370 Seminar in Graphics/Image Processing

Information Security

CS 6750 Cryptography and Communication Security

CS 6740 Network Security

CS 6760 Privacy, Security and Usability

CS 6540 Foundations of Formal Methods and Software Analysis

CS 7580 Special Topics in Software Engineering – Software Security

Networks

CS 5700 Fundamentals of Networking and Internetworking

CS 6710 Wireless Networks

CS 6750 Cryptography and Communication Security

CS 6740 Network Security

CS 7780 Special Topics in Networks

CS 7770 Seminar in Computer Networks

CS 7775 Seminar in Computer Security

Programming Languages

CS 5400 Principles of Programming Languages

CS 6510 Advanced Software Development

CS 6410 Compilers

CS 6412 Semantics of Programming Languages

CS 7480 Special Topics in Programming Languages

CS 7470 Seminar in Programming Languages

CS 7570 Seminar in Software Development

Software Engineering

CS 5610 Web Development

CS 6520 Methods of Software Development

CS 6530 Analysis of Software Artifacts

CS 6540 Foundations of Formal Methods and Software Analysis

CS 6510 Advanced Software Development

CS 7580 Special Topics in Software Engineering

CS 7575 Seminar in Software Engineering

Systems

CS 5620 Computer Architecture

CS 5650 Research in High Performance Computing

CS 6610 Parallel Computing

CS 6740 Network Security

CS 7680 Special Topics in Computer Systems

CS 7670 Seminar in Computer Systems

Theory

CS 6800 Applications of Information Theory to Computer Science

CS 6810 Distributed Algorithms

CS 7805 Theory of Computation

CS 6750 Cryptography and Computer Security

CS 6610 Parallel Computing

CS 7880 Special Topics in Theoretical Computer Science

CS 7870 Seminar in Theoretical Computer Science

Reading and Project Courses

CS 8982 MS Readings

CS 8984 MS Readings and Research in Computer Science

CS 8674 Master's Project in Computer Science

CS 6964 Co-op

CS 7990 Master's Thesis in Computer Science

CS 7996 Master's Thesis Continuation (0 SH)

CS 8949 Research Work Experience (0 SH)

CS 8984 PhD Readings and Research in Computer Science

CS 9990 PhD Dissertation in Computer Science

CS 9996 PhD Dissertation Continuation

ELECTIVES

Any course that appears in a concentration above may count as an elective. Other courses offered at the graduate level at Northeastern

University may be taken as electives provided written permission is given by the student's faculty advisor *and* approval is obtained from the Graduate School of College of Computer and Information Science. Elective authorization petitions are available in the College Administrative Office at 202 WVH and on the graduate website under the Graduate Forms tab.

SPECIMEN ACADEMIC SCHEDULE

Most graduate courses in computer science are offered in the late afternoon and early evening, which enables many students to pursue their graduate degrees while continuing with their daytime employment. Courses may be offered in different semesters from year to year. However, the following schedule may serve as a general guide.

Currently, all courses in the College of Computer and Information Science are offered on the Boston campus only.

Graduate Course Offering Plan

2009- 2010

Fall 2009	**Spring 2010**
CS 5010/5011 PDP	CS 5010/5011 PDP
CS 5600 Computer Systems Development	CS 5500 Managing Software
CS 5800 Algorithms	CS 5800 Algorithms
CS 7400 Int. PPL	CS 7600 Int. Computer Systems
CS 7800 Advanced Algorithms	CS 7805 Theory of Computation
	CS 5100 Foundations of AI
CS 5200 Intro. to Database Systems	CS 5200 Intro. to Database Systems
CS 5340 Human/Computer Interaction	

CS 5400 PPL	CS 5400 PPL
CS 5620 Computer Architecture	CS 5610 Web Development
CS 5700 Fund. Of Comp Netwk	CS 5700 Fund. Of Comp Netwk
CS 6200 Information Retrieval	CS 6410 Compilers
CS 6220 Data Mining	
CS 6520 Advanced Software Development	CS 6710 Wireless Network
CS 6740 Network Security	CS 6740 Network Security
CS 6750 Cryptography & Comp. Security	CS 7480 Topics in PL
CS 7880 Topics in Theory	CS 7780 Topics in Networks

Interdisciplinary Courses

IA 5240 Ethics, Privacy & Digital Rights	IA 5210 Computer Forensics
IA 5200 Security Risk Management	

Please note that

(1) MS students interested in pursuing future PhD studies are encouraged to take the intensive core courses, in place of the regular core courses. Approval *must* be obtained from the instructor.

(2) Students without undergraduate OS background should take CS 5600 before taking CS 7600.

(3) At most 8 semester credit hours of IA courses can be counted toward MS in CS.

(4) Course offerings are subject to change.

READING AND PROJECT COURSES

Every reading and/or project course requires a petition, approved by the Graduate Committee. Petitions are available in the College Administrative Office at 202 WVH.

MASTER'S THESIS

The Master's thesis option consists of 8 semester hours of research, culminating into an MS. thesis. This can be accomplished through one of the following two options:

Option 1: Two 4 credit MS Thesis courses: CS 7990 *taken consecutively.*

Option 2: *Either* a Readings Course CS 8982 *or* a Project Course CS 8984, followed by MS Thesis CS 7990.

Both of these options may only be undertaken with the agreement of a thesis advisor and one other official reader.

Thesis Proposal

A student wishing to select the Master's thesis option must submit a short proposal to the Graduate Committee, signed by the advisor, which describes the project and lists the official reader. The reader may be chosen from the faculty of the college, from another NU department, or from another institution or the industrial community when appropriate. The proposal should be submitted at least one month before the thesis project is to begin. The Graduate Committee may accept or reject the proposal, ask for revisions, or ask that additional readers be added to the proposal. Both the merits of the proposal and the academic performance of the student will be considered in deciding whether to accept a proposal for the MS Thesis.

Thesis

The thesis advisor guides the research topic. The result of the research is to be an original contribution to the field of Computer Science. The thesis should be developed in terms of the current literature and will include a thorough literature search and review. Emphasis is to be placed upon clear writing, logical development, and significance of the issues. Acceptance of the thesis requires the agreement of the thesis advisor and the reader(s).

Thesis defense

The student will defend the thesis at a public presentation. The defense will be directed by the thesis advisor and the reader(s) will be in attendance. The thesis defense is open to the public and should be announced at least one week ahead. The candidate will give a lecture on the subject of the thesis and this will be followed by questions from those in attendance concerning the results of the thesis as well as related matters.

Publication

Upon acceptance, the MS thesis will be issued as a College of Computer and Information Science technical report and an electronic copy will be archived at UMI.

5. DOCTOR OF PHILOSOPHY PROGRAM

The goal of the PhD program is to equip its graduates to conduct state-of-the-art research in computer science, either in academia or in industry. The curriculum aims to fulfill this goal by providing the student with:

1. A broad background in the fundamentals of computer science.
2. Advanced courses in the dissertation area.
3. An intensive research experience, culminating in the writing of a dissertation.

Students are strongly encouraged to participate in summer internships for at least two summers during their course of studies.

ADMISSIONS REQUIREMENTS

A Bachelor's degree in Computer Science or equivalent is required.

Applicants must submit an official application, official transcripts from all colleges/universities attended, a personal statement, official scores of the GRE general test, and three letters of recommendation. International students must also submit official scores of the TOEFL examination. Acceptance to the College of Computer and Information Science is granted upon

recommendation of the College Graduate Committee after a review of the completed application.

ACADEMIC REQUIREMENTS

A minimum of 16 semester hours of course work beyond the Master's degree (not including the required courses to be admitted to PhD candidacy), or 48 semester hours of course work beyond the BS/BA degree, is required of all students.

Admission to Candidacy

All students must demonstrate sufficient knowledge in the fundamentals of computer science, as well as the ability to carry out research in an area of computer science.

Course Requirements

All students are required to take the required six courses including:

Core:

- CS 7600 Intensive Systems;
- CS 7400 Intensive Principles of Programming Languages;
- CS 7800 Advanced Algorithms;
- CS 7805 Theory of Computation;

and two others approved by the PhD Committee in a field chosen from the list given below (usually in the student's area of specialization). Pre-approved courses are listed below.

- *Artificial Intelligence*

  CS 5100 and CS 6140

- *Database Management*

  CS 5200 and CS 6220

- *Human Computer Interaction*

CS 5340 and CS 6350

- *Programming Languages and Software Design*

  CS 6510, CS 6410, CS 6412 or CS 7480

- *Networks*

  CS 5700, CS 6710, or 6740

- *Others*

  approval by the Graduate Committee (interdisciplinary topics are highly encouraged)

The student must maintain a minimum GPA of 3.5 among the six courses satisfying the above course requirement and a grade of B or better in each of these courses. Students who have taken equivalent courses in other institutions may petition to be exempted from the course(s) (subject to the approval of the PhD Committee). Each student may repeat a course once for no more than three out of the six courses if they do not receive a B or better in the course. Students with an MS degree in Computer Science may petition to the PhD Committee for an exemption from these courses. Petition forms are available in the College Administrative Office at 202 WVH.

The fields listed do not necessarily represent areas of specialization or separate tracks within the PhD program. Rather, they attempt to delineate areas on which the student must be examined in order to measure his or her ability to complete the degree. Therefore, they may be adjusted in the future to reflect changes in the discipline of computer science and in faculty interests within the College of Computer and Information Science.

Similarly, these fields do not represent the only areas in which a student may write his or her dissertation. They are, however, intended to serve as a basis for performing fundamental research in computer science.

Research/Survey Paper

To demonstrate research ability, the student is required to submit to the PhD Committee a research paper or a survey paper in an area of specialty under the supervision of a faculty advisor. Normally the length of the paper should not exceed 15 pages. A submitted paper from a student is considered to have fulfilled the *Paper Requirement* if

1. The paper has been submitted to a selective conference,

2. The student has made substantial contribution to the paper,

3. The advisor has endorsed the paper with a written statement indicating the student's contribution, and

4. The PhD Committee has voted on a positive recommendation.

Upon completion of the course and the research paper requirements, the student is admitted to candidacy for the PhD degree. *It is highly recommended that the student complete the candidacy requirement by the end of his/her* ***second*** *year.*

Residency

One year of continuous full-time study is required after admission to the PhD candidacy. It is expected that during this period the student will make substantial progress in preparing for the Comprehensive Examination.

Comprehensive Examination

The examination will be taken after the student has achieved sufficient depth in a field of study in order to prepare a prospectus for the PhD dissertation. This process should take place no later than the fall semester of the fifth year in residence.

Prior to taking the Comprehensive Examination, the student will prepare a thesis proposal for the examination, which describes the proposed research including the relevant background materials from the literature. The thesis proposal should clearly specify the research problems to be attacked, the techniques to be used, and a schedule of milestones towards completion. Normally the thesis proposal should not exceed fifteen pages, excluding appendices and bibliography. The thesis proposal must be approved by the Comprehensive Committee,

It is strongly recommended that the same members should serve on both the Comprehensive and Thesis Committees. With the help of the advisor, a student will select the Comprehensive Committee consisting of 4 members to be approved by the PhD Committee. The 4 members must include the advisor, 2 other faculty members from the College and an external examiner (optional for Comprehensive Committee). To help the PhD Committee to make an

informed decision, a copy of the external examiner's resume should be submitted at the same time.

Upon approval of the written Proposal, the student has to present the proposed work orally in a public forum, followed by a closed-door oral examination from the Comprehensive Committee. The student may not take the Comprehensive Examination more than two times.

Doctoral Dissertation

Upon successful completion of solving the research proposed in the Thesis Proposal, the candidate will prepare the dissertation for approval by the Doctoral Committee. The dissertation must contain results of extensive research and make an original contribution to the field of computer science. The work should give evidence of the candidate's ability to carry out independent research. It is expected that the dissertation should be of sufficient quality to merit publication in a reputable journal in computer science.

Doctoral Committee

If the Thesis Committee is the same as the Comprehensive Committee, no further approval is needed. If the Thesis Committee is changed in its composition, approval process will follow that of the Comprehensive Committee.

Dissertation Defense

The dissertation defense is held in accordance with the regulations of the University Graduate Council. It will consist of a lecture given by the candidate on the subject matter of the dissertation. This will be followed by questions from the Doctoral Committee and others in attendance concerning the results of the dissertation as well as any related matters. The examination will be chaired by the PhD advisor.

TIME AND TIME LIMITATION

After the establishment of degree candidacy, a maximum of five years will be allowed for the completion of the degree requirements, unless an extension is granted by the College Graduate Committee.

TRANSFER CREDIT

A maximum of 9 semester hours of credit obtained at another institution may be accepted towards the degree, provided the credits consist of work taken at the graduate level for graduate credit, carry grades of 3.000 or better, have been earned at an accredited institution, and have not been used toward any other degree. No transfer credit will be given for courses listed as Interdisciplinary Courses.

ELECTIVES OUTSIDE THE COLLEGE

Students are encouraged to take electives outside the College, with the approval of both the thesis advisor and the Director of Graduate Studies, as part of their study. Relevant courses are typically offered in the departments of Electrical and Computer Engineering, Mathematics, Philosophy, Psychology, and Sociology. Courses in other areas may also be approved as part of the plan of study.

SPECIMEN CURRICULUM

Because a PhD program is highly individualized, it is inappropriate to sketch out a semester-by-semester, course-by-course program. Instead, we will attempt to describe the major activities of each year's study for a hypothetical student. Our hypothetical student comes to us with a BS in Computer Science and a firm plan to take a PhD along the way, we will comment on how the program might vary for other categories of students.

The following table provides a recommended course scheduling for a PhD Student:

Year	Fall Semester	Spring Semester
1	CS 7400 Intensive PPL or CS 7800 Advanced Alg Elective (area of interest)	CS 7600 Intensive Sys or CS 7805 Thy of Comp Elective (area of interest)
2	CS 7800 Advanced Alg or CS 7400 Intensive PPL	CS 7805 Thy of Comp or CS 7600 Intensive Sys

	Elective	Elective
3	Elective Thesis or Reading	Elective Thesis or Reading
4	Reading Thesis Cont or Reading	Reading Thesis Cont or Reading
5-6	Thesis Continuation	Thesis Continuation

Year 1. In the fall and spring, the student takes one intensive core course each semester and one or two courses in his/her area of specialization if such an area has been identified. Students whose research interests lie within the network and algorithm areas, are encouraged to take CS 7800 and CS 7805 during the first year, while others are encouraged to take CS 7400 and CS 7600. During this year, the student should be working towards identifying an area of research, as well as a potential faculty advisor. Students with strong background in Computer Science and know their research directions, are encouraged to start research projects as soon as possible. Such a student would normally take courses only as necessary to fill in background gaps and should work towards the completion of research paper.

Year 2. During the academic year, the student should continue to take one core course in each semester. At the same time, the student is strongly encouraged to undertake supervised reading and research courses in the proposed area of study. The student may choose to obtain the MS degree provided he/she has completed the MS degree requirements. The student should participate in a research seminar if s/he has not done so during the first year of studies. Students are strongly encouraged to complete their paper requirements by the end of the year.

Year 3-4. During this time, the student's time is devoted almost entirely to research. Continuing the work from Year 2, the student

undertakes a series of more and more challenging research problems. The paper requirement is expected to be completed *no later than* the end of Year 3. By the end of Year 4, the student isolates a thesis problem and completes the Comprehensive Examination requirement.

Years 5-6. The student works on the dissertation problem and writes the thesis. By the end of the fifth year, the thesis is at least ready to be written. In theoretical areas, the student should be ready to defend the dissertation at approximately the end of Year 5. In systems areas, the thesis work is more likely to extend to a sixth year.

6. SPECIAL STUDENTS

The College of Computer and Information Science offers students the opportunity to take graduate courses in the non-degree status of special student. Special students are allowed to enroll in a graduate course only with the permission of the instructor. This category is designed for students interested in obtaining specialized knowledge in one or several fields of Computer Science without formally pursuing a graduate degree.

Acceptance as a special student is unrelated to admission to the degree program. However, a maximum of 12 semester hours of credit earned as a special student can be counted toward degree requirements, if the student is subsequently admitted to a degree program.

ADMISSIONS REQUIREMENTS

Applicants must submit an official application, official transcripts from all Colleges/Universities attended, a personal statement, two letters of recommendation, and a $50 application fee. Acceptance to the College of Computer and Information Science as a special student is granted upon joint recommendation of the course instructor, and the Graduate Director, after a review of the completed application. Special student status will not be offered to international students.

7. APPLICATION PROCEDURE AND FINANCIAL AID

APPLICATION PROCEDURE

All application material is located online at the address below. For information on applying, please contact the Graduate office at one of the following:

Telephone: (617) 373-2464

Fax: (617) 373-5121

E-mail: csgradinfo@ccs.neu.edu

WWW: http://www.ccs.neu.edu/graduate/applications.html

Supplemental application should be returned to:

The College of Computer and Information Science

Northeastern University

360 Huntington Ave, 202 West Village H

Boston MA 02115

All applications must be accompanied by a nonrefundable $50 application fee. No application is processed until this fee has been received. Checks should be made payable to **Northeastern University**.

Financial Aid and Graduate Assistantships

A limited amount of financial aid is available to graduate students in the College of Computer and Information Science through loans, grants, and graduate assistantships.

Stipend Graduate Assistantship

These are available only to full-time students selected on the basis of academic and professional background. Priority is given to students who are admitted to the PhD program. Students with high academic achievement are invited to apply. The graduate assistantships carry a full tuition scholarship, in addition to which students may receive a stipend over a two-semester period as payment for the performance of 20 hours a week of assigned duties, including counseling students and assisting faculty in course preparation and research. The 2009-2010 stipend is $17,588 for two semesters. Outstanding students may receive fellowships in addition to the stipend.

Students interested in Stipend Graduate Assistantships must apply in writing at the time of their application. The deadline for applying for an assistantship is **January 15**.

GSS (Graduate Student Scholarship)

These scholarships carry a tuition waiver of 8 semester credit hours per semester and are awarded based on academic excellence. All applicants will be considered at the time of their completed MS or PhD application submission. No additional application is needed.

Deans' Scholarship

The Office of Financial Aid administers the Dean's Scholarship, which provides a tuition discount of up to 30% to awardees.

Other

Northeastern University offers graduate students many ways to obtain financial aid, which are administered by the Office of Financial Aid. Other forms of assistance are based on need, which include the Perkins Loan, the College Work-Study Program, and the Guaranteed Student Loan Program. For detailed information, contact the Office of Student Financial Services, 356 Richards Hall, (617) 373-3190; http://www.customerservice.neu.edu.

8. GENERAL REGULATIONS

ACADEMIC INTEGRITY[1]

Commitment to the Principles of Intellectual Honesty and Integrity is essential to the Mission of Northeastern University.

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[1] For more information, please refer to
http://www.atsweb.neu.edu/judicialaffairs

Academic Integrity is important for two reasons. First, independent and original scholarship ensures that students derive the most from their educational experience and the pursuit of knowledge. Second, academic dishonesty violates the most fundamental values of an intellectual community and depreciates the achievements of the entire University community. Accordingly, Northeastern University views academic dishonesty as one of the most serious offenses that a student can commit while in college.

The following is a broad overview of what constitutes academic dishonesty, but is not meant to be an all-encompassing definition.

CHEATING

Intentionally using or attempting to use unauthorized materials, information or study aids in any academic exercise.

Examples:

- Unauthorized use of notes, text, or other aids during an examination.
- Copying from another student's examination, research paper, case write-up, lab report, homework, computer disc, etc.
- Talking during an examination.
- Handing in the same paper for more than one course without the explicit permission of the instructor.
- Perusing a test before it is given.
- Hiding notes in a calculator for use during an examination.

FABRICATION

Intentional and unauthorized falsification, misrepresentation, or invention of any information, data, or citation in an academic exercise.

Examples:

- Making up the data for a research paper.
- Altering the results of a lab experiment or survey.
- Listing a citation for a source not used.
- Stating an opinion as a scientifically proven fact.

PLAGIARISM

Intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise without providing proper documentation of source by way of a footnote, endnote, or inter-textual note.

THE FOLLOWING SOURCES DEMAND NOTATION:

- Word-for-word quotation from a source, including another student's work.
- Paraphrase: using the ideas of others in your own words.
- Unusual or controversial facts - facts not apt to be found in many places.
- Interviews, radio, television programs, and telephone conversations.

UNAUTHORIZED COLLABORATION

This refers to instances when students, each claiming sole authorship, submit separate reports, which are substantially similar to one another. While several students may have the same source material (as in case write-ups), the analysis, interpretation, and reporting of the data must be each individual's.

PARTICIPATION IN ACADEMICALLY DISHONEST ACTIVITIES

Examples:

- Stealing an examination.
- Purchasing a pre-written paper through a mail-order or other service, including via the Internet.
- Selling, loaning, or otherwise distributing materials for the purpose of cheating, plagiarism, or other academically dishonest acts.
- Alteration, theft, forgery, or destruction of the academic work of other students, library materials, laboratory materials, or academic records including transcripts, course registration cards, course syllabi, and examination/course grades.

- Intentionally missing an examination or assignment deadline to gain an unfair advantage.

FACILITATING ACADEMIC DISHONESTY

Intentionally or knowingly helping or attempting to violate any provision of this policy.

Examples:

- Inaccurately listing someone as co-author of a paper, case write-up or project who did not contribute.
- Sharing a take-home examination, homework assignment, case write-up, lab report, etc., with another without expressed permission from the instructor.
- Taking an examination or writing a paper for another student.

All members of the Northeastern University community, students, faculty, and staff share the responsibility to bring forward known acts of apparent academic dishonesty. Any member of the academic community who witnesses an act of academic dishonesty should report it to the appropriate faculty member or to the Graduate Director or to the Director of the Office of Student Conduct and Conflict Resolution.

THE TRANSCRIPT

The transcript (or record) is the official document of a student's academic performance while attending Northeastern University, listing the courses taken, the grades earned, and a variety of other information such as transfer credits and Academic Probation status.

It is imperative that a student periodically examine the transcript for accuracy. An official copy of the transcript may be obtained in the Registrar's Transcript Office in 118 Hayden Hall. Unofficial copies are available via the myNEU Web Portal. Upon graduation, a student's record is closed and no further changes can be made except in cases of an administrative error made on the transcript.

THE INCOMPLETE (I) GRADE

An instructor may elect to issue an incomplete (I) grade if the following are true:

- A student has already completed a substantial portion of the course, with passing grades.
- A student is unable to complete the entire course because of extenuating and unforeseen circumstances such as serious illness or family emergency.

An incomplete grade is explicitly not to be used as a mechanism to avoid receiving an undesirable grade when a student is performing poorly in a course. An incomplete grade cannot be awarded if a student is currently on academic probationary status.

If an incomplete grade is given, the instructor must complete an incomplete grade form, available in the Computer and Information Science Main Office, specifying the reason for the incomplete grade and indicating the agreed upon method for completing the course requirements. A copy of the form should be retained by both the student and the instructor and the original left in the Main Office.

Although the instructor determines the actual length of period for clearing an incomplete, this period cannot be longer than one calendar year from the end of the semester in which the course was taken. Exceptions to this limit are considered by the Graduate Committee on a case by case basis but, normally, if the incomplete is not cleared within one year, a student will be required to retake the course to clear it.

9. COURSE DESCRIPTIONS

All courses, other than the Interdisciplinary courses, assume an undergraduate background in Algorithms and Data Structures. All courses are 4 semester hours, unless otherwise noted.

INTERDISCIPLINARY COURSES

IA 5010 Foundations of Information Assurance (not for MS CS credit)

Builds a common cross-disciplinary understanding in the foundations of information assurance. Presents an overview of basic principles and security concepts related to information systems, including workstation security, system security, and communications security. Introduces information security via database technology. Discusses Legal Infrastructure such as

DMCA, Telecommunications Act, Wire Fraud, and other ethical issues. Covers Security Methods, Controls, Procedures, Economics of Cyber crime, Criminal Procedure and Forensics; Describes the use of Cryptography as a tool, Software Development Processes and Protection.

IA 5110 Computer Systems Security (not for MS CS credit)

IA 5130 Network Security Practice (not for MS CS credit)

IA 5120 Applied Cryptography (not for MS CS credit)

Provides a survey of both the principles and the practice of cryptography. Topics covered include symmetric encryption schemes including DES and AES; public key cryptosystems such as RSA, Discrete Logarithm; hash functions, authentication and digital signatures; key management and digital certificates. Discusses network security protocols and applications, including Kerberos and SSL.

MS CORE COURSES
Prereq: admitted to MS program or completion of all transition courses

CS 5010 Program Design Paradigm

This graduate course for students in the MS program introduces modern program design paradigms. It starts with functional program design, introducing the notion of a design recipe. The latter consists of two parts: a task organization (ranging from the description of data to the creation of a test suite) and a data-oriented approach to the organization of programs (ranging from atomic data to self-referential data definitions and functions-as-data). The course then progresses to object-oriented design, explaining how it generalizes and contrasts with functional design. In addition to studying program design, students also practice pair programming and public code review techniques, as found in industry today. STUDENT MUST REGISTER FOR CS G5011 LAB IN ORDER TO GET CREDIT FOR THIS COURSE.

CS 5011 Program Design Paradigm Lab (0 credit hours)

Required recitation session with CS 5010.

CS 5500 Managing Software Development

Covers software life cycle models (waterfall, spiral, etc.), domain engineering methods, requirements analysis methods (including formal specifications), software design principles and methods, verification and testing methods, resource and schedule estimation for individual software engineers, component-based software development methods and architecture, languages for describing software processes. Includes a project where some of the software engineering methods (from domain modeling to testing) are applied in an example.

CS 5600 Computer Systems

Studies the structure, components, design, implementation, and internal operation of computer systems, focusing mainly on the operating system level. Briefly reviews computer hardware and architecture, including the arithmetic and logic unit, and the control unit. Covers current operating system components and construction techniques, including the memory and memory controller, I/O device management, device drivers, memory management, file system structures, and the user interface. Introduces distributed operating systems, discusses issues arising from concurrency and distribution, such as scheduling of concurrent processes, interprocess communication and synchronization, resource sharing and allocation, deadlock management and resolution. Includes examples from real operating systems. Will expose students to the system concepts through programming exercises.

CS 5800 Algorithms

Presents the mathematical techniques used for the design and analysis of computer algorithms. Focuses on algorithmic design paradigms and techniques for analyzing the correctness, time and space complexity of algorithms. Topics chosen from: asymptotic notation, recurrences, loop invariants, Hoare triples, sorting and searching, advanced data structures, lower bounds, hashing, greedy algorithms, dynamic programming, graph algorithms, and NP-completeness.

PHD CORE COURSES

Prereq: admitted to PhD program or permission of instructor

CS 7400 Intensive Principles of Programming Languages

Prereq: Knowledge of Lisp or permission of instructor

Studies the basic components of programming languages; specification of syntax and semantics; and description and implementation of programming language features. Discusses examples from a variety of languages.

CS 7600 Intensive Computer Systems

Studies the structure, components, design, implementation, and internal operation of computer systems, focusing mainly on the operating system level. Briefly reviews computer hardware and architecture, including the arithmetic and logic unit, and the control unit. Covers current operating system components and construction techniques, including the memory and memory controller, I/O device management, device drivers, memory management, file system structures, and the user interface. Briefly discusses distributed operating systems, real time systems and addresses issues such as concurrent processes, scheduling, interprocess communication and synchronization. Some relevant distributed algorithms will be discussed as time allows.

The course will also cover design and analysis techniques for desirable properties in computer systems selected from the following: functional correctness (in the absence of faults), performance and throughput, fault-tolerance and reliability, real-time response, security, and quality-of-service. Includes examples from real operating systems. The course will emphasize abstraction while programming exercises will be used to facilitate the understanding of concepts.

CS 7800 Advanced Algorithms

Presents advanced mathematical techniques for designing and analyzing computer algorithms. Reviews some of the material covered in CS 5800 and then covers advanced topics. Emphasizes theoretical underpinnings of techniques used to solve problems arising in diverse domains. Topics include asymptotic analysis, advanced data structures, dynamic programming, greedy algorithms and matroid theory, amortized analysis, randomization, string matching, algebraic algorithms, and approximation algorithms. Introduces Turing Machines, P and NP classes, polynomial-time-reducibility, and NP-completeness.

CS 7805 Theory of Computation
Prereq: CS 7800 MS: Theory

Examines formal models of computation, notions of undecidability, and basic complexity theory. Models of computation include finite state automata, pushdown automata, and Turing machines. Discusses the properties of regular sets and context-free languages. Also covers partial recursive functions, primitive recursive functions, recursively enumerable sets, Turing decidability and unsolvable problems. Discusses the concept of reductions, time and space complexity classes, and the polynomial-time hierarchy.

CS 7090 Research Overview of Computer Science (1 SH)

Students will be exposed to all current research activities within the College.

REGULAR COURSES

ARTIFICIAL INTELLIGENCE

CS 5100 Foundations of Artificial Intelligence

Prereq: Lisp or Java programming MS: AI PhD: AI

This course introduces the fundamental problems, theories and algorithms of the artificial intelligence field. Topics covered include: heuristic search and game trees; knowledge representation using predicate calculus; automated deduction and its applications; problem solving and planning; introduction to machine learning. Required coursework includes the creation of working programs that solve problems, reason logically, and/or improve their own performance using techniques presented in the course.

CS 6110 Knowledge-based Systems

Prereq: CS 5100 MS: AI PhD: AI

This course focuses on the acquisition, organization and use of world knowledge in computers, and the challenge of creating programs with common sense. Topics include: knowledge representation and reasoning models beyond predicate calculus; Bayesian inference and other models of reasoning and decision making under uncertainty; rule-based expert systems; case-based and analogical reasoning; introduction to natural language processing. Required coursework include the creation of working programs that store and manipulate world knowledge using techniques presented in the course.

CS 6120 Natural Language Processing

Prereq: CS 5100 MS: AI PhD: AI

This course provides an introduction to the computational modeling of human language, the ongoing effort to create computer programs that can communicate with people in natural language, and current applications of the natural language field such as automated document classification, intelligent query processing, and information extraction. Topics include: computational models of grammar and automatic parsing; statistical language models and the analysis of large text corpuses; natural language semantics and programs

that understand language; models of discourse structure; and language use by intelligent agents. Required coursework includes formal and mathematical analysis of language models, and implementation of working programs that analyze and interpret natural language text.

CS 6140 Machine Learning

Prereq: CS 5100 MS: AI PhD: AI

This course provides a broad look at machine learning techniques and issues, including algorithms for: supervised learning, including back-propagation neural networks and decision tree induction; unsupervised learning; reinforcement learning; and explanation-based learning. Also covers simulated annealing and genetic algorithms, and introduces computational learning theory and other methods for analyzing and measuring the performance of learning algorithms. Coursework includes a programming term project.

CS 7180 Special Topics in Artificial Intelligence

Prereq: CS 5100 or permission of instructor. MS: AI

Topics vary

CS 7170 Seminar in Artificial Intelligence (2 SH)

Prereq: CS 5100 or permission of instructor.

Students will read and present various survey and research papers in Artificial Intelligence. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

COMPUTER HUMAN INTERACTION

CS 5340 Computer/Human Interaction

Prereq: Knowledge of C/UNIX MS: HCI, PhD: HCI

This course covers the principles of human-computer interaction and the design and evaluation of user interfaces. Topics include an overview of human information processing sub-systems (perception, memory, attention and problem-solving), how the properties of these systems affect the design of user interfaces; the principles, guidelines, and specification languages for

designing good user interfaces, with emphasis on toolkits and libraries of standard graphical-user-interface objects; and a variety of interface evaluation methodologies that can be used to measure the usability of software. Additional topics may include: World Wide Web design principles and tools, computer-supported cooperative-work, multi-modal and "next generation" interfaces, speech and natural language interfaces, virtual reality interfaces. Coursework includes both the creation and implementation of original user interface designs, and the evaluation of user interfaces created by others.

CS 6350 Empirical Research Methods

MS: HCI, PhD: HCI

Presents an overview of methods for conducting empirical research within Computer Science. These methods help provide objective answers to questions about the usability, effectiveness, and acceptability of systems. The course covers the basics of the scientific method, building from a survey of objective measures to the fundamentals of hypothesis testing using relatively simple research designs, and on to more advanced research designs and statistical methods. The course also includes a significant amount of fieldwork, spanning the design, conduct and presentation of small empirical studies. Students will also work on a project using at least one advanced statistical analysis technique, such as causal path analysis, and will also prepare a final report and presentation on the results of the study.

DATABASE MANAGEMENT

CS 5200 Database Management Systems

MS: DB PhD: DB

Introduces relational database management systems as a class of software systems. The course covers design theory, query language and performance/tuning issues. Topics include relational Algebra, SQL Query optimization, stored procedures, user-defined functions, cursors, embedded SQL programs, client-server interfaces, entity-relationship diagrams, normalization, B-trees, concurrency, transactions, database security,

constraints, object-relational DBMSs, specialized engines such as spatial, text, XML conversion and time series. The course will include exercises using a commercial relational or object-relational database management system.

CS 6200 Information Retrieval

MS: DB, AI PhD: DB, AI

Provides an introduction to information retrieval systems and different approaches to information retrieval. Topics covered include evaluation of information retrieval systems; retrieval, language, and indexing models; file organization; compression; relevance feedback; clustering; distributed retrieval and metasearch; probabilistic approaches to information retrieval; Web retrieval; filtering, collaborative filtering, and recommendation systems; cross-language IR; multimedia IR; and machine learning for information retrieval.

CS 6220 Data Mining Techniques

Prereq: CS 5800 or CS 7800 MS: DB PhD: DB

This course covers various aspects of data mining including OLAP technology, data characterization, classification, association rules, cluster Analysis, time series, and so on. The class project involves hands-on practice of mining useful knowledge from a large database using the Analysis Services component of Microsoft SQL Serve.

CS 7280 Special Topics in Database Management

Prereq: CS 5210 or permission of instructor. MS: DB

Topics vary. Possible areas are object-oriented database systems and distributed data-base systems.

CS 7270 Seminar in Database Systems (2 SH)

Prereq: CS 5210 or permission of instructor.

Students will read and present various survey and research papers in Database Systems. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

GRAPHICS

CS 5310 Computer Graphics

Prereq: Linear Algebra MS: Graphics

Introduces the fundamentals of two-dimensional and three-dimensional computer graphics with an emphasis on approaches for obtaining realistic images. Covers two-dimensional algorithms for drawing lines and curves, anti-aliasing, filling, and clipping. Studies rendering of three-dimensional scenes composed of spheres, polygons, quadric surfaces, and bi-cubic surfaces using ray-tracing and radiosity. Includes techniques for adding texture to surfaces using texture and bump maps, noise, and turbulence.

CS 5320 Digital Image Processing

Prereq: Linear Algebra MS: Graphics

Studies the fundamental concepts of digital image processing, including digitization and display of images, manipulation of images to enhance or restore image detail, encoding (compression) of images, detection of edges and other object features in images, and the formation of computed tomography (CT) images. Introduces mathematical tools such as linear systems theory and Fourier analysis and uses them to motivate and explain these image processing techniques.

CS 5330 Pattern Recognition and Computer Vision

Prereq: Linear Algebra MS: Graphics

Introduces fundamental techniques for low-level and high-level computer vision. Examines image formation, early processing, boundary detection, image segmentation, texture analysis, shape from shading, photometric stereo, motion analysis via optic flow, object modeling, shape description, and object recognition (classification). Discusses models of human vision (gestalt effects, texture perception, subjective contours, visual illusions, apparent motion, mental rotations, cyclopean vision).

CS 6310 Computational Imaging

Prereq: CS 5320 or ECE G311 or permission of instructor MS: Graphics

Introduces the latest computational methods in digital imaging that overcome the traditional limitations of a camera and enable novel imaging applications. The course provides a practical guide to topics in image capture and manipulation methods for generating compelling pictures for computer graphics and for extracting scene properties for computer vision, with several examples.

CS 7380 Special Topics in Graphics/Image Processing
Prereq: permission of instructor.

Topics vary.

CS 7370 Seminar in Graphics/Image Processing (2 SH)
Prereq: Consent of instructor MS: Graphics

Students will read and present various survey and research papers in Graphics and Image Processing. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

NETWORKS

CS 5700 Fundamentals of Networking and Internetworking

Prereq: undergraduate probability theory MS: Netwk PhD: Netwk

Studies network protocols and architectures. Discusses issues of performance evaluation of computer networks including performance metrics, evaluation tools and methodology, simulation techniques and limitations. Presents the abstract network design and evaluation issues in the context of the Internet. Topics include: performance analysis of medium access control protocol, error detection techniques and automatic repeat request algorithms; sliding window and reliable/ordered services, queuing disciplines including FQ and WFQ, spanning tree and learning bridges, shortest path routing, flow control schemes such as window flow control and leaky bucket rate control schemes, congestion control, quality of service, and fairness. Internet protocols, such as TCP, UDP and others are used as examples to demonstrate how internetworking is realized. Includes programming assignments.

CS 6710 Wireless Networks

Prereq: CS 5700 or permission of instructor MS: Network

Covers both theoretical issues related to wireless networking and practical systems for both wireless data networks and cellular wireless telecommunication systems. Topics covered include fundamentals of radio communications, channel multiple access schemes, wireless local area networks, routing in multi-hop Ad-hoc wireless networks, mobile IP, and TCP improvements for wireless links, cellular telecommunication systems and quality of service in the context of wireless networks. Requires a project that addresses some recent research issues in wireless and mobile networking.

CS 6740 Network Security

Prereq: CS 5700 (CS 6750 is strongly recommended).

Studies the theory and practice of computer security, focusing on the security aspects of multi-user systems and the internet. Introduces cryptographic tools such as encryption, key exchange, hashing and digital signatures in terms of their applicability to maintaining network security. Discusses security protocols for mobile networks. Topics include: firewalls, viruses, Trojan horses, password security, biometrics, VPNs, internet protocols such as SSL, IPSec, PGP, SNMP and others.

CS 6750 Cryptography and Communication Security [see theory]

Prereq: CS 5800/CS 7800 (or taken concurrently) MS: Netwk, Theory, Info Sec

Studies the design and use of cryptographic systems for communications and other applications such as e-commerce. Discusses the history of cryptographic systems, the mathematical theory behind the design, their vulnerability and the different cryptanalytic attacks. Topics include: stream ciphers such as shift register sequences; block ciphers such as DES and AES; public-key systems such as RSA, Discrete Logarithms; signature schemes; hash functions such as MD5 and SHA1; protocol schemes such as Identification schemes, Zero-Knowledge proofs, Authentication schemes and Secret Sharing schemes. Key management problems including Needham-Schroeder protocols and certificates will be discussed.

CS 6760 Privacy, Security and Usability

Prereq: CS 5600 or CS 7600

Usability and security are widely seen as two antagonistic design goals for complex computer systems. This course challenges convention wisdom and encourages students to discover ways that security, privacy and usability can be made synergistic in system design. Topics include computer forensics, network forensics, user interface design, backups, logging, economic factors affecting adoption of security technology, trust management and related public policy. Case studies such as PGP, S/MIME, SSL will be used. Basic cryptography and hash functions will be introduced as it is needed. Coursework includes analysis of papers, problem sets, and a substantial term project.

CS 7780 Special Topics in Networks

Prereq: CS 5700 or permission of instructor. MS: Netwk
Topics vary.

CS 7770 Seminar in Computer Networks (2 SH)

Prereq: CS 5700 or permission of instructor.

Students will read and present various survey and research papers in Computer Networks. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

CS 7775 Seminar in Computer Security (2 SH)

Prereq: CS 6750 or permission of instructor.

Students will read and present various survey and research papers in cryptography and computer security. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

PROGRAMMING LANGUAGES

CS 5400 Principles of Programming Languages

Prereq: CS 5010 or permission of instructor

Studies the basic components of programming languages; specification of syntax and semantics; and description and implementation of programming language features. Discusses examples from a variety of languages.

CS 6510 Advanced Software Development
Prereq: CS 5400/CS 7400 MS: PL, SE PhD: PL, SE

Presents current ideas and techniques in software methodology and provides a means for students to apply these techniques. Students will be expected to design, implement, test, and document a software project.

CS 6410 Compilers
Prereq: CS 5400/CS 7400 MS: PL PhD: PL

Each student will write a small compiler. Topics include parser generation, abstract syntax trees, symbol tables, type checking, generation of intermediate code, simple code improvement, register allocation, run-time structures, and code generation.

CS 6412 Semantics of Programming Languages
Prereq: CS 5400/CS 7400 and discrete mathematics MS: PL PhD: PL
Studies mathematical models for the behavior of programming languages. Operational, denotational, and equational specifications. Lambda-calculi and their properties. Applications of these techniques, such as rapid prototyping and correctness of program optimizations.

CS 7480 Special Topics in Programming Languages
Prereq: CS 5400/CS 7400 or permission of instructor. MS: PL
Topics vary.

CS 7470 Seminar in Programming Languages (2 SH)

Prereq: CS 5400/CS 7400 or permission of instructor.

Students will read and present various survey and research papers in Programming Languages. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

CS 7570 Seminar in Software Development (2 SH)

Prereq: CS 5500/CS 6510 or permission of instructor.

Students will read and present various survey and research papers in Software Development. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

SOFTWARE ENGINEERING

CS 5610 Web Development MS: SE

Discusses web development for sites that are dynamic, data-driven, and interactive. Focuses on the software development issues of integrating multiple languages, assorted data technologies, and web interaction. Considers ASP.NET, C#, HTTP, HTML, CCS, XML, XSLT, Javascript, AJAX, RSS/Atom, SQL and web services. Each student must deploy individually designed web experiments that illustrate the web technologies and at least one major integrative web site project. Students may work as a team with the permission of the instructor. Each student or team must also create extensive documentation of their goals, plans, design decisions, accomplishments, and user guidelines. All source files must be open and be automatically served by a sources server.

CS 6520 Methods of Software Development MS: SE

Studies concepts of object-oriented programming that forms the basis for components (e.g., generic programming, programming by contracts, programming with metaclasses), software architecture for supporting components (e.g., implicit invocation, filters, reflection), and the concrete realizations of components in some industrial standards (e.g., JavaBeans, EJB, CORBA, COM/DCOM). Selected topics in component research will also be covered. Students will do a project where some creation, deployment, and evolution methods of software components are applied.

CS 6530 Analysis of Software Artifacts

Prereq: CS 5500 MS: SE

Addresses all kinds of software artifacts - specifications, designs, code, etc. - and will cover both traditional analyses, such as verification and testing, and promising new approaches, such as model checking, abstract execution and new type systems. The focus will be the analysis of function (for finding errors in artifacts and to support maintenance and reverse engineering), but the course will also address other kinds of analysis (such as performance and security).

CS 6540 Foundations of Formal Methods and Software Analysis
Prereq: CS 5500/CS 6520 MS: SE

Covers necessary mathematical background such as first-order logic, and some measure theory. Studies the formal methods in more depth and breadth. Discusses the current state of the art in verification and semantics of probabilistic, real-time, and hybrid systems.

CS 6510 Advanced Software Development [see programming languages p.32]

CS 7580 Special Topics in Software Engineering
Prereq: CS 5500/CS 6520 or permission of instructor. MS: SE
Topics vary.

CS 7575 Seminar in Software Engineering (2 SH)

Prereq: CS 5500/CS 6520 or permission of instructor.

Students will read and present various survey and research papers in Software Engineering. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

SYSTEMS

CS 5620 Computer Architecture
Prereq: CS 5600/CS 7600 or permission of instructor. MS: Systems

Studies the design of digital computer system components, including the CPU, the memory subsystem, and interconnection busses and networks. Explores modern design techniques for increasing computer system capacity. Emphasizes the growing gap between CPU and RAM speed, and the parallel operation of the growing number of functional units in a CPU. Topics include pipelining, cache, new CPU architecture models, memory bandwidth and latency, multiprocessing and parallel processing architectures, cache coherence, and memory consistency.

CS 6610 Parallel Computing
Prereq: CS 5600/CS 7600 and CS 5800/CS 7800 MS: Systems, Theory

Studies the principles of parallel processing, a variety of parallel computer architecture models, including SIMD, MIMD, dataflow, systolic arrays, and network of workstations, and algorithms for parallel computation on the various models. Topics include interconnection network design, memory organization, cache and bus design, processor technologies, algorithms for sorting, combinatorial, and numerical problems, graph algorithms, matrix multiplication, and FFT, and the mapping of these algorithms to different architectures.

CS 5650 Research in High Performance Computing
Prereq: CS 5600/CS 7600 and permission of instructor. MS: Systems

Introduces students to research in the domain of High Performance Computing. Each instance of this course will cover a single topic with broad open questions. The required systems background needed to investigate these questions will be covered in the first part of the course. Then, working in teams, students will have an opportunity to address different aspects of the open questions so that in combination the entire class may learn more than any single team could accomplish. Example topics include: use of new hardware such as GPU's on video boards; use of new software tools for multi-core computing; development of check-pointing packages for more robust long computations; software for GUI window systems; and cloud computing.
CS 6740 Network Security [see network p.30]

CS 7680 Special Topics in Computer Systems

Prereq: CS 5600/CS 7600 or permission of instructor. MS: Systems
Topics vary.

CS 7670 Seminar in Computer Systems (2 SH)

Prereq: CS 5600/CS 7600 or permission of instructor.

Students will read and present various survey and research papers in Computer Systems. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

THEORY

CS 6800 Applications of Information Theory to Computer Science
Prereq: undergraduate probability theory and/or permission of instructor
MS: Theory

This course serves as an introduction to Information Theory and its applications to various computational disciplines: the basic concepts of Information Theory are covered, including entropy, relative entropy, mutual information, and the asymptotic equipartition property. The course will concentrate on applications of Information Theory to computer science and computational disciplines, including compression, coding, Markov chains, machine learning, information retrieval, statistics, computational linguistics, computational biology, wired and wireless networks, and image and speech processing. The course is self-contained; no prior knowledge of Information Theory is required or assumed.

CS 6810 Distributed Algorithms
Prereq: CS 5800/CS 7800 or permission of instructor. MS: Theory

Covers the design and analysis of algorithms and problems arising in distributed systems, with emphasis on network algorithms. The main concerns are efficiency of computation and communication, fault tolerance, and asynchrony. Topics include leader election, graph algorithms, datalink protocols, packet routing, logical synchronization and clock synchronization, resource allocation, self-stabilization of network protocols, graph partitions.

***CS 7805* Theory of Computation** [see PhD core p.25]

***CS 6750* Cryptography and Comunication Security** [see network p.30]

***CS 6610* Parallel Computing** [see systems p.34]

CS 7880 Special Topics in Theoretical Computer Science
Prereq: CS 5800/CS 7800 or permission of instructor. MS: Theory

Topics vary. Possible areas are advanced cryptography, approximation algorithms, computational algebra, formal verification, network algorithms, online computation, parallel computing, and randomness and computation.
CS 7870 Seminar in Theoretical Computer Science (2 SH)

Prereq: CS 5800/CS 7800 or permission of instructor.

Students will read and present various survey and research papers in Theoretical Computer Science. Faculty supervisor and topics will vary from semester to semester. May be repeated for credit for PhD students.

READINGS, PROJECTS, AND THESIS

CS 8982 MS Readings and Research in Computer Science *(may be taken for 2 to 4 credit hours /per course, with approval of the Graduate School)*
Prereq: permission of instructor.
Selected readings under the supervision of a faculty member

CS 8674 Master's Project in Computer Science
Prereq: completion of 16 semester hours and agreement of a project supervisor.
Selected project under the supervision of a faculty member.

CS 7990 Master's Thesis in Computer Science

Prereq: agreement of a thesis supervisor. May be repeated for credit.

CS 7996 Master's Thesis Continuation (0 SH)
Prereq: at least 8 credit hours of CS7990 or agreement of a thesis supervisor.

CS 8949 Research Work Experience (0 SH)
Prereq: PhD students only
The purpose of this course is to provide an opportunity for all doctoral students to engage in industry research in the area of their dissertation. Doctoral students will register for this course before starting their off campus internships.

CS 8984 PhD Readings and Research in Computer Science

Prereq: permission of instructor.

Selected readings under the supervision of a faculty member

CS 9990 PhD Thesis in Computer Science

Prereq: PhD candidate

CS 9996 PhD Thesis Continuation

Prereq: at least 2 semesters of CS 9990

COOP

CS 6964 Co-op (no credit is given)

Students participating in the Cooperative Education Program must register for this course every semester while on Co-op.

APPROVED ELECTIVES

At most 8 semester credit hours of the following IA courses can be counted towards MS CS.

IA 5200 Security Risk Management and Assessment
Prereq: IA 5010 or taken concurrently or permission of instructor. MS: Info Sec

Creates a competency in the development of information security policies and plans including controls for physical, software and networks. Discusses different malicious attacks, such as viruses and Trojan horses, detection strategies, countermeasures, damage assessment and control. Covers information system risk analysis and management, audits and log files. Uses case studies, site visits and works with commercial products.

IA 5210 Information System Forensics

Prereq: IA 5010 or taken concurrently or permission of instructor. MS: Info Sec

Designed to allow students to explore the techniques used in computer forensic examinations. Examines computer hardware, physical and logical disk structure and computer forensic techniques. Hands-on experiences will be conducted on DOS, Windows operating systems, Macintosh, Novell, and Unix/Linux platforms. Students will build on basic computer skills and gain hands-on experience with the tools and techniques to investigate, seize and analyze computer based evidence using a variety of specialized forensic software in an IBM-PC environment.

IA 5240 Ethics, Privacy and Digital Rights

Prereq: IA 5010 or taken concurrently or permission of instructor. MS: Info Sec

Understand the legal and ethical issues associated with information security including access, use and dissemination. Emphasis on legal infrastructure relating to information assurance such as the Digital Millenium Copyright Act and Telecommunications Decency Act, and emerging technologies for management of digital rights. Examine the role of information security in various domains such as healthcare, scientific research, personal communications such as email. Examine criminal activities such as computer fraud and abuse, desktop forgery, embezzlement, child-pornography, computer trespass, and computer piracy.

10. THE UNIVERSITY AND THE COLLEGE

Northeastern University, founded in 1898, offers a wide variety of curricula through six undergraduate colleges and two schools, nine graduate and professional schools, two part-time undergraduate divisions, and a number of continuing and special education programs and institutes. Northeastern is one of the largest private universities in the country, with approximately 14,000 full-time and 500 part-time undergraduates, and 2,200 full-time and 1,600 part-time graduate students. The world leader in cooperative education, it offers a program that gives students the opportunity to integrate their studies with actual experience in educational, vocational, and cultural learning situations outside the formal classroom.

Since its inception, the college has recognized the importance of developing and maintaining a strong working relationship with leaders in the computer industry. The involvement and guidance of managers and scientists from computer and high-technology companies in Boston and around the nation has spurred the growth of the University's research and its professional training programs. The college facilitates and encourages industrial collaboration and corporate sponsorship of students. Companies with which the college has collaborated include IBM, the MITRE Corporation, BBN, and Draper Laboratories.

CAMPUS AND COMMUNITY

Northeastern University is located in Boston, a leading scientific, educational and cultural center. Over fifty degree-granting institutions are located within a 25-mile radius. Surrounding the University are many of Boston's cultural, educational, and historic centers. Within walking distance are many fine restaurants and hotels, in addition to the Museum of Fine Arts, the Boston Public Library, Symphony Hall, and Fenway Park.

STUDENT GROUP

The Graduate School of the College of Computer and Information Science offered its first classes in the fall of 1984. As of the 2004-2005 academic year, the College had 103 full- and part-time MS students, 63 PhD students, and 12 special students.

TUITION AND FEES

The College of Computer and Information Science operates on a semester system. All courses are four semester hour courses, except as noted. Tuition for the 2008-2009 academic year is $1,110 per semester-hour.

All full-time students, including those with assistantships and fellowships, pay a nonrefundable University Health Service fee of approximately $1600 per year for health insurance coverage. Payment of this fee also entitles the student to medical care provided by the University Health Service. The majority of this fee may be waived with proof of current personal health insurance coverage.

In addition, there is a one-time fee of $100 charged to new graduate international students, payable upon acceptance to Northeastern.

For a complete listing of tuition costs for the 2008-2009 academic year, please refer to http://www.neu.edu/registrar/billing-tuition0809.html. For information regarding all other fees, please visit http://www.neu.edu/registrar/billing-fees0809.html

Tuition statements are mailed to students by the Customer Service Center. Checks should be made payable to Northeastern University on or before the date specified on the tuition statement. All financial obligations to the University must be fulfilled prior to graduation.

HOUSING

Accommodations in a University apartment, designed for two, three, or four students, are available on a first-come, first-served basis. Room and board expenses may vary according to the facility assigned to the student. Further information is available from the Director of Residential Life, 4 Speare Place, Boston, MA 02115, or at www.housing.neu.edu In addition, there are many privately owned apartments for rent throughout the Boston area. Please refer to http://commuter.neu.edu for information on off campus housing.

ADDITIONAL NORTHEASTERN INFORMATION

The *Northeastern University College of Computer and Information Science Graduate Program Guidebook* should be used in conjunction with the *Undergraduate Catalog, Graduate Student Handbook, Cooperative Education Handbook,* and other procedural guides that contain Northeastern University's primary statements about academic programs, policies, and procedures; degree requirements; student responsibilities; student academics

and cocurricular life; faculty rights and responsibilities; and general personnel policies, benefits, and services.

ACCREDITATION

Northeastern University is accredited by the New England Association of Schools and Colleges, Inc., which accredits schools and colleges in the six New England states. Accreditation by the association indicates that the institution has been carefully evaluated and found to meet standards agreed upon by qualified educators.

DELIVERY OF SERVICES

Northeastern University assumes no liability for delay or failure to provide educational or other services or facilities due to causes beyond its reasonable control. Causes include, without limitation, power failure, fire, strikes by University employees or others, damage by natural elements, and acts of public authorities. The University will, however, exert reasonable efforts, when it judges them to be appropriate, to provide comparable services, facilities, or performance; but its inability or failure to do so shall not subject the University to liability.

EQUAL OPPORTUNITY EMPLOYMENT POLICY

Northeastern University does not discriminate on the basis of race, color, religion, sex, sexual orientation, age, national origin, disability, or veteran status in admission to, access to, treatment in, or employment in its programs and activities. In addition, Northeastern University will not condone any form of sexual harassment. Handbooks containing the University's nondiscrimination policies and its grievance procedures are available in the Office of Affirmative Action and Diversity. Inquiries regarding the University's nondiscrimination policies may be directed to:

Office of Affirmative Action
424 Columbus Place
Northeastern University
Boston, Massachusetts 02115
617.373.2133

Inquiries concerning the application of nondiscrimination policies may also be referred to the Regional Director, Office for Civil Rights, United States

Department of Education, J.W. McCormack Building, Post Office Court House, Room 222, Boston, Massachusetts 02109-4557.

FAMILY EDUCATIONAL RIGHTS AND PRIVACY ACT

In accordance with the Family Educational Rights and Privacy Act of 1974, Northeastern University permits its students to inspect their records wherever appropriate and to challenge specific parts of them when they feel it is necessary to do so. Specific details of the law as it applies to the University are printed in the Undergraduate and Graduate Student Handbook and are distributed annually at registration for the University's colleges and graduate schools.

INSUFFICIENT ENROLLMENT DISCLAIMER

Northeastern University reserves the right to cancel any course if minimum enrollments, appropriate faculty, or academic facilities are unavailable to meet standards.

TUITION AND FEE POLICY

Tuition rates, all fees, rules and regulations, and courses and course content are subject to revision by the president and the Board of Trustees at any time.

TUITION DEFAULT POLICY

In cases where the student defaults on his or her tuition, the student shall be liable for the outstanding tuition and all reasonable associated collection costs incurred by the University, including attorneys' fees.

CLEARY ACT

Northeastern is committed to assisting all members of the University community in providing for their own safety and security. Information regarding campus security and personal safety, including topics such as crime prevention, University police law enforcement authority, crime reporting policies, crime statistics for the most recent three-year period, and disciplinary procedures, is available upon request from the Northeastern University Director of Public Safety, 360 Huntington Avenue, Boston, MA 02115, or by calling 617.373.2696.