

The Graduate Program in Computer Science

Academic Year 2008-2009



Department of Computer Science
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A. INTRODUCTION AND WELCOME

This document is for graduate students enrolled in Computer Science. It specifies the department's academic requirements. It also covers policies and procedures relevant to graduate student life, and provides other contact information. While this information may be of interest to students applying for admission, this document does not cover the admission process. See the department's web site (<http://www.cs.iastate.edu>) for information about admissions.

If you are new to Iowa State, welcome! As you will discover, Iowa State University is a major land grant university located in Ames, Iowa. Ames is a pleasant, small, yet cosmopolitan, city with a population of 50,000 (25,000 students). Ames has a vibrant cultural scene, and a secondary school system that ranks one of the best in the United States.

In the department of Computer Science, it is our goal to help you achieve excellence in research and scholarship. The Department of Computer Science has strong, world-renowned research programs with a faculty rich in diversity, breadth and depth of research opportunities. We stress both theoretical and experimental methods for solving fundamental as well as practical problems.

In addition to our department's own laboratories, students can take part in many other research opportunities. These include the Laurence H. Baker Center for Bioinformatics and Computational Biology (BCB), (www.bioinformatics.iastate.edu), the Center for Computational Intelligence, Learning, and Discovery (www.cild.iastate.edu), the Center for Integrative Animal Genomics (www.ciag.iastate.edu), the Department of Energy's Ames Laboratory (www.external.ameslab.gov), the Information Systems Security Laboratory, (<http://www.iac.iastate.edu/IAC/>), and the Virtual Reality Applications Center (www.vrac.iastate.edu). The department also participates in interdisciplinary graduate programs in: Bioinformatics and Computational Biology (www.bcb.iastate.edu), Information Assurance (www.iac.iastate.edu/EDU/masters.html), Human Computer Interaction (www.hci.iastate.edu), and Neuroscience (www.neuroscience.iastate.edu). All of these provide a stimulating academic environment that nurtures leading-edge research and innovative education in Computer Science. Students interested in pursuing these opportunities should apply for admission to the respective interdepartmental program as well.

The Department of Computer Science offers a Master of Science (MS) and Doctor of Philosophy (Ph.D.) degree. The first MS degree in Computer Science at Iowa State University was awarded in 1959 and the first Ph.D. in 1962. MS students typically complete degree requirements in 2 years. Ph.D. students can complete their degree in 4 years. The MS graduates of our program typically pursue employment in industry whereas most of the Ph.D. graduates typically take up faculty positions in academia or opportunities in industrial research laboratories.

B. GRADUATE STUDENT CONTACTS

B.1.1. Graduate Secretary

Ms. Linda Dutton, 213 Atanasoff Hall, grad_adm@cs.iastate.edu, 515-294-8361.

The graduate secretary can help answer questions and provide general assistance to getting along in graduate school. The graduate secretary has graduate college forms that are not available on the web. All forms should be submitted to the graduate secretary, who will secure the DOGE's signature, and forward forms to the graduate college on your behalf.

B.1.2. Director of Graduate Education (DOGE)

Dr. Wallapak Tavanapong, 232 Atanasoff Hall, tavanapo@cs.iastate.edu, 515-294-2987

All aspects of graduate studies are overseen by the DOGE. The DOGE approves various forms for the department. The department's Graduate Committee, comprised of faculty members and a graduate student representative, is chaired by the DOGE and is responsible for the department's academic policies.

B.1.3. Department Executive Officers

Dr. Carl K. Chang, Chair, 226 Atanasoff Hall, chang@cs.iastate.edu, 515-294-4377

Dr. Johnny Wong, Associate Chair, 202 Atanasoff Hall, wong@cs.iastate.edu, 515-294-2586

Dr. Shashi Gadia, Associate Chair, 203 Atanasoff Hall, gadia@cs.iastate.edu, 515-294-2253

B.1.4. Graduate Advisory Committee (GAC)

<http://www.cs.iastate.edu/~gac/>

The GAC is a volunteer group run by graduate students in the department. These experienced graduate students can help and give advice on all topics.

C. GRADUATE PROGRAM OVERVIEW

Graduate degrees obtainable through the Computer Science Department are the M.S. degree (with thesis) and the Ph.D.

C.1. DEGREE REQUIREMENTS

To obtain a degree, students must satisfy two sets of requirements:

- (a) Graduate College requirements and
- (b) Computer Science departmental requirements.

The Graduate College requirements are detailed in the following documents.

- *The Graduate College Handbook*
<http://www.grad-college.iastate.edu/publications/gchandbook/homepage.html>
- *The Graduate College Thesis Requirements*
<http://www.grad-college.iastate.edu/thesis/homepage.html>

The Computer Science department's requirements are summarized below, in section D.

C.2. GRADUATE ADVISOR

Upon admission, all students will work with the faculty members of the Graduate Committee, who will assist with academic matters.

During the first year of study, you will choose a faculty member¹ (with his or her consent), to be your *major professor*. The major professor will serve as your primary academic advisor and the chair of your program of study (POS) committee (see below). Besides supervising your academic program and research, your advisor can be of general assistance to you. Please consult with your advisor when you have questions, problems, or need help in any matter. You should make an appointment with your advisor each semester prior to course registration, to go over your plan of study and review your academic progress.

Selecting a major professor is perhaps one of the most important steps in making progress towards your degree. Students should not feel pressured to make a final decision about their future major professor until they have had an opportunity to interact with, and explore research opportunities in several laboratories or research groups. Many faculty members like to know a student reasonably well before they agree to accept the student into their research group. Participation in research seminars, research projects, or courses offered by professors can help both the student and the professor assess compatibility of their research interests, work habits, etc. that are essential for the success of a student-mentor relationship.

When a Computer Science faculty member agrees to serve as a student's major professor, the faculty member is expected to arrange assistantship support for the remainder of the student's degree program, as long as the student remains in good standing and is making good progress towards the degree. Very few professors are able to "guarantee" a specific source of graduate assistantship support for several years. It is important, therefore, for each student to take an active role in

¹ If appropriate, you may have two co-advisors.

discussing future assistantship funding with the major professor. Most students receive support as either a Research Assistant (RA) or a Teaching Assistant (TA), with funding supplied by the major professor and/or the department. In some cases, students receive support from other sources, such as scholarships, training grants, or competitive research assistantships.

C.3. PROGRAM OF STUDY (POS) COMMITTEE

The Program of Study (POS) committee is chaired by your advisor, and formally supervises your research; it officially approves your thesis or dissertation. Details on the composition of this committee vary with the degree, and are described below. Your advisor will help you choose the members of your committee to best suit your research. The committee is made official by filing a POS committee form.

The POS itself is a plan for what courses you will take to fulfill the degree requirements. It is agreed to by your POS committee and made official by filing a POS course form. Both forms should be filed by the end of your second semester of graduate study.

D. SATISFACTORY ACADEMIC PROGRESS

Each semester all student records are reviewed by the DOGE and Graduate Committee members to assess progress toward academic goals. In cases where progress appears to be inadequate or marginal, the major professor is invited to join the Graduate Committee to assist in developing a set of specific recommendations, which are then communicated to the student by the DOGE.

D.1.1. Satisfactory Academic Progress Towards a Ph.D.

- Choice of Major Professor to be made by May 1 (or December 1 if admitted in spring) during the first academic year of study in the graduate program.
- Program of Study (POS) Committee to be formed, and the POS form (listing the courses to be taken) by the end of the **third** semester of study in the graduate program.
- Research productivity. Requires evaluation by the major professor. Additional evidence of research productivity, e.g., publications, posters, manuscripts or technical reports, may be requested at the discretion of the Graduate Education Committee.
- Minimum GPA of 3.2 during the first year and cumulative GPA of 3.3 or above in courses that appear on the Program of Study.

D.1.2. Satisfactory Academic Progress Towards a M.S.

- Choice of Major Professor to be made by February 1 (or September 1 if admitted in spring) during the first academic year study in the graduate program.

- Program of Study (POS) Committee to be formed, and the POS form (listing the courses to be taken) by the end of the **second** semester of study in the graduate program.
- Research productivity. Requires evaluation by the major professor. Additional evidence of research productivity, e.g., publications, posters, manuscripts or technical reports, may be requested at the discretion of the Graduate Committee.
- Minimum GPA of 3.2 during the first year and cumulative GPA of 3.3 or above in courses that appear on the Program of Study.

E. GRADUATE DEGREE REQUIREMENTS

E.1. REQUIREMENTS FOR THE MS DEGREE

E.1.1. Admission Status: Full admission

Students entering with provisional or restricted admission will be upgraded to full admission once all requirements for full admission have been met.

E.1.2. Formation of POS Committee

It is the responsibility of each MS student to find members (especially the chair or co-chairs) for the POS committee and to complete the POS paperwork as soon as possible, but in no case later than the end of the **second** semester of graduate study. The master's POS committee consists of at least three (3) members of the graduate faculty. It must include two (2) members, including the major professor, from the major or program. The committee must include member(s) from different fields of emphasis so as to ensure diversity of perspectives. A term member of the graduate faculty may participate in the direction of a student's master's research as a co-major professor if a member of the graduate faculty serves as a co-major professor and jointly accepts responsibility for the direction of a program of study.

E.1.3. Course, Research and Credit Requirements

Each student's POS must include at least 31 credits—but no more than 36 credits—including the following:

a. Core Courses: 511, 531 (6 credits)²

b. Breadth Requirement: At least three (3) Computer Science graduate courses from at least two (2) of the breadth areas (9 credits) listed in the Ph.D. breadth requirements.

c. Thesis or Creative Component: One of the following options.

² INFAS students are only required to take 511 or 531 (but not both)

- i. Thesis Option:** Six (6) credits of research identified as Com S 699 culminating in the preparation of a thesis.
- ii. Creative Component Option:** Three (3) credits identified as Com S 599 culminating in a formal paper. The paper will be filed with the department as a technical report. (Note that this option is not available if you are admitted as a Ph.D. student or have Ph.D. student status in the department.)

Regardless of the option, a final oral examination is required. This examination focuses on the thesis or creative component.

- d. Electives:** Graduate course (9 credits) in Computer Science or other relevant discipline(s) (must be available for graduate minor credit). Computer Engineering courses must be 500-level or above. Computer Science courses must not include Com S 590, 690, and 699. At most, three (3) credits of Com S 610 can be counted for this requirement.
- e. Research Colloquia.** (1 Credit). Attend Computer Science Research Colloquia. Written summary is required. Offered on a satisfactory-failed basis. The course is intended for first-year graduate students in Computer Science to familiarize themselves with research in Computer Science and computing by attending colloquium series and thesis presentations offered by the department.

Subject to the following restrictions:

The POS must include at least three (3) credits in Computer Science at the 600-level (excluding 610 and 699).

E.1.4. Grade Requirements

- a. A grade of B- or better in each course in 2a.
- b. An average grade point of 3.0 or above over all the courses in 2a and 2b.
- c. A maximum of 2 C's (C, C+) and no grade below a C on the POS.

E.1.5. Research Requirements and Guidelines

Thesis:

- a. Effort involved should be approximately six (6) credit hours (Com S 699).
- b. A research topic should be chosen in consultation with the Major Professor. The result of the research must be an original contribution to the field of Computer Science and must include a thorough literature review.

c. A thesis must be written in the form prescribed by the Graduate College (See: <http://www.grad-college.iastate.edu/thesis/homepage.html>). A copy should be given to each member of the POS committee two (2) weeks prior to the final oral examination. The abstract of the thesis must be given to the graduate secretary at least one (1) week prior to the final oral examination.

Creative Component Paper:

- a. Creative effort is reflected in three (3) credits of Com S 599.
- b. The topic should be chosen in consultation with the Major Professor. It should be developed in terms of the current literature and written to exhibit the student's understanding of the issues.
- c. Final papers for creative components should be in a form suitable for publication. Emphasis is placed on clear writing, logical development, and significance of understanding.
- d. A copy of the paper should be given to each member of the POS committee two (2) weeks prior to the final oral examination. The abstract of the paper must be given to the graduate secretary at least one (1) week prior to the final oral examination. A completed copy of the paper must be filed with the department.

E.2. REQUIREMENTS FOR THE PH.D. DEGREE

The purpose of the Ph.D. program is to train students to conduct original research in Computer Science. Each student is required to attain knowledge and proficiency commensurate with a leadership role in Computer Science. The specific degree requirements are as follows:

E.2.1. Admission Status

Full admission to the Ph.D. program, is a prerequisite for pursuing a Ph.D. degree. Students entering with provisional or restricted admission need to have their status upgraded to full admission upon satisfying of all requirements for full admission.

E.2.2. Formation of POS Committee

It is the responsibility of each Ph.D. student to find members (especially the chair or co-chairs) for the POS committee and to complete the POS paperwork as soon as possible, but in no case later than the end of the **third** semester of graduate study.

The POS committee for a doctoral program consists of at least five (5) members of the graduate faculty. It must include at least three (3) members, including the major professor, from within the student's major or program. The committee must include member(s) from different fields of emphasis so as to ensure diversity of perspectives. A term member of the graduate faculty may participate in the direction of a student's dissertation research as a co-major professor if a member of the graduate faculty serves as a co-major professor and jointly accepts responsibility for direction of the dissertation.

E.2.3. Course, Research, and Credit Requirements

Each POS must include at least 72 credits in the program-related portion. Up to 36 credits from a student's master's degree can be applied to the POS³. Requirements including the following:

a. Core Courses: 511, 531 (6 credits); both with a grade of "B" or higher.

b. Breadth Requirement: One (1) Computer Science graduate course drawn from each of four (4) distinct areas in the following list, totaling 12 credits. (The courses Com S 511, 611, 531, 631, and 633 cannot be taken for this requirement.) Grades for all of the courses used for this requirement must be a "B" or higher.

- Architecture – Com S 581, 583, 681.
- Artificial Intelligence – Com S 572, 573, 574, 634, 672, 673.
- Bioinformatics and Computational Biology – Com S 544, 549, 550, 551, 567, 568, 569, 570, 594, 596.
- Database Systems – Com S 561, 562, 661.
- Distributed Computing and Networks – Com S 586, 587, 612, 686.
- Human-Computer Interaction (HCI) – Com S 557, 657, 558, 575.
- Operating Systems – Com S 552, 554, 652.
- Performance Analysis – Com S 555, 556.
- Parallel Computing – Com S 525, 526, 625, 626.
- Programming Languages – Com S 540, 541, 641.
- Robotics and Computational Methods – Com S 507, 509, 518, 577.
- Software Engineering – Com S 512, 515.
- Statistics 430.

c. Research: Minimum of 36 total research credits of which 24 must be completed under the supervision of the POS committee.

f. Electives: May include graduate courses in Computer Science or other relevant discipline(s). Courses must be available for graduate minor credit. A maximum of 17 credit hours of non-Computer Science courses can appear on the POS. Computer Engineering courses must be 500-level or above.

³Master's students should avoid putting more than the required number of credits on their POS to avoid problems with this rule.

g. Research Colloquia. (1 Credit). Attend Computer Science Research Colloquia. Written summary is required. Offered on a satisfactory-failed basis. The course is intended for first-year graduate students in Computer Science to familiarize themselves with research in Computer Science and computing by attending colloquium series and thesis presentations offered by the department.

Subject to the following restrictions:

- The POS must include at least 6 credits of Com S 600-level courses (excluding Com S 699 and including, at most, 3 credits of Com S 610).
- A maximum of 6 credits of Com S 590, 610 and 690 can appear on the POS.
- The POS committee must certify that either (1) the student has taken Stat 430, “Empirical Methods for Computer Science Research” or equivalent, or (2) that the student does not need this background.

E.2.4. Area Proficiency

Demonstrate a high level of proficiency in the chosen area of research. This can be accomplished by attaining a 3.5 GPA in three courses in the student’s area, all of which are completed at ISU. The POS committee is responsible for selecting the courses in the student’s area that can be used for this requirement. (The “student’s area” does not have to correspond exactly to one of the areas defined for the breadth requirement.)

E.2.5. Research Skills Requirement

Demonstrated proficiency in reading, writing, and speaking skills through *one* of the following:

a. Foreign Language. Demonstrated proficiency in foreign language by either earning a score equal to or better than the 50th percentile level score on the GSFLT foreign language examination or by one academic year of formal study in a foreign language at a grade of B or better. The student and his/her POS Committee should deem the choice of language relevant to the student’s area of research. English may be considered as a foreign language only for those students whose native tongue (other than English) is deemed an acceptable language for research.

b. English. Demonstrated proficiency in communication skills with a grade of B or better by taking a two semester sequence. The sequence will consist of English 314 and a 500-level course in either English or Journalism carrying graduate minor credit. These credits must be taken in addition to the 72 credit total.

c. Publication. Demonstrate proficiency in communication skills by publishing a paper in English, as the sole or major author, in a reputable computer journal or conference proceedings, with written reports from the referees. The student is encouraged to present a colloquium on this material to the Computer Science faculty and graduate students.

On the basis of the publication, the student's POS committee will decide if the research communication skills of the candidate are adequate or if the candidate would be well served by further development of these skills. In the former case, the manner in which the research communication skills have been satisfied are to be documented by the POS committee in the form of copies of:

- 1) the article, and
- 2) the referee reviews and letter of acceptance. This document is to be placed in the student's file.

E.2.6. Grade Requirement

The POS must include no more than two C's (C, C+) and no grade below a C.

E.2.7. Required Examinations

a. Preliminary Examination: The purpose of the Preliminary Examination is to ensure that the graduate student is prepared to pursue a significant, enduring program of original research. The area proficiency requirements must be completed prior to completing the preliminary exam.

Phase 1 of the preliminary examination is written. This portion of the examination contains the following components: an original research paper that is publishable in a refereed computer science journal. The student must be a sole or major author of any paper used. Papers that have already been published or that have been used to satisfy other requirements (e.g., M.S. research) are permissible, provided that they meet the stated criteria; OR, a comprehensive written examination on areas of Computer Science pertinent to the student's primary area of research and administered and judged by the POS committee.

Phase 2 is an oral presentation of the student's proposed Ph.D. research, including a description of relevant existing literature and the student's progress to date. This phase may also, at the discretion of the POS committee, include oral examination of Phase 1 material. Prior to scheduling the Preliminary Examination, each Ph.D. student must satisfy the Area Proficiency Requirement, form a POS Committee, and satisfy the Research Skills Requirement. Either phase of the preliminary examination may, with the approval of the POS committee, be retaken once.

b. Final Oral Examination. This examination is a defense of the dissertation.

E.2.8. Research and Dissertation Requirement

The most important component of the Ph.D. program is original research, culminating in the preparation of a Ph.D. dissertation. It is expected that each Ph.D. student's research will also lead to publications in refereed Computer Science conferences, journals, or as a book. The dissertation must satisfy the graduate college's requirements, see the graduate college's thesis requirements: <http://www.grad-college.iastate.edu/thesis/homepage.html>.

E.3. REQUIREMENTS FOR A CO-MAJOR AT THE PH.D. LEVEL

E.3.1. Course, Research, and Credit Requirements

- a. Core courses (6 credits): 511, 531; both with a grade of "B" or higher.
- b. Elective courses – Minimum of 21 credits. This must include one (1) Computer Science graduate course from each of four (4) distinct areas listed in the Ph.D. breadth requirements.
- c. At least three (3) credits of Com S 610.

Subject to the following restrictions:

- At least 36 credits, including dissertation research credits, must be earned under the supervision of the POS committee.
- The course credits (excluding Com S 590, 610, 690, 699) must add up to at least 36 credits.
- The POS must include at least 6 credits of COM S 600-level courses (excluding 699 and including, at most, three (3) credits of 610)
- A maximum of 6 credits of Com S 590, 610 and 690 can appear on the POS.

E.3.2. Grade requirements for the Ph.D.

No more than two C's (C, C+) and no grade below a C on the POS.

E.3.3. Required Examinations

a. Preliminary Examination: The purpose of the Preliminary Examination is to ensure that the graduate student is prepared to pursue a significant, enduring program of original research. The area proficiency requirements must be completed prior to completing the preliminary exam.

Phase 1 of the preliminary examination is written. This portion of the examination contains the following components: an original research paper that is publishable in a refereed computer science journal. The student must be a sole or major author of any paper used. Papers that have already been published or that have been used to satisfy other requirements (e.g., M.S. research) are permissible, provided that they meet the stated criteria; OR, a comprehensive written examination on areas of Computer Science pertinent to the student's primary area of research and administered and judged by the POS committee.

Phase 2 is an oral presentation of the student's proposed Ph.D. research, including a description of relevant existing literature and the student's progress to date. This phase may also, at the discretion of the POS committee, include oral examination of Phase 1 material.

Prior to scheduling the Preliminary Examination, each Ph.D. student must satisfy the Area Proficiency Requirement, form a POS Committee, and satisfy the Research Skills Requirement. Either phase of the preliminary examination may, with the approval of the POS committee, be retaken once.

b. Final Oral Examination. This examination is a defense of the dissertation.

E.3.4. Selection of Major Professor and POS

The graduate student will normally select a Major Professor and Co-major Professor graduate faculty member from each department. The POS Committee will consist of at least two members from each department and one member outside of both departments.

E.3.5. Research and Dissertation Requirement

The most important component of the Ph.D. program is original research, culminating in the preparation of a Ph.D. dissertation. It is expected that each Ph.D. student's research will also lead to publications in refereed journals. See the graduate college's thesis requirements for further details: <http://www.grad-college.iastate.edu/thesis/homepage.html>.

E.4. GRADUATE MINOR REQUIREMENTS

E.4.1. Minor Outside Computer Science

Computer Science graduate students may request a minor in another graduate program provided they:

- Receive permission and meet requirements of the minor department.
- Have a minor representative from the minor department on the POS committee
- Receive approval from the POS committee

Minor must be declared on the POS and listed on all pertinent paperwork.

E.4.2. Minor in Computer Science

Students pursuing graduate degrees in other disciplines can obtain a graduate minor in Computer Science. A graduate minor in Computer Science consists of at least 12 credits chosen from Com S 309, 311, 321, 330, 331, 342, 352, 362, 363, 401, 425, 430, 454, 455, 461, 472, 474, and Com S courses numbered 511 or above. The course selection must also satisfy the following conditions.

1. At most one of Com S 321, 330, 362 may be included in the 12-credit minimum.
2. At least 3 credits must be chosen from courses at or above the 400 level.
3. Excludes Com S 590, 599, 610, 690, & 699.

Any exceptions must be petitioned by the student's POS Committee and approved by the Graduate Committee. When a graduate student chooses a minor in Computer Science, one member of their Program of Study committee must be a faculty member from Computer Science.

F. COURSE DESCRIPTIONS

F.1. COURSES OPEN FOR NON-MAJOR GRADUATE CREDIT

Courses open for non-major graduate credit are: 309, 311, 321, 330, 331, 342, 352, 362, 363, 381, 401, 409, 412, 416, 417, 418, 425, 426, 430, 440, 454, 455, 461, 471, 472, 474, 477, 481.

COM S 309. Software Development Practices. (3-1) Cr. 3. F.S. *Prereq: Com S 228 with C- or better, Com S 229 or Cpr E 211, Engl 250.* A practical introduction to methods for managing software development. Process models, requirements analysis, structured and object-oriented design, coding, testing, maintenance, cost and schedule estimation, metrics. Programming projects. **Nonmajor Graduate Credit**

COM S 311. Design and Analysis of Algorithms. (3-1) Cr. 3. F.S. *Prereq: 228 with C- or*

better, Math 166, Engl 250, and Com S 330 or Cpr E 310. Basic techniques for design and analysis of efficient algorithms. Sorting, searching, graph algorithms, computational geometry, string processing and NP-completeness. Design techniques such as dynamic programming and the greedy method. Asymptotic, worst-case, average-case and amortized analyses. Data structures including heaps, hash tables, binary search trees and red-black trees. Programming projects. Credit may not be applied toward graduation for both Com S 311 and 381. **Nonmajor Graduate Credit**

COM S 319. Software Construction and User Interfaces. (Cross-listed with S E.) (3-0) Cr. 3. F. *Prereq: Com S 309.* Basic theory of grammars, parsing. Language paradigms. State transition and table-based software design. Rapid system prototyping. Review of principles of object orientation, object oriented analysis using UML. Event-driven and clock-driven simulation. Software construction methods. Frameworks and APIs. User interface architecture, evaluation of user interface. Design of windows, menus, and commands. Introduction to format specification and model-based software design. Introduction to domain-specific software engineering. **Nonmajor Graduate Credit**

COM S 321. Introduction to Computer Architecture and Machine-Level Programming. (3-1) Cr. 3. F.S. *Prereq: C- or higher in 228, Cpr E 210 and Engl 250.* Introduction to computer architecture and organization. Emphasis on evaluation of performance, instruction set architecture, datapath and control, memory-hierarchy design, and pipelining. Assembly language on a simulator. **Nonmajor Graduate Credit**

COM S 330. Discrete Computational Structures. (3-1) Cr. 3. F.S. *Prereq: C- or higher in 228, C- or higher in Math 166 and Engl 250.* Concepts in discrete mathematics as applied to computer science. Logic, proof techniques, set theory, relations, graphs, combinatorics, discrete probability and number theory. **Nonmajor Graduate Credit**

COM S 331. Theory of Computing. (Cross-listed with LING.) (3-1) Cr. 3. F.S. *Prereq: C- or higher in 228, C- or higher in Com S 330 or Cpr E 310, C- or higher in Math 166, and Engl 250.* Models of computation: finite state automata, pushdown automata and Turing machines. Study of grammars and their relation to automata. Limits of digital computation, unsolvability and Church-Turing thesis. Chomsky hierarchy and relations between classes of languages. **Nonmajor Graduate Credit**

COM S 342. Principles of Programming Languages. (3-1) Cr. 3. F.S. *Prereq: 321; 330 or Cpr E 310; either 309, 362 or 363; Engl 250.* Organization of programming languages emphasizing language design concepts and semantics. Study of language features and major programming paradigms, especially functional programming. Programming projects. **Nonmajor Graduate Credit**

COM S 350. Number Theory. (Cross-listed with MATH.) (3-0) Cr. 3. S. *Prereq: Math 307 or 317.* Divisibility, integer representations, primes and divisors, linear diophantine equations, congruences, and multiplicative functions. Applications to cryptography. **Nonmajor Graduate Credit**

COM S 352. Introduction to Operating Systems. (3-1) Cr. 3. F.S. *Prereq:* 321, and 362 or 363; *Engl* 250. Survey of operating system issues. Introduction to hardware and software components including: processors, peripherals, interrupts, management of processes, threads and memory, deadlocks, file systems, protection, virtual machines and system organization, and introduction to distributed operating systems. Programming projects. **Nonmajor Graduate Credit**

COM S 362. Object-Oriented Analysis and Design. (3-0) Cr. 3. F.S. *Prereq:* 228 with C- or better, *Engl* 250. Object-oriented requirements analysis and systems design. Design notations such as the Unified Modeling Language. Design Patterns. Group design and programming with large programming projects. **Nonmajor Graduate Credit**

COM S 363. Introduction to Database Management Systems. (3-0) Cr. 3. F.S. *Prereq:* 228 with C- or better, *Engl* 250. Relational, object-oriented, and semistructured data models and query languages. SQL, ODMG, and XML standards. Database design using entity-relationship model, data dependencies and object definition language. Application development in SQL-like languages and general purpose host languages with application program interfaces. Information integration using data warehouses, mediators and wrappers. Programming Projects. **Nonmajor Graduate Credit**

COM S 401. Projects in Computing and Business Applications. (2-2) Cr. 3. F. *Prereq:* *Engl* 250, *Sp Cm* 212, *Com S* 309, and either 362 or 363. Applications of software development methods (requirements collection and analysis, software design, project management, documentation and testing), programming techniques, database designs and administration, network application programming to solve computing needs in business settings. A study of practical applications of emerging technologies in computing. Emphasis on semester-long team programming projects. Lab assignments. Oral and written reports. **Nonmajor Graduate Credit**

COM S 409. Software Requirements Engineering. Dual-listed with 509; (Cross-listed with S E.) (3-0) Cr. 3. F. *Prereq:* *Com S* 309, *Engl* 250, *Sp Cm* 212. The requirements engineering process, including identification of stakeholders, requirements elicitation techniques such as interviews and prototyping, analysis fundamentals, requirements specification, and validation. Use of Models: State-oriented, Function-oriented, and Object-oriented. Documentation for Software Requirements. Informal, semi-formal, and formal representations. Structural, informational, and behavioral requirements. Non-functional requirements. Use of requirements repositories to manage and track requirements through the life cycle. Case studies, software projects, written reports, and oral presentations will be required. **Nonmajor Graduate Credit**

COM S 412. Formal Aspects of Specification and Verification. (Cross-listed with CPR E, S E.) (3-0) Cr. 3. *Prereq:* *Com S* 309, 319. Introduction to propositional/predicate/temporal logic, program verification using theorem proving, model-based verification using model checking, and tools for verification. **Nonmajor Graduate Credit**

COM S 417. Software Testing. (Cross-listed with S E.) (3-0) Cr. 3. S. *Prereq:* *Com S* 309, 319, *Engl* 250, *Sp Cm* 212. Comprehensive study of software testing, principles, methodologies,

management strategies and techniques. Test models, test design techniques (black box and white-box testing techniques), integration, regression, system testing methods, and software testing tools. **Nonmajor Graduate Credit**

COM S 418. Introduction to Computational Geometry. Dual-listed with 518; (3-0) Cr. 3. Alt. S., offered 2010. *Prereq: 311 or permission of instructor.* Introduction to data structures, algorithms, and analysis techniques for computational problems that involve geometry. Line segment intersection, polygon triangulation, 2D linear programming, range queries, point location, arrangements and duality, Voronoi diagrams and Delaunay triangulation, convex hulls, robot motion planning, visibility graphs. Other selected topics. Programming assignments. **Nonmajor Graduate Credit**

COM S 421. Logic for Mathematics and Computer Science. (Cross-listed with MATH.) (3-0) Cr. 3. S. *Prereq: Math 301 or 307 or 317 or Com S 330.* Propositional and predicate logic. Topics selected from Horn logic, equational logic, resolution and unification, foundations of logic programming, reasoning about programs, program specification and verification, model checking and binary decision diagrams. **Nonmajor Graduate Credit**

COM S 425. High Performance Computing for Scientific and Engineering Applications. (Cross-listed with CPR E.) (3-1) Cr. 3. S. *Prereq: 311, 330, Engl 250, Sp Cm 212.* Introduction to high performance computing platforms including parallel computers and workstation clusters. Discussion of parallel architectures, performance, programming models, and software development issues. Sample applications from science and engineering. Practical issues in high performance computing will be emphasized via a number of programming projects using a variety of programming models and case studies. Oral and written reports. **Nonmajor Graduate Credit**

COM S 426. Introduction to Parallel Algorithms and Programming. Dual-listed with 526; (Cross-listed with CPR E.) (3-2) Cr. 4. F. *Prereq: Cpr E 308 or Com S 321, Com S 311.* Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms. **Nonmajor Graduate Credit**

COM S 430. Advanced Programming Tools. (3-1) Cr. 3. F. *Prereq: 311, 362 or 363, Engl 250, Sp Cm 212.* Topics in advanced programming techniques and tools widely used by industry (e.g., event-driven programming and graphical user interfaces, standard libraries, client/server architectures and techniques for distributed applications). Emphasis on programming projects in a modern integrated development environment. Oral and written reports. **Nonmajor Graduate Credit**

COM S 433. Computational Models of Nanoscale Self-Assembly. Dual-listed with 533; (3-0) Cr. 3. S. *Prereq: C- or higher in 331 or consent of the instructor.* Modeling and analysis of natural and engineered systems that spontaneously assemble themselves from small components. Topics include biomolecular self-assembly, tile assembly models, computation via self-assembly, distributed folding, origami models, and self-repair. Emphasis on mathematical methods of describing, simulating, programming, and verifying the behaviors of self-assembling

systems. Graduate credit requires a written or oral report on current research. **Nonmajor Graduate Credit**

COM S 440. Principles and Practice of Compiling. Dual-listed with 540; (3-1) Cr. 3. Alt. S., offered 2011. *Prereq: 331, 342, Engl 250, Sp Cm 212.* Theory of compiling and implementation issues of programming languages. Programming projects leading to the construction of a compiler. Projects with different difficulty levels will be given for 440 and 540. Topics: lexical, syntax and semantic analyses, syntax-directed translation, runtime environment and library support. Written reports. **Nonmajor Graduate Credit**

COM S 444. Introduction to Bioinformatics. Dual-listed with 544; (Cross-listed with BCB, BIOL, CPR E, GEN.) (4-0) Cr. 4. F. *Prereq: Math 165 or Stat 401 or equivalent.* Broad overview of bioinformatics with a significant problem-solving component, including hands-on practice using computational tools to solve a variety of biological problems. Topics include: database searching, sequence alignment, gene prediction, RNA and protein structure prediction, construction of phylogenetic trees, comparative and functional genomics. **Nonmajor Graduate Credit**

COM S 454. Distributed and Network Operating Systems. Dual-listed with 554; (Cross-listed with CPR E.) (3-1) Cr. 3. Alt. S., offered 2011. *Prereq: 311, 352, Engl 250, Sp Cm 212.* Laboratory course dealing with practical issues of design and implementation of distributed and network operating systems and distributed computing environments (DCE). The client server paradigm, inter-process communications, layered communication protocols, synchronization and concurrency control, and distributed file systems. Graduate credit requires additional in-depth study of advanced operating systems. Written reports. **Nonmajor Graduate Credit**

COM S 455. Simulation: Algorithms and Implementation. Dual-listed with 555; (3-0) Cr. 3. Alt. F., offered 2010. *Prereq: 311 and 330, Stat 330, Engl 150, Sp Cm 212.* Introduction to discrete-event simulation with a focus on computer science applications, including performance evaluation of networks and distributed systems. Overview of algorithms and data structures necessary to implement simulation software. Discrete and continuous stochastic models, random number generation, elementary statistics, simulation of queuing and inventory systems, Monte Carlo simulation, point and interval parameter estimation. Graduate credit requires additional in-depth study of concepts. Oral and written reports. **Nonmajor Graduate Credit**

COM S 461. Principles and Internals of Database Systems. Dual-listed with 461; (3-1) Cr. 3. F. *Prereq: 311, Engl 250, Sp Cm 212 and Com S 363.* Models for structured and semistructured data. Algebraic, first order, and user-oriented query languages. Database schema design. Physical storage, access methods, and query processing. Transaction management, concurrency control, and crash recovery. Database security. Information integration using data warehouses, mediators, wrappers, and data mining. Parallel and distributed databases, and special purpose databases. Oral and written reports. **Nonmajor Graduate Credit**

COM S 471. Computational Linear Algebra and Fixed Point Iteration. (Cross-listed with MATH.) (3-0) Cr. 3. F.S. *Prereq: Math 265 and either Math 266, or 267; knowledge of a programming language.* Computational error, solutions of linear systems, least squares,

similarity methods for eigenvalues, solution of nonlinear equations in one and several variables.

Nonmajor Graduate Credit

COM S 472. Principles of Artificial Intelligence. Dual-listed with 572; (3-1) Cr. 3. F. *Prereq:* 311, 330 or Cpr E 310, Stat 330, Engl 250, Sp Cm 212, Com S 342 or comparable programming experience. Specification, design, implementation, and selected applications of intelligent software agents and multi-agent systems. Computational models of intelligent behavior, including problem solving, knowledge representation, reasoning, planning, decision making, learning, perception, action, communication and interaction. Reactive, deliberative, rational, adaptive, learning and communicative agents and multiagent systems. Artificial intelligence programming. Graduate credit requires a research project and a written report. Oral and written reports. **Nonmajor Graduate Credit**

COM S 474. Elements of Neural Computation. (3-1) Cr. 3. Alt. F., offered 2010. *Prereq:* 311, 330 or Cpr E 310, Stat 330, Math 165, Engl 250, Sp Cm 212, Com S 342 or comparable programming experience. Introduction to theory and applications of neural computation and computational neuroscience. Computational models of neurons and networks of neurons. Neural architectures for associative memory, knowledge representation, inference, pattern classification, function approximation, stochastic search, decision making, and behavior. Neural architectures and algorithms for learning including perceptions, support vector machines, kernel methods, bayesian learning, instance based learning, reinforcement learning, unsupervised learning, and related techniques. Applications in Artificial Intelligence and cognitive and neural modeling. Hands-on experience is emphasized through the use of simulation tools and laboratory projects. Oral and written reports. **Nonmajor Graduate Credit**

COM S 477. Problem Solving Techniques for Applied Computer Science. Dual-listed with 577; (3-0) Cr. 3. Alt. F., offered 2009. *Prereq:* 228; 330 or Cpr E 310, Math 166, Math 307 or Math 317, or consent of the instructor. Selected topics in applied mathematics and modern heuristics that have found applications in areas such as geometric modeling, graphics, robotics, vision, human machine interface, speech recognition, computer animation, etc. Polynomial interpolation, roots of polynomials, resultants, solution of linear and nonlinear equations, approximation, data fitting, fast Fourier transform, linear programming, nonlinear optimization, Lagrange multipliers, genetic algorithms, integration of ODEs, curves, curvature, Frenet Formulas, cubic splines, and Bezier curves. Programming components. Written report for graduate credit. **Nonmajor Graduate Credit**

COM S 481. Numerical Solution of Differential Equations and Interpolation. (Cross-listed with MATH.) (3-0) Cr. 3. S.SS. *Prereq:* Math 265 and either Math 266 or 267; knowledge of a programming language. Polynomial and spline interpolation, orthogonal polynomials, least squares, numerical differentiation and integration, numerical solution of ordinary differential equations. **Nonmajor Graduate Credit**

COM S 486. Fundamental Concepts in Computer Networking. (3-0) Cr. 3. S. *Prereq:* 352. An introduction to fundamental concepts in the design and implementation of computer communication in both the wired and wireless networks, their protocols, and applications.

Layered network architecture in the Internet, applications, transport, Socket APIs, network, and data link layers and their protocols, multimedia networking, and network security. **Nonmajor Graduate Credit**

F.2. PRIMARILY GRADUATE COURSES (OPEN TO QUALIFIED UNDERGRADUATES)

COM S 502. Complex Adaptive Systems Seminar. (Cross-listed with CAS.) (1-0) Cr. 1. F.S. *Prereq: Admissions to CAS minor.* Understanding core techniques in artificial life are based on basic readings in complex adaptive systems. Understand techniques of complex system analysis methods including: Evolutionary computation, Neural nets, Agent based simulations (Agent based Computational Economics). Large-scale simulations are to be emphasized, e.g. power grids, whole ecosystems.

COM S 503. Complex Adaptive Systems Concepts and Techniques. (Cross-listed with CAS.) (3-0) Cr. 3. S. *Prereq: Admission to CAS minor or related field.* Survey of complex systems and their analysis. Examples are drawn from engineering, computer science, biology, economics and physics.

COM S 509. Software Requirements Engineering. Dual-listed with 409; (3-0) Cr. 3. F. *Prereq: 309.* The requirements engineering process including identification of stakeholders requirements elicitation techniques such as interviews and prototyping, analysis fundamentals, requirements specification, and validation. Use of Models: State-oriented, Function-oriented, and Object-oriented. Documentation for Software Requirements. Informal, semi-formal, and formal representations. Structural, informational, and behavioral requirements. Non-functional requirements. Use of requirements repositories to manage and track requirements through the life cycle. Case studies, software projects, written reports, and oral presentations will be required.

COM S 511. Design and Analysis of Algorithms. (Cross-listed with CPR E.) (3-0) Cr. 3. F. *Prereq: Com S 311.* A study of basic algorithm design and analysis techniques. Advanced data structures, amortized analysis and randomized algorithms. Applications to sorting, graphs, and geometry. NP-completeness and approximation algorithms.

COM S 512. Formal Methods in Software Engineering. (3-0) Cr. 3. S. *Prereq: 311, 330.* A study of formal techniques for specification and verification of software systems. Topics include temporal logic, propositional and predicate logic, model checking, process algebra, theorem proving. Tools providing automated support for these techniques will also be discussed.

COM S 515. Software System Safety. (3-0) Cr. 3. F. *Prereq: 309 or 311, 342.* An introduction to the analysis, design, and testing of software for safety-critical and high-integrity systems. Analysis techniques, formal verification, fault identification and recovery, model checking, and certification issues. Emphasizes a case-based and systematic approach to software's role in safe systems.

COM S 518. Introduction to Computational Geometry. Dual-listed with 418; (3-0) Cr. 3. Alt. S., offered 2010. *Prereq: 311 or permission of instructor.* Introduction to data structures, algorithms, and analysis techniques for computational problems that involve geometry. Line segment intersection, polygon triangulation, 2D linear programming, range queries, point location, arrangements and duality, Voronoi diagrams and Delaunay triangulation, convex hulls, robot motion planning, visibility graphs. Other selected topics. Programming assignments. A scholarly report must be submitted for graduate credit.

COM S 525. Numerical Analysis of High Performance Computing. (Cross-listed with CPR E, MATH.) (3-0) Cr. 3. S. *Prereq: Cpr E 308, or one of Math 471, 481; experience in scientific programming; knowledge of FORTRAN or C.* Development, analysis, and testing of efficient numerical methods for use on current state-of-the-art high performance computers. Applications of the methods to the students' areas of research.

COM S 526. Introduction to Parallel Algorithms and Programming. Dual-listed with 426; (Cross-listed with CPR E.) (3-2) Cr. 4. F. *Prereq: Cpr E 308 or Com S 321, Com S 311.* Models of parallel computation, performance measures, basic parallel constructs and communication primitives, parallel programming using MPI, parallel algorithms for selected problems including sorting, matrix, tree and graph problems, fast Fourier transforms.

COM S 531. Theory of Computation. (3-0) Cr. 3. S. *Prereq: 331.* A systematic study of the fundamental models and analytical methods of theoretical computer science. Computability, the Church-Turing thesis, decidable and undecidable problems, and the elements of recursive function theory. Time complexity, logic, Boolean circuits, and NP-completeness. Role of randomness in computation.

COM S 533. Computational Models of Nanoscale Self-Assembly. Dual-listed with 433; (3-0) Cr. 3. S. *Prereq: C- or higher in 331 or consent of the instructor.* Modeling and analysis of natural and engineered systems that spontaneously assemble themselves from small components. Topics include biomolecular self-assembly, tile assembly models, computation via self-assembly, distributed folding, origami models, and self-repair. Emphasis on mathematical methods of describing, simulating, programming, and verifying the behaviors of self-assembling systems. Graduate credit requires a written or oral report on current research.

COM S 540. Principles and Practice of Compiling. Dual-listed with 440; (3-1) Cr. 3. Alt. S., offered 2011. *Prereq: 331, 342, Engl 250, Sp Cm 212.* Theory of compiling and implementation issues of programming languages. Programming projects leading to the construction of a compiler. Projects with different difficulty levels will be given for 440 and 540. Topics: lexical, syntax and semantic analyses, syntax-directed translation, runtime environment and library support. Written reports.

COM S 541. Programming Languages. (3-1) Cr. 3. F. *Prereq: 342 or 440.* Survey of the goals and problems of language design. Formal and informal studies of a wide variety of programming language features including type systems. Creative use of functional and declarative programming paradigms.

COM S 544. Introduction to Bioinformatics. Dual-listed with 444; (Cross-listed with BCB, CPR E, GDCB.) (4-0) Cr. 4. F. *Prereq: Math 165 or Stat 401 or equivalent.* Broad overview of bioinformatics with a significant problem-solving component, including hands-on practice using computational tools to solve a variety of biological problems. Topics include: database searching, sequence alignment, gene prediction, RNA and protein structure prediction, construction of phylogenetic trees, comparative and functional genomics.

COM S 549. Advanced Algorithms in Computational Biology. (Cross-listed with BCB, CPR E.) (3-0) Cr. 3. Alt. S., offered 2010. *Prereq: 311 and either 228 or 208.* Design and analysis of algorithms for applications in computational biology, pairwise and multiple sequence alignments, approximation algorithms, string algorithms including in-depth coverage of suffix trees, semi-numerical string algorithms, algorithms for selected problems in fragment assembly, phylogenetic trees and protein folding. No background in biology is assumed. Also useful as an advanced algorithms course in string processing.

COM S 550. Evolutionary Problems for Computational Biologists. (Cross-listed with BCB.) (3-0) Cr. 3. Alt. F., offered 2009. *Prereq: Com S 311 and some knowledge of programming.* Discussion and analysis of basic evolutionary principles and the necessary knowledge in computational biology to solve real world problems. Topics include character and distance based methods, phylogenetic tree distances, and consensus methods, and approaches to extract the necessary information from sequence-databases to build phylogenetic trees.

COM S 551. Computational Techniques for Genome Assembly and Analysis. (Cross-listed with BCB.) (3-0) Cr. 3. Alt. F., offered 2009. *Prereq: 311 and some knowledge of programming.* Huang. Introduction to practical sequence assembly and comparison techniques. Topics include global alignment, local alignment, overlapping alignment, banded alignment, linear-space alignment, word hashing, DNA-protein alignment, DNA-cDNA alignment, comparison of two sets of sequences, construction of contigs, and generation of consensus sequences. Focus on development of sequence assembly and comparison programs.

COM S 552. Principles of Operating Systems. (3-0) Cr. 3. Alt. S., offered 2010. *Prereq: 352.* A comparative study of high-level language facilities for process synchronization and communication. Formal analysis of deadlock, concurrency control and recovery. Protection issues including capability-based systems, access and flow control, encryption, and authentication. Additional topics chosen from distributed operating systems, soft real-time operating systems, and advanced security issues.

COM S 554. Distributed and Network Operating Systems. Dual-listed with 454; (Cross-listed with CPR E.) (3-1) Cr. 3. Alt. S., offered 2011. *Prereq: 311, 352.* Laboratory course dealing with practical issues of design and implementation of distributed and network operating systems and distributed computing environments (DCE). The client server paradigm, inter-process communications, layered communication protocols, synchronization and concurrency control, and distributed file systems. Graduate credit requires additional in-depth study of advanced operating systems. Written reports.

COM S 555. Simulation: Algorithms and Implementation. Dual-listed with 455; (3-0) Cr. 3. Alt. F., offered 2010. *Prereq: Com S 311 and 330, Stat 330.* Introduction to discrete-event simulation with a focus on computer science applications, including performance evaluation of networks and distributed systems. Overview of algorithms and data structures necessary to implement simulation software. Discrete and continuous stochastic models, random number generation, elementary statistics, simulation of queuing and inventory systems, Monte Carlo simulation, point and interval parameter estimation. Graduate credit requires additional in-depth study of concepts. Oral and written reports.

COM S 556. Analysis Algorithms for Stochastic Models. (3-0) Cr. 3. Alt. S., offered 2011. *Prereq: Com S 331, Math 307, and Stat 330.* Introduction to the use of stochastic models to study complex systems, including network communication and distributed systems. Data structures and algorithms for analyzing discrete-state models expressed in high-level formalisms. State space and reachability graph construction, model checking, Markov chain construction and numerical solution, computation of performance measures, product-form models, approximations, and advanced techniques.

COM S 557. Computer Graphics and Geometric Modeling. (Cross-listed with M E, CPR E.) (3-0) Cr. 3. F.S. *Prereq: 421, programming experience in C.* Fundamentals of computer graphics technology. Data structures. Parametric curve and surface modeling. Solid model representations. Applications in engineering design, analysis, and manufacturing.

COM S 558. Introduction to the 3D Visualization of Scientific Data. (Cross-listed with GEOL, HCI.) (2-2) Cr. 3. Alt. S., offered 2011. *Prereq: Graduate-student standing in the mathematical or natural sciences.* Introduction to visualizing scientific information with 3D computer graphics and their foundation in human perception. Overview of different visualization techniques and examples of 3D visualization projects from different disciplines (natural sciences, medicine, engineering). Class project in interactive 3D visualization using the OpenDX, VTK or a similar system.

COM S 561. Principles and Internals of Database Systems. Dual-listed with 461; (3-1) Cr. 3. F. *Prereq: Graduation classification..* Models for structured and semistructured data. Algebraic, first order, and user-oriented query languages. Database schema design. Physical storage, access methods, and query processing. Transaction management, concurrency control, and crash recovery. Database security. Information integration using data warehouses, mediators, wrappers, and data mining. Parallel and distributed databases, and special purpose databases. Oral and written reports. Satisfactory Fail Only

COM S 562. Implementation of Database Systems. (3-0) Cr. 3. F. *Prereq: 461 or 561.* Implementation topics and projects are chosen from the following: Storage architecture, buffer management and caching, access methods, design, parsing and compilation of query languages and update operations, application programming interfaces (APIs), user interfaces, query optimization and processing, and transaction management for relational, object-oriented, semistructured (XML), and special purpose database models; client-server architectures, metadata and middleware for database integration, web databases.

COM S 567. Bioinformatics I (Fundamentals of Genome Informatics). (Cross-listed with BCB, CPR E.) (3-0) Cr. 3. F. *Prereq:* Com S 208; Com S 330; Stat 341; credit or enrollment in Biol 315, Stat 430. Biology as an information science. Review of algorithms and information processing. Generative models for sequences. String algorithms. Pairwise sequence alignment. Multiple sequence alignment. Searching sequence databases. Genome sequence assembly.

COM S 568. Bioinformatics II (Advanced Genome Informatics). (Cross-listed with BCB, GDCB, STAT.) (3-0) Cr. 3. S. *Prereq:* BCB 567, BBMB 301, Biol 315, Stat 430, credit or enrollment in Gen 411. Advanced sequence models. Basic methods in molecular phylogeny. Hidden Markov models. Genome annotation. DNA and protein motifs. Introduction to gene expression analysis.

COM S 569. Bioinformatics III (Structural Genome Informatics). (Cross-listed with BBMB, BCB, MATH, CPR E.) (3-0) Cr. 3. F. *Prereq:* BCB 567, Gen 411, Stat 430. Algorithmic and statistical approaches in structural genomics including protein, DNA and RNA structure. Structure determination, refinement, representation, comparison, visualization, and modeling. Analysis and prediction of protein secondary and tertiary structure, disorder, protein cores and surfaces, protein-protein and protein-nucleic acid interactions, protein localization and function.

COM S 570. Bioinformatics IV (Computational Functional Genomics and Systems Biology). (Cross-listed with BCB, GDCB, STAT, CPR E.) (3-0) Cr. 3. S. *Prereq:* BCB 567, Biol 315, Com S 311 and either 208 or 228, Gen 411, Stat 430. Algorithmic and statistical approaches in computational functional genomics and systems biology. Analysis of high throughput gene expression, proteomics, and other datasets obtained using system-wide measurements. Topological analysis, module discovery, and comparative analysis of gene and protein networks. Modeling, analysis, simulation and inference of transcriptional regulatory modules and networks, protein-protein interaction networks, metabolic networks, cells and systems: Dynamic systems, Boolean, and probabilistic models. Ontology-driven, network based, and probabilistic approaches to information integration.

COM S 572. Principles of Artificial Intelligence. Dual-listed with 472; (3-1) Cr. 3. F. *Prereq:* 311, 331, Stat 330, Com S 342 or comparable programming experience. Specification, design, implementation, and selected applications of intelligent software agents and multi-agent systems. Computational models of intelligent behavior, including problem solving, knowledge representation, reasoning, planning, decision making, learning, perception, action, communication and interaction. Reactive, deliberative, rational, adaptive, learning and communicative agents. Artificial intelligence programming. Graduate credit requires a research project and a written report. Oral and written reports.

COM S 573. Machine Learning. (3-1) Cr. 3. S. *Prereq:* 311, 362, Stat 330. Algorithmic models of learning. Design, analysis, implementation and applications of learning algorithms. Learning of concepts, classification rules, functions, relations, grammars, probability distributions, value functions, models, skills, behaviors and programs. Agents that learn from observation, examples, instruction, induction, deduction, reinforcement and interaction. Computational learning theory. Data mining and knowledge discovery using artificial neural networks, support vector machines, decision trees, Bayesian networks, association rules, dimensionality reduction, feature selection

and visualization. Learning from heterogeneous, distributed, dynamic data and knowledge sources. Learning in multi-agent systems. Selected applications in automated knowledge acquisition, pattern recognition, program synthesis, bioinformatics and Internet-based information systems. Oral and written reports.

COM S 574. Intelligent Multiagent Systems. (3-0) Cr. 3. Alt. F., offered 2009. *Prereq:* *Stat 330, Com S 331, Com S 572 or Com S 573 or Com S 472 or Com S 474.* Specification, design, implementation, and applications of multi-agent systems. Intelligent agent architectures; infrastructures, languages and tools for design and implementation of distributed multi-agent systems; Multi-agent organizations, communication, interaction, cooperation, team formation, negotiation, competition, and learning. Selected topics in decision theory, game theory, contract theory, bargaining theory, auction theory, and organizational theory. Selected topics in knowledge representation and ontologies. Agent-based systems and the Semantic Web. Applications in distributed intelligent information networks for information retrieval, information integration, inference, and discovery from heterogeneous, autonomous, distributed, dynamic information sources.

COM S 575. Computational Perception. (Cross-listed with CPR E, HCI.) (3-0) Cr. 3. S. *Prereq:* *Graduate standing or permission of instructor.* This class covers statistical and algorithmic methods for sensing, recognizing, and interpreting the activities of people by a computer. This semester we will focus on machine perception techniques that facilitate and augment human-computer interaction. The main goal of the class is to introduce computational perception on both theoretical and practical levels. You will work in small groups to design, implement, and evaluate a prototype of a human-computer interaction system that uses one or more of the techniques covered in the lectures.

COM S 577. Problem Solving Techniques for Applied Computer Science. Dual-listed with 477; (3-0) Cr. 3. Alt. F., offered 2009. *Prereq:* *228; 330 or Cpr E 310, Math 166, Math 307 or Math 317, or consent of the instructor.* Selected topics in applied mathematics and modern heuristics that have found applications in areas such as geometric modeling, graphics, robotics, vision, human machine interface, speech recognition, computer animation, etc. Homogeneous coordinates and transformations, perspective projection, quaternions and rotations, polynomial interpolation, roots of polynomials, resultants, solution of linear and nonlinear equations, approximation, data fitting, Fourier series and fast Fourier transform, linear programming, nonlinear optimization, Lagrange multipliers, parametric and algebraic curves, curvature, Frenet formulas, Bezier curves. Programming components. A scholarly report is required for graduate credit.

COM S 581. Computer Systems Architecture. (Cross-listed with CPR E.) (3-0) Cr. 3. F. *Prereq:* *Cpr E 381.* Quantitative principles of computer architecture design, instruction set design, processor architecture: pipelining and superscalar design, instruction level parallelism, memory organization: cache and virtual memory systems, multiprocessor architecture, cache coherency, interconnection networks and message routing, I/O devices and peripherals.

COM S 583. Reconfigurable Computing Systems. (Cross-listed with CPR E.) (3-0) Cr. 3. *Prereq:* *Background in computer architecture, design, and organization.* Introduction to

reconfigurable computing, FPGA technology and architectures, spatial computing architectures such as systolic and bit serial adaptive network architectures, static and dynamic rearrangeable interconnection architectures, processor architectures incorporating reconfigurability.

COM S 586. Computer Network Architectures. (3-0) Cr. 3. F. *Prereq: 511, 552 or Cpr E 489.*

Design and implementation of computer communication networks: layered network architectures, local area networks, data link protocols, distributed routing, transport services, network programming interfaces, network applications, error control, flow/congestion control, interconnection of heterogeneous networks, TCP/IP, ATM networks, multimedia communications, IP and application multicast, overlay networks, network security and web computing.

COM S 587. Principles of Distributed and Network Programming. (3-0) Cr. 3. F. *Prereq: 352 or Cpr E 489 or equivalent.* Programming paradigms for building modern distributed applications, including multithreaded client-server programming, distributed object frameworks and programming languages. Directory services. Web-based computing. Mobile computing. Peer-to-Peer computing. Network multimedia applications. Reliability and manageability of networked systems, including aspects of distributed system security, verification of concurrent systems, and network management.

COM S 590. Special Topics. Cr. arr. Repeatable. *Prereq: Permission of instructor.*
Satisfactory Fail Only

COM S 592. Research Colloquia. Cr. 1. F.S. *Prereq: Graduation classification.* Attend Computer Science Research Colloquia. Written summary is required. Offered on a satisfactory-failed basis.

COM S 596. Genomic Data Processing. (Cross-listed with BCB, GDCB.) (3-0) Cr. 3. F. *Prereq: Some knowledge of programming.* Study the practical aspects of genomic data processing with an emphasis on hand-on projects. Students will carry out major data processing steps using bioinformatics tools. Topics include base-calling, raw sequence cleaning and contaminant removal; shotgun assembly procedures and EST clustering methods; genome closure strategies and practices; sequence homology search and function prediction; annotation and submission of GenBank reports; and data collection and dissemination through the Internet. Useful post-genomic topics like microarray design and data analysis will also be covered.

COM S 596. Genomic Data Processing. (Cross-listed with BCB, GDCB.) (3-0) Cr. 3. F. *Prereq: Some knowledge of programming.* Study the practical aspects of genomic data processing with an emphasis on hand-on projects. Students will carry out major data processing steps using bioinformatics tools. Topics include base-calling, raw sequence cleaning and contaminant removal; shotgun assembly procedures and EST clustering methods; genome closure strategies and practices; sequence homology search and function prediction; annotation and submission of GenBank reports; and data collection and dissemination through the Internet. Useful post-genomic topics like microarray design and data analysis will also be covered.

Com S 598. Computer Science Internship. Cr. R. F.S.SS. Prereq: permission of the Director of Graduate Education (DOGE), graduate classification. Work experience in professional setting appropriate to the student's degree program.

COM S 599. Creative Component. Cr. 1-3. Creative component for nonthesis option of Master of Science degree. Satisfactory Fail Only

F.3. ADVANCED GRADUATE COURSES

COM S 610. Seminar. Cr. arr. Satisfactory Fail Only

COM S 611. Advanced Topics in Analysis of Algorithms. (3-0) Cr. 3. Repeatable. Alt. S., offered 2011. *Prereq: 511, 531.* Advanced algorithm analysis and design techniques. Topics include graph algorithms, algebraic algorithms, number-theoretic algorithms, randomized and parallel algorithms. Intractable problems and NP-completeness. Advanced data structures.

COM S 612. Distributed Algorithms. (3-0) Cr. 3. Alt. S., offered 2010. *Prereq: 511 or 531.* The theory of distributed computation. Algorithms, lower bounds and impossibility results. Leader Elections, mutual exclusion, consensus and clock synchronization algorithms. Synchronous, asynchronous and partially synchronous distributed systems models. Shared memory and message passing systems. Fault-tolerance and randomization. Broadcast and multicast. Wait-free object simulations. Distributed shared memory.

COM S 625. Issues in Parallel Programming and Performance. (3-0) Cr. 3. Alt. S., offered 2011. *Prereq: 511.* Parallel solutions of numerical and non-numerical problems, implementation of parallel programs on parallel machines, performance and other computational issues in parallel programming.

COM S 626. Parallel Algorithms for Scientific Applications. (Cross-listed with CPR E.) (3-0) Cr. 3. *Prereq: 526.* Algorithm design for high-performance computing. Applications to finite-element and finite difference methods for numerical simulations, sparse matrix computation, multidimensional tree data structure and particle-based methods, random numbers and Monte Carlo applications, algorithms for computational biology.

COM S 631. Advanced Topics in Computational Complexity. (3-0) Cr. 3. Repeatable. Alt. F., offered 2010. *Prereq: 531.* Advanced study in the quantitative theory of computation. Time and space complexity of algorithmic problems. The structure of P, NP, PH, PSPACE, and other complexity classes, especially with respect to resource-bounded reducibilities and complete problems. Complexity relative to auxiliary information, including oracle computation and relativized classes, randomized algorithms, advice machines, Boolean circuits. Kolmogorov complexity and randomness.

COM S 633. Advanced Topics in Computational Randomness. (3-0) Cr. 3. Repeatable. Alt. F., offered 2009. *Prereq: 531.* Advanced study of the role of randomness in computation. Randomized algorithms, derandomization, and probabilistic complexity classes. Kolmogorov

complexity, algorithmic information theory, and algorithmic randomness. Applications chosen from cryptography, interactive proof systems, computational learning, lower bound arguments, mathematical logic, and the organization of complex systems.

COM S 634. Theory of Games, Knowledge and Uncertainty. (3-0) Cr. 3. Alt. S., offered 2011. *Prereq:* 330. Fundamentals of Game Theory: individual decision making, strategic and extensive games, mixed strategies, backward induction, Nash and other equilibrium concepts. Discussion of Auctions and Bargaining. Repeated, Bayesian and evolutionary games. Interactive Epistemology: reasoning about knowledge in multiagent environment, properties of knowledge, agreements, and common knowledge. Reasoning about and representing uncertainty, probabilities, and beliefs. Uncertainty in multiagent environments. Aspects and applications of game theory, knowledge, and uncertainty in other areas, especially Artificial Intelligence and Economics, will be discussed.

COM S 641. Advanced Topics in Programming Language Semantics. (3-0) Cr. 3. Repeatable. Alt. S., offered 2010. *Prereq:* 531, 541. Operational and other mathematical models of programming language semantics. Type systems and their soundness. Applications of semantics on areas such as program correctness, language design or translation.

COM S 652. Advanced Topics in Distributed Operating Systems. (3-0) Cr. 3. Repeatable. Alt. F., offered 2009. *Prereq:* 552. Concepts and techniques for network and distributed operating systems: Communications protocols, processes and threads, name and object management, synchronization, consistency and replications for consistent distributed data, fault tolerance, protection and security, distributed file systems, design of reliable software, performance analysis.

COM S 657. Advanced Topics in Computer Graphics. (3-0) Cr. 3. Alt. F., offered 2010. *Prereq:* 228, IE/ME/CPR E/COM S 557. Modern lighting models: Rendering Equation, Spherical Harmonics, Lafortune, Cook-Torrance. Non-polygonal primitives: volumes, points, particles. Textures: filtering, reflections creation. Graphics hardware: pipeline, performance issues, programmability in vertex and fragment path. Per-pixel lighting. Nonphotorealistic rendering. Radiosity; Ray tracing.

COM S 661. Advanced Topics in Database Systems. (3-0) Cr. 3. Repeatable. Alt. F., offered 2010. *Prereq:* 461 or 561. Advanced topics chosen from the following: database design, data models, query systems, query optimization, incomplete information, logic and databases, multimedia databases; temporal, spatial and belief databases, semistructured data, concurrency control, parallel and distributed databases, information retrieval, data warehouses, wrappers, mediators, and data mining.

COM S 672. Advanced Topics in Computational Models of Learning. (3-0) Cr. 3. Repeatable. Alt. S., offered 2010. *Prereq:* Com S 572 or 573 or 472 or 474. Selected topics in Computational Learning Theory (PAC learning, Sample complexity, VC Dimension, Occam Learning, Boosting, active learning, Kolomogorov Complexity, Learning under helpful distributions, Mistake Bound Analysis). Selected topics in Bayesian and Information Theoretic

Models (ML, MAP, MDL, MML). Advanced statistical methods for machine learning. Selected topics in reinforcement learning.

COM S 673. Advanced Topics in Computational Intelligence. (3-0) Cr. 3. Repeatable. Alt. S., offered 2011. *Prereq:* Com S 572 or 573 or 472 or 474. Advanced applications of artificial intelligence in bioinformatics, distributed intelligent information networks and the Semantic Web. Selected topics in distributed learning, incremental learning, multi-task learning, multi-strategy learning; Graphical models, multi-relational learning, and causal inference; statistical natural language processing; modeling the internet and the web; automated scientific discovery; neural and cognitive modeling.

COM S 681. Advanced Topics in Computer Architecture. (Cross-listed with CPR E.) (3-0) Cr. 3. Alt. S., offered 2011. *Prereq:* 581. Current topics in computer architecture design and implementation. Advanced pipelining, cache and memory design techniques. Interaction of algorithms with architecture models and implementations. Tradeoffs in architecture models and implementations.

COM S 686. Advanced Topics in High-Speed Networks. (3-0) Cr. 3. Alt. S., offered 2010. *Prereq:* 586. Advanced topics in IP networks and optical networks. QoS routing and scheduling, multicast, multiprotocol label switching (MPLS), traffic engineering. Optical network architectures, routing and wavelength assignment algorithms, optical multicast, traffic grooming, optical burst switching, lightpath protection/restoration schemes, and IP over WDM.

COM S 699. Research. Cr. arr. Repeatable. *Prereq:* Approval of instructor. Satisfactory Fail Only

G. POLICIES AND PROCEDURES

G.1. PETITIONS AND EXCEPTIONS

Exceptions to policies regulations may be approved by the graduate committee. Requests for exceptions must clearly state the rationale for the exception and what alternate procedure will be completed to satisfy the requirements. This must be in writing from the student, approved by the student's POS committee, and submitted to the Graduate Committee representing the departmental graduate faculty.

RETURNING FOR A PH.D.

Students aspiring to return to graduate study for a Ph.D. after having left the graduate program upon receiving their MS degree must satisfy the following criteria:

- GPA over 3.5 during their previous graduate study in Computer Science at ISU.
- Recommended to continue for Ph.D. by POS Committee at M.S. Final Defense
- Support of their potential major professor who submitted request to the DOGE.

Assistantship support for students returning for a Ph.D. is not guaranteed.

G.2. SWITCHING FROM PH.D. TO MS

Students who are admitted to the Ph.D. program and who later wish to transfer to the M.S. program must make the transfer concomitant with selection of a major professor (before the start of the second year). Students will be financially responsible for their education after the transfer. Transfers after the first year require approval of the CS Graduate Committee.

G.3. FUNDING

G.3.1. Overview of Funding

The department of Computer Science will make its best effort to provide support through a combination of fellowships, teaching assistantships (TA) and research assistantships (RA) to all Ph.D. and M.S. students who are making satisfactory progress in the degree program into which they were admitted. (The department makes no commitments regarding continued support of students originally admitted into the Ph.D. program if they change their degree objective from Ph.D. to M.S).

Graduate assistants are employed for ¼-time (10 hours per week), 1/3 time (15 hours per week) or ½-time (20 hours per week). These assistantships are limited and awarded on a competitive

basis. Reappointment eligibility is based on academic progress, performance evaluation, and availability of funds.

International students should contact the International Student and Scholar Services (ISS) for specifics regarding employment related to their visa http://www.iastate.edu/~internat_info.

The maximum number of departmental support given is:

- Four (4) semesters of support prior to completing the M.S. requirements
- Seven (7) semesters before the Ph.D. Preliminary Examination is passed
- Ten (10) semesters before the Ph.D. is granted
- To be eligible for financial support beyond the M.S. degree, the following criteria must be satisfied:
 1. cumulative GPA of at least 3.5 in Computer Science graduate courses,
 2. recommendation by POS committee for continuation toward the Ph.D.,
 3. recommendation for continuation by a Computer Science professor directing the student's Ph.D. research.

The Graduate Committee requires a memo from student and major professor requesting special permission for continued funding if time limits are exceeded. This memo should include: estimated time to completion of degree, why extra time is required, and research plan. Not all requests are granted.

G.3.2. Fellowships

Qualified US citizens and permanent residents may be nominated for fellowships and traineeships offered by NSF and NIH funded training programs at ISU (e.g., the Integrative Graduate Education and Research Training (IGERT) program in Bioinformatics (www.igert.iastate.edu)).

Highly-qualified graduate students may be nominated for fellowships offered by various organizations (e.g., IBM, Pioneer Hi-Bred, NSF, NIH, DOE, NASA).

The stipend and other benefits associated with such fellowships are typically determined by the funding source.

G.3.3. Stipends (TA or RA)

- Pre-M.S. -- \$1,450/month
- Post-M.S. -- \$1,500/month

There are two ways for a student to qualify for Post M.S. stipends in Computer Science.

1. The successful completion of the M.S. oral defense and submission of a thesis.
 2. The successful completion of the M.S. degree requirements (minimum of 24 course credits, 6 hours of research), and a completed original research paper that is either published, or in the judgment of the POS committee, publishable, in a refereed Computer Science venue. The major professor will notify the graduate student office via email of satisfactory completion and stipend change.
- Post-PH.D. Preliminary Exam -- \$1,550/month.

Students qualify for the post Ph.D. preliminary stipend by successfully completing the Ph.D. Preliminary Examination.

G.4. TERMINATION OF APPOINTMENT

One or more of the following may be grounds for termination of appointment:

A. Failure to maintain the stipulated cumulative grade point average (3.0) set by the Graduate College for appointment. The assistant will be dismissed at the end of the semester in which notice of academic probation is received, but the grace period may be extended for a specified period of time by an agreement between the DOGE and the Graduate Dean.

B. Failure to comply with graduate student responsibilities.

C. Personal conduct seriously prejudicial to the university, including violation of the Regents' "Uniform Rules of Personal Conduct" and general university regulations.

D. Neglect of duty or incompetence.

G.5. CRITERIA FOR RENEWAL OF ASSISTANTSHIPS (TA, RA)

G.5.1. Criteria for Renewal of TA Appointments

Decisions concerning continuing TA appointments are made by the Department Chair, in consultation with the DOGE and with input from faculty. Prerequisites for continuing TA appointment are:

- (a) **Satisfactory Academic Progress** – It is certified by the DOGE / Graduate Committee.
- (b) **Satisfactory performance of assigned TA responsibilities** – It is determined by the Chair based on written evaluations from TA supervisors, student evaluation, and other appropriate form of input. Graduate students must submit complete GTA applications before the deadline in order to be considered.

- (c) **English proficiency** – Applicants must achieve Level 1 SPEAK-TEACH test rating for students who have been in the program for at least 2 years, and level 2 for all others.
- (d) **Timely progress towards degree** - It is expected that Ph.D. students will successfully defend their dissertations by the 10th semester of study in the graduate program and M.S. students will defend their thesis by the end of the 4th semester of study in the graduate program.
- (e) **Application for renewal of TA appointment** – Application must be completed before the departmental deadline for applications for renewal of TA appointments).

In rare cases, students who fail to meet some of the above criteria may be offered renewal of TA appointment, subject to availability of funds, at the discretion of the department chair, in consultation with the DOGE, provided one or more of the following criteria are met:

- (a) **Exceptional research productivity** (as evident from publication of research papers in refereed conferences and journals) or **research potential** (in the case of students who have been in the program for less than 2 years)
- (b) **Endorsement from Major Professor**
- (c) **Ability to assist in a broad range of courses taught in the department**
- (d) **Match with specific teaching needs of the department**
- (e) **Exceptionally good TA evaluations**
- (f) **Specific Request from Instructor for a specific course**
- (g) **Extenuating circumstances**

G.5.2. Criteria for Renewal of RA Appointments

Decisions concerning continuing RA appointments are typically made by the research supervisor, **subject to availability of funds**. Prerequisites for renewal of RA appointment are:

- (a) **Satisfactory Academic Progress** (as certified by the DOGE / Graduate Committee).
- (b) **Satisfactory performance of assigned RA responsibilities** - determined by the research supervisor
- (c) **Timely progress towards degree** - It is expected that Ph.D. students will successfully defend their dissertations by the 10th semester of study in the graduate program and M.S. students will defend their thesis by the end of the 4th semester of study in the graduate program.

In rare cases, students who fail to meet some of the above criteria may be offered renewal of RA appointment at the discretion of the research supervisor provided one or more of the following criteria are met:

- (d) **Exceptional research productivity** (as evident from publication of research papers in refereed conferences and journals)
- (e) **Endorsement of the POS committee**
- (f) **Extenuating circumstances**

REGISTRATION, FEE ASSESSMENT, AND WITHDRAWAL PROCEDURES

G.5.3. Registration

All students who attend classes at ISU must register and pay assessed tuition and fees. The ISU [Schedule of Classes](#) is the official source of information about registration and fee payment for all students at ISU and may be found:

- on the ISU Office of Registrar's [World Wide Web site](#) and,
- in department and college offices.

Specific dates for registration are listed:

- on the Registrar's [web page](#),
- on the University Calendar,
- in the ISU [Schedule of Classes](#),
- in the [Iowa State Daily](#), and
- on many department bulletin boards.

Registration for summer session should be completed during the spring, at the same time as registration for fall semester. All students are encouraged to register for courses on the web through AccessPlus. Detailed instructions are provided in the ISU [Schedule of Classes](#) and on the ISU Office of Registrar's [World Wide Web site](#).

G.5.4. Audit Registration

Audit registration means taking courses without receiving formal credit. The audit policy provisions are as follows:

- Instructors must approve ALL audits.
- Students must register for audits by day 10 of the semester.
- Changes to or from an audit must be made in the first 10 days of the semester.
- Students are assessed tuition and fees as though they were taking the course for credit.
- The course DOES NOT count in determining full-time student status.

Audited courses do not appear on the student's permanent record unless the "[Request for Audit\(s\) to Appear on Transcript](#)" form is completed and signed by the student, course instructor, and major professor. Copies of this form, which are available from the Graduate College, must

be filed with the Graduate College, Pearson Hall. (For a list of other Graduate College forms, see [Appendix B](#) or check the Graduate College's [web site](#).) After the fifth class day, if a student changes a regular course to an audit, that course will appear on his/her permanent record as a drop. Audits are not acceptable as registration for loan deferments.

G.6. TUITION AND FEES

G.6.1. Graduate Students on Assistantship

Fee Assessment. Graduate assistants must register and pay tuition and fees for each term in which they hold an appointment for more than five class days. (See [Credit Load Limitations](#))

State of Iowa students with graduate assistantships:

- 1/4 time or more for three months (six weeks in the summer) or more are assessed Iowa resident tuition and may earn a Graduate College tuition scholarship.
- 1/4 time or more for more than five class days but less than three months (six weeks in the summer) are assessed tuition by the credit hour and are **not** eligible for a Graduate College tuition scholarship.

Nonresident students (non-Iowa students and nonresident aliens) with graduate assistantships:

- 1/4 time or more for three months (six weeks in the summer) or more
 - retain their non-residency classification,
 - are assessed resident tuition as long as the graduate assistantship is continued, and
 - may earn a Graduate College tuition scholarship.
- 1/4 time or more for more than five class days but less than three months (six weeks in the summer)
 - retain their non-residency classification,
 - are assessed tuition by the credit hour, and
 - are **not eligible** for a Graduate College tuition scholarship

Students on **restricted admission** status or **probation** may be appointed to an assistantship on a term basis but are **not eligible** for a Graduate College tuition scholarship.

G.6.2. Graduate Students on Fellowship

Graduate students receiving fellowships that provide for payment of tuition and/or fees are assessed the full-time rate in accordance with their residency status. Assistantship support provided to such students is considered to be supplemental income, so fee reduction and the Graduate College tuition scholarship normally associated with assistantship support do not apply.

G.6.3. Graduate Students on Other Appointments

Graduate students appointed as instructors, research associates, postdoctoral research associates, or assistant professors are approved by the Office of the Registrar for state of Iowa residency and pay resident tuition according to the number of credit hours taken. Spouses of students holding any of these appointments are also approved for state of Iowa residency and pay the same resident tuition. Nonresident students (non-Iowa and nonresident aliens) with the above appointments and their spouses have the nonresident portion of their tuition waived only while the appointment is in effect. State of Iowa residency is not granted as a result of the graduate appointment.

G.6.4. Minimum Fee

The Iowa State Board of Regents has set the minimum fee for graduate registration at the rate for two credit hours. In circumstances where students must be registered for minimum credit hours (e.g., term of preliminary or final oral examinations), they will be charged tuition and fees for no less than the equivalent of two credits.

G.7. WITHDRAWAL FROM THE UNIVERSITY

Withdrawal is not permanent for graduate students; it always applies to a specific term. Reentry is activated when registration for a future term occurs. To withdraw for a specific term, a student must:

- complete a "Request for Withdrawal" form,
- have the form signed by the academic adviser or major professor, and
- submit the signed form to the classification officer in the Graduate College (Pearson Hall).

The effective date of the withdrawal is the date the form is signed by the classification officer in the Graduate College. The withdrawal slip is forwarded to the Office of the Registrar where it is recorded.

If the student completes the withdrawal procedure, no indication of the courses for which the student registered is placed on the permanent record. A notation of withdrawal and the withdrawal date are placed on a student's permanent record. Students who withdraw are not eligible for incompletes (I marks) during that term. Students who withdraw after completing first half-semester courses receive grades for those courses.

If these procedures for withdrawing from the university are not followed, the instructors of the courses involved will assign whatever grades or marks they consider appropriate. Since these grades may be Fs, the student who fails to follow the prescribed withdrawal procedures may adversely affect their ability to reenter later or transfer to another institution.

Students who withdraw before the first day of classes avoid tuition and fee assessment. Fee adjustments for those withdrawing after classes start will vary according to the detailed

instructions found in the fees and payment section in the ISU [Schedule of Classes](#) and [Tuition and Fees website](#). The [ISU Continuing and Distance Education Office](#) (102 Scheman, 515-294-6222) has a separate policy for off-campus courses.

G.8. CODE OF COMPUTER ETHICS

<http://www.cs.iastate.edu/documents/cs-ethics.html>

You, as a user of computer science computing facilities, are responsible for adhering to accepted standards of ethical behavior. Any unethical use of resources (information, software, hardware), either local to the department or externally accessible via computer networks, will be treated like any other ethical violation as outlined in the Student Information Handbook and in applicable faculty and staff handbooks.

Computer information (stored or in transit) should be treated with the same respect, integrity, and confidentiality as the written or spoken word. Viewing and using information (programs, files or other data) without authorized permission is an invasion of privacy. Such behavior, if used for academic gain, is considered plagiarism. Modifying information and preventing or delaying access to resources are considered acts of destruction. Ethical standards apply even when information is left unprotected. The following statements are general guidelines for ethical use of the computing resources.

All users of departmental computers must have an authorized account. Faculty, staff and computer science majors are provided with continuing accounts. Each non-major is provided with an account for the duration of the enrollment in specific computer science classes. Other accounts must be requested by an individual or sponsoring professor and must be authorized by a designated department administrator. Unless otherwise specified, each account becomes the sole responsibility of its owner and is to be used solely for authorized purposes. For example, student accounts are intended to be used for class assignments and other departmental-oriented activities that are consistent with obtaining an education in computer science. Use of an account by individuals other than the owner or use of an account on the behalf of other individuals is prohibited.

Users are expected to take reasonable precautions to guard against unauthorized use of their accounts or access to confidential information through careful selection of passwords and protection of files. (See [Guidelines to Password Selection and Maintenance](#) for guidelines on password selection and maintenance.)

Users must not browse, access, copy or change private or public files for which they clearly have no authorization. Also disallowed is the modification of the computer system, damage or alteration of software, and the copying of software specifically licensed for use by the department or university.

Because computing resources are limited, they should be used efficiently in order to minimize any adverse impact on others, e.g. game playing should not be excessive and must be avoided entirely whenever it negatively impacts the accessibility of the computing resources. Compute-intensive processes that are expected to execute for an extended period should be run at low priority. The use of invasive software, such as ``worms" and ``viruses" destructive to computer systems is illegal. Misuse, waste and/or the disruption of the intended use of resources is prohibited (e.g., the flooding of other users with excessive and/or unwanted information).

The installation and use of any program on departmental computers that provides a service to others on the network, or prolonged connections to (or extensive use of) external network services (e.g., http daemons, connection-maintaining daemons, IRC bots or those that appear to act in this manner) via departmental computers must be pre-authorized by the department.

Sending rude, obscene or harassing materials via any electronic means (e.g., electronic mail, bulletin boards, news groups) is forbidden. Also disallowed are random mailings, chain letters and general mailing of messages of commercial, religious, or political nature. Messages of philanthropic content are allowed only if sanctioned by the university.

Displaying material of a sexually explicit or suggestive nature can be considered intimidating, demeaning, hostile or offensive to others and is in violation of the Iowa State University Sexual Harassment Policy.

Hardware, software, manuals, supplies, etc. must not be removed from computing sites.

Abuse or misuse of resources will be regarded as illegal and/or unethical behavior. Any observed or suspected violations are to be reported to the instructor or appropriate department administrator.

Computer Science Department facilities are the property of Iowa State University and the State of Iowa and as such, their use is governed by departmental and university regulations and by state laws. Violators may be billed for illegal use and may be prosecuted under Chapter 716A, Computer Crime of the Iowa Code.

Adapted from the Iowa State University Computer Code of Ethics, the NSF Code of Ethics, the Internet Code of Ethics, September, 1995.