Department of Computer Science Electrical Engineering

UMKC 2007-08 Graduate and Professional Catalog (1.0)

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Contents

Department of Computer Science Electrical Engineering

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Curators' Professor:
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Assistant Professor Emeritus:
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Assistant Teaching Professors:
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Adjunct/Affiliate Faculty:
Charlie Bi (Children's Mercy Hospital), Mark Hoffman (Cerner), Jeff Rydberg-Cox (associate professor, English language and literature)

Description

The CSEE Department has about 25 full-time faculty members, including a Curators' professor, a UMKC Trustee's professor and two Fulbright Senior Specialists. Our faculty is at the forefront in research with funding from NSF and industries. We have strong partnerships with:

- Black & Veach
- Burns & McDonnell
- Cerner
- General Electric
- Honeywell
- Sprint Nextel

most of which are headquartered in the Kansas City area.

In the life sciences area, we are strenghtening partnerships with life and health sciences schools at UMKC and life sciences partners in the Kansas City area through the Kansas City Area Life Sciences Institute (KCALSI).

We have research strengths in the following areas:

- Networking and Telecommunications (design, protocols, routing, security, teletraffic modeling, monitoring, performance modeling, RF/wireless communication, optical, mobile computing, sensors, queueing theory, graph algorithms, etc.).
- Software Engineering and Systems (object-oriented design and analysis, database/information management, middleware, intelligent agents, peer-to-peer computing, mobile databases, data mining, knowledge discovery, intrusion detection, etc.).
- Bio-Informatics (biological data mining, functional property based protein databases, intelligent software agents in biology, biometric signal processing, computational genomics, etc.).
- Communications, Signal and Image Processing (digital signal processing, computational electromagnetics, RF and antenna theory and design, biomedical image processing, biometrics, neural networks, etc.).
- Computer Engineering (VLSI chip design, performance, low power devices, cache designs, embedded systems, system-on-chip, ASIC/FPGA design).
- Algorithms (complexity, distributed and parallel computations, graph, optimization, and combinatorial algorithms).

The CSEE department is committed to excellence in teaching. We stay on the top of the technology curve and continually offer new courses in emerging/hot topics. Our graduates are sought after by regional as well as national companies.

Approximately 575 students were enrolled in the CSEE department in the Fall 2006 semester: 330 at the undergraduate level (all degree programs), 210 at the masters level (both CS and EE), and 35 students participated in UMKC's Interdisciplinary Ph.D. program through a discipline in CSEE.

Student Organizations

The SCE **Student Council** addresses the need of the students within the School of Computing and Engineering. CSEE encourages every student to actively participate in a student organization that matches his or her interests. These organizations include:

ACM (Association for Computing Machinery) is the leading professional organization in Computer Science and its student chapter is very active. Among others, it sponsors and participates in numerous programming contests.

AITP (Association of Information Technology Professionals) caters to the interest of both information technology students and business students. Their office is in the Henry W. Bloch School of Business and Public Administration.

IEEE (Institute of Electrical and Electronics Engineers, Inc.) is the leading professional organization in Electrical and Computer Engineering. Many (if not most) in the Computer Science profession are also members of IEEE. Our student chapter won the prestigeous *Region 5 RAB Student Branch Membership Growth and Leadership Award* in 2003, the *Region 5 Student Branch Web Site Contest* in 2005, and was *Runner Up* in the *IEEE International Student Branch Web Site Contest*, also in 2005.

Eta Kappa Nu is the Honor Society in Electrical and Computer Engineering. The student chapter at UMKC, Theta Pi, was installed in 1980.

Upsilon Pi Epsilon is the International Honor Society for the computing and information discipline. A UPE student chapter was founded in 2004.

Financial Assistance

A variety of financial awards are available to our graduate students. The most common awards are the Chancellor's nonresident awards (CNR) and the Deans International Computing and Engineering awards (DICE). Both are awarded on a competitive basis to our best applicants only during initial enrollment. Graduate teaching and graduate research assistantships are also available; however they are usually not available to incoming master's level students in their first semester.

Scholarships and Awards

There are two types of scholarships and awards available to MS students. No special application form is required to be submitted; the graduate admission committee makes this decision based on the regular application material submitted by the applicants.

Domestic Students (CNR)

For U.S. citizens/permanent residents who are nonresidents of Missouri, a number of nonresident tuition waiver scholarships, known as the chancellor's nonresident (CNR) award, is available for our best applicants; the amount of this award is equal to the nonresident fee differential (currently valued at approximately $7,800 per year for students taking a full-time load each semester.)

Domestic Students (GEM)

A qualified applicant can also apply for a fellowship through the GEM (the National Consortium for Graduate Degrees for Minorities in Engineering and Science) program, which is to U.S. citizens from underrepresented groups; our school is one of the selected schools certified by GEM. For additional information on GEM, go to http://www.gemfellowship.org.

International Students (DICE)

For international students, the Dean's International Award for Computing and Engineering (DICE) is a competitive award available to the most qualified applicants. The amount of this new award is currently valued at up to $7,300 per year for students taking a full load each semester. This award is only for students newly admitted to SCE and is determined at the time of admission.

Graduate Teaching and Research Assistantships

A limited number of graduate assistantships are available each semester. Research assistantships are available through various faculty conducting funded research, and information on these can be obtained from individual faculty. Most faculty with funded research programs will award research assistantships to students they have been able to observe in classroom performance. A limited number of teaching assitantships are available to fully-enrolled graduate students who have successfully passed the school's verbal and comprehensive exams. The actual number of assistantships awarded each semester is based on total student enrollment. Typically, awards are for quarter-time support, with three-eighths or half-time support a possibility and may include tuition fee waivers. Priority will be given to students with excellent communication skills and to students in the Interdisciplinary Ph.D. program. Students wishing to be considered must present a simulated lecture that will be videotaped for review. International students must also pass a SPEAK test, administered at UMKC's Applied Language Institute and can not be considered for a teaching assistantship during their first semester of enrollment. Students must apply for these opportunities by sending their application materials by e-mail to griffiths@umkc.edu.

Graduate Programs

The Department of Computer Science Electrical Engineering offers a Master of Science in Computer Science (MS-CS) and Master of Science in Electrical Engineering (MS-EE). Also, our department houses three disciplines in support of the Interdisciplinary Ph.D. program of UMKC:

- Computer Science
- Electrical and Computer Engineering
- Telecommunication and Computer Networking

For more information on the doctoral program, see the description Interdisciplinary Ph.D. Program in the School of Graduate Studies section of this catalog.

Master of Science in Computer Science

The University of Missouri-Kansas City has created an exciting and uniquely designed program of graduate study in computer science. Significant changes have occurred within this discipline in recent years and our graduate program in computer science reflects those changes, providing in-depth education in the new technology and skills most in demand in this growing industry.

The UMKC graduate student has the unique opportunity to get a concentrated state-of-the-art education in a limited number of the most dynamic, challenging and professionally significant specialty areas. This is made possible by unusual advantages which the UMKC program possesses:

- An interdisciplinary approach to new technology.
- Faculty who are each actively pursuing research in these areas.

Students can earn an M.S. degree in computer science with an emphasis in:

- Bioinformatics
- Networking and Telecommunications
- Software Engineering and Systems

Many courses are offered in these emphasis areas. Contact us by phone: (816) 235-**1193** or send an e-mail csee@umkc.edu.

Admission Requirement

The University of Missouri-Kansas City's graduate program in computer science will accept college and university graduates whose past performance indicates an ability to succeed in graduate study in computer science. This ability can be demonstrated by the following undergraduate preparation.

1. A sound background in computer science as indicated by an above-average understanding (e.g. a cumulative GPA in CS coursework of 3.0 or better with no single course grade lower than 2.0) of the content of the following courses:
   - Problem Solving and Programming I (CS 101)
   - Problem Solving and Programming II (CS 201)
   - Introduction to Computer Architecture (CS 281)
   - Discrete Structures I and II (CS 191, 291)
   - Data Structures and Algorithms (CS 352)
   - Applied Probability (CS 394R)
   - Introduction to Operating Systems (CS 431)
   - Advanced Computer Architecture (CS 481)
2. A sound background in mathematics as indicated by an above average understanding (e.g. a GPA of 3.0 or better with no single course grade lower than 2.0) of calculus (minimum of 10 hours) and of the content of at least two additional upper-level courses in areas such as linear algebra, differential equations, abstract algebra, numerical analysis or mathematical logic.
3. A GPA of 3.0 or better in all undergraduate work.

4. Official results of the Graduate Record Exam (GRE) general test. The applicant must score in at least the 75th percentile on the quantitative portion of the GRE. Admission to our degree programs is competitive and a higher score is recommended.
5. For international students, a minimum test score of TOEFL 550/ CBT 213 is needed.
6. Prospective students who want to be considered for acceptance to the M.S. degree program should submit the following documents:
   - Transcripts for all graduate and undergraduate work completed so far; syllabi of these courses (or a URL to these) is strongly suggested.
   - Copies of academic and scholarly diplomas received.
   - GRE scores and, for international students, TOEFL scores, as well as a statement of purpose, i.e. a one- or two-page essay in which the prospective students indicate their career objectives.
   - For international students with a degree from outside the United States, it is strongly advised that the syllabus for coursework taken at their undergraduate institutions be included. Further, a certified statement clarifying how the final grade is computed should be included.

It is possible that a prospective student has obtained a solid understanding of either computer science or mathematics through work or other experience rather than formal study. These students must submit a detailed description of such experience and ask a supervisor to write a letter of reference supporting the application.

Applications will be reviewed by the master's committee when all documentation is received. For full consideration for the semester indicated, completed applications should be received by the follwing dates:

- For fall semester admission (semester starts in August):
  - U.S. students/permanent residents: June 1.
  - International students: Jan. 15.
- For spring semester admission (semester starts in January):
  - U.S. students/permanent residents: Nov. 1 of the preceding year.
  - International students: Oct. 1 of the preceeding year.

U.S. citizens or permanent residents should submit application forms and required supporting materials to:

Mailing Address
University of Missouri-Kansas City
Office of Admissions
120 Administrative Center
5100 Rockhill Road
Kansas City, MO 64110-2499

Their telephone number is (816) 235-**1111** and their e-mail address is admit@umkc.edu.

International students should use the international application form and return the application, along with required supporting materials to:

Mailing Address
University of Missouri-Kansas City
Office of International Student Affairs
5100 Rockhill Road
Kansas City, MO 64110-2499

Their telephone number is (816) 235-**1113** and their e-mail address is isao@umkc.edu.

Prospective students can request additional information or request information regarding their application by contacting UMKC at the above addresses or by sending e-mail to: csee@umkc.edu.

Advising

Initially, the student will be advised by the academic adviser assigned to them during the first semester of enrollment. In order to enroll in any course, the student must have the signature of the adviser. No student can enroll without such a signature. If a student enrolls in a class without their adviser's signature or approval, that class may not count toward graduation requirements. Also see the section "Starting the Program".

In the semester that results in 12 hours of credit toward the master's degree, students should decide between a thesis option and a non-thesis option. If students decide on a non-thesis option, they should consult with their adviser and submit a plan of study for approval. If students decide on a thesis option, they should seek a thesis adviser, who then also becomes the academic adviser. The thesis adviser must be a full member of the graduate faculty and, in collaboration with the student, will then appoint two other graduate or associate graduate faculty members to be on the student's thesis committee. The thesis committee may consist of more than three members, but the majority of committee members must have full graduate faculty status. Again, a plan of study must be submitted for approval.

Student Learning Outcomes

Upon graduating, students will have demonstrated that they can apply the core technologies from computer science and from their chosen emphasis areas. They will have developed an analytical mindset and understand the limitations of current theories and technologies. They will be able to design a system under realistic constraints, which they are able to implement using modern tools and techniques. They will have had an opportunity to take in-depth course work in the area of computer networking, telecommunications, software engineering and bioinformatics.

Curricular Description

The graduate program in computer science is unique and dynamic and is tailored for specialization in one of three emphasis areas:

- Bioinformatics
- Networking and Telecommunications
- Software Engineering and Systems

In addition to selecting an emphasis area, a student must select a concentration area as described below.

Core Requirement
All students are required to complete a core curriculum of CS 5592 and two courses selected from CS 5520, CS 5551 or CS 5566.

Emphasis Areas
All students are required to complete courses in an emphasis area. Students following the thesis option must complete at least nine credit hours from 5500/5600-level courses in this area. Students following the non-thesis option must complete at least 12 credit hours from 5500/5600-level courses in this area. The approved emphasis areas and associated courses are:

- Bioinformatics
  CS 5560, CS 5566, CS 5567, CS 5570, CS 5590 CI and others.
- Networking and Telecommunications
  CS 5511, CS 5513, CS 5514, CS 5517, CS 5520, CS 5521, CS 5522, CS 5526 and others.

- Software Engineering and Systems
  CS 5531, CS 5551, CS 5552, CS 5554, CS 5570, CS 5572, CS 5670 and others.

Concentration Areas
All students are required to complete at least two 5500/5600-level courses in a concentration different from their emphasis area. Pre-approved concentrations and associated courses are:

- Bioinformatics
  CS 5560, CS 5566, CS 5567, CS 5570, CS 5590 CI and others.
- Networking and Telecommunications
  CS 5511, CS 5513, CS 5514, CS 5517, CS 5520, CS 5521, CS 5522, CS 5526 and others.
- Software Engineering and Systems
  CS 5531, CS 5551, CS 5552, CS 5554, CS 5570, CS 5572, CS 5670 and others.

If a student desires a concentration other than these, a petition must be submitted to the graduate committee requesting that a concentration be recognized for the student's specific degree plan. It should specifically state which courses the student wants to include in this concentration, it should explain why these courses together form a coherent group and how these courses fit the student's academic goals. Students must seek permission before including other courses in their program of study.

Degree Requirement

To earn an M.S. degree in computer science, the student must satisfy both the general master of science degree requirements of the University of Missouri-Kansas City and the requirements of the CSEE Department for either the thesis or non-thesis option as outlined below.

Specific Requirements for the Thesis Option:

1. Complete a minimum of 27 hours of approved coursework for graduate credit with a cumulative GPA of at least 3.0.
2. Additionally, complete a minimum of three hours CS 5599 Research and Thesis.
3. Complete a minimum of nine hours in the emphasis area.
4. Contact a thesis adviser in the semester in which the student completes 12 hours of graduate work.
5. Present evidence of research abilities in the form of a master's thesis resulting from enrollment in at least three hours of CS 5599 Research and Thesis.
6. Pass a general oral examination which may cover all the work covered in the student's graduate program.
7. Satisfy all common requirements (see below).

Specific Requirements for the Non-Thesis Option:

1. Complete a minimum of 36 hours of approved coursework for graduate credit with a cumulative GPA of at least 3.0.
2. Complete a minimum of 12 hours in the emphasis area.
3. Contact an adviser after completing 12 hours of graduate work to complete the program of study.
4. Satisfy all common requirements (see below).

Common Requirements and Limitations for Both Options:

1. Satisfy the core requirement, presently CS 5592 and two of the three courses: CS 5520, CS 5551, and CS 5566.
2. Complete a minimum of six hours in the secondary concentration.
3. Each student must have a plan of study approved by both the student's supervisory committee and the graduate officer before the end of the semester in which the student completes 12 credit hours of graduate work.
4. No more than nine credit hours total from any transferred coursework taken outside the CSEE department and from CS 411, CS 421, CS 423, CS 457, CS 458, CS 461, (only one of CS 470 and CS 471), CS 493 and CS 494R can be used to satisfy degree requirements; these courses cannot be identical to courses already taken for a prior degree and must be completed with a 3.0 or higher GPA for each course used. Other 300- and 400-level courses do not count toward fulfillment of degree requirements.
5. No more than three hours of CS 5597 (directed readings) can be used to satisfy degree requirements. All CS 5597 courses to be applied to the master of science in computer science degree requirements must be approved by the SCE Master's Committee at least six weeks before classes begin.
6. No more than one course grade below 3.0 may be applied toward the degree requirements.

Transfer Credit
Not more than six hours of graduate credit may be transferred from another recognized graduate school or from another academic unit within UMKC. Transfer credit may be applied toward the master's degree requirements on the approval of the student's graduate adviser and the Master's Committee. No credit hours may be transferred when those hours have been used toward the completion of any other degree program, graduate or undergraduate. The total amount of transfer credit and credit from approved CS 400-level classes shall not exceed nine hours.

Academic Regulations

For smooth completion of the degree program, a student must follow various academic regulations as described below:

Starting the Program
When accepted into the program, the student's first contact is with the computer science principal graduate adviser or with members of the graduate committee during the orientation session. At this initial meeting, a review will be made of the student's status in the program and the student will be required to provide a tentative program of study within the first semester. Such a program should reflect the deficiency and prerequisite courses that have been prescribed and may have to be taken prior to taking courses for graduate credit.

The most immediate concern is for the courses to be taken in the first semester. The principal graduate adviser will help the student select those initial courses.

Within the first semester, the student will be assigned a graduate adviser (faculty) who will then become the primary contact person for that student until a thesis adviser (for thesis option) is selected. The chair of the CSEE graduate committee or his/her designee will notify the student of the identity of the specific graduate adviser. It will be the responsibility of students, in conjunction with their advisers/chairs, to devise a program of study using the degree requirements worksheet and the course planning worksheet. This should be submitted to the graduate committee, usually by the end of the second semester. The CSEE graduate committee is in charge of handling procedural issues related to the M.S. program in computer science. Any request for exception to rules, regulations or policies should be directed to this committee.

Deficiences
The graduate committee reviews and evaluates all applications for admissions to the M.S. degree programs. Frequently, they review applications from students whose past academic record show strong positive indications for success as a graduate student, yet have not satisfied all courses needed for full admission. The committee may offer these students admission to the program on a conditional basis and compile a list of

"deficiency courses". The successful completion of these courses with a grade of B or better will be a condition of full admission to the program. The student is then required to complete all such deficiencies as a contractual obligation at the earliest opportunity.

The committee creates this list based on the transcripts and syllabus submitted by the applicant. However, it is possible that applicants have indeed satisfied one or more of their listed deficiencies. In these cases, the student should contact their academic adviser as soon as possible in the first semester to initiate a petition to waive the deficiencies in question. The written petition with all the needed supporting documentation (such as course syllabus) attached, must be submitted no later than four weeks (two weeks for summer) before the end of the first semester of enrollment. The decision of the committee is final and can be one of three:

- The waiver is granted.
- The student is allowed to take an examination.
- The waiver is denied and the student must pass the class with a B (3.0) or higher.

The committee's decision is final, so it is important that students consult with their adviser to ensure that all the proper documentation supporting the waiver is submitted.

If the student is allowed to take an examination, it must take place no later than the second semester of enrollment. Deficiency examinations are offered once each semester and the date is announced six to eight weeks in advance. The student may take the exam only once. If the student does not perform satisfactorily on the exam, then the student must enroll in the course to satisfy the deficiency requirement.

All deficiencies shall be satisfied within three semesters of admission. If deficiencies are not satisfied within this time period, enrollment will be limited to deficiency courses until all deficiencies have been satisfied.

Graduate Course Prerequisites
Note that there are graduate level courses that have an undergraduate course as prerequisite and that not all undergraduate courses can be taken for graduate credit.

Program of Study
A graduate degree indicates mastery of a coherent program in a chosen field and the ability to engage in creative projects in that specialty. The program of study is vital in assuring the completion of a formal program of study designed to ensure the mastery of specified knowledge and skills.

Forms for the program of study specification may be obtained from the CSEE Department Office. It is required that the program be approved by the student's graduate adviser and the graduate committe chair in the semester in which the student will complete 12 credit hours toward the degree, which is usually during the second semester of enrollment. It is then forwarded to the graduate officer for further approval and handling.

Once a program of study has been approved, it is the student's responsibility to ensure that all curricular requirements and prerequisites are satisfied. If a change in the approved program is needed, a petition must be submitted to the student's adviser who forwards it to the graduate committee for approval. It is not expected that more than four courses will change from the original program of study. If more than four courses are changed, then a new program of study should be filed.

Academic Loads
A graduate student enrolled in the fall or spring semester in nine or more credit hours is considered full time. A graduate student enrolled in the summer semester in five or more credit hours is considered full time. Any student enrolled in less than the above number of hours is considered part time. A student who is enrolled for six credit hours during a regular semester may be considered full time if the student has at least a quarter-time graduate research/teaching assistantship. A student's academic load may be restricted as deemed fit by the student's graduate adviser or the CSEE master's committee.

International students will be required to take an English Proficiency Test administered by the International Student Affairs Office. Performance on the test may result in recommendations that the student take one or more English language courses during the first semester. It is strongly recommended that the student abide by those recommendations.

Students holding graduate teaching assistantships and graduate research assistantships should take a minimum of six credit hours during each of the fall and spring semesters and a minimum of three credit hours during the summer session. However, GTA/GRAs who have completed all coursework and who are working on research need to enroll in only one credit hour. International students must abide by the requirements of the U.S. Immigration Service and should consult the International Student Affairs Office regarding this matter.

Enrollment Policies
To remain in good standing, the student must enroll for at least one semester during each calendar year until all the courses in the program of study are completed. After this time, the student must be continuously enrolled each fall and spring semester until the degree is awarded. The student must be enrolled in the semester in which the degree will be received. Students working as graduate assistants during the summer must be enrolled during the summer semester. Failure to follow the above policies will result in a need to apply for new admission to the program under the degree requirements in effect at the time of re-admission.

Academic Standing
The student must maintain at least a 3.0 GPA every semester. Deficiency courses, if any, must be passed with a B (3.0) or higher. A 400-level course in which the student receives a grade lower than B (3.0) can not be used to satisfy the degree requirements. Similarly, a 5000-level course in which the student receives a grade lower than C (2.0) can not be used to satisfy the degree requirements. However, all grades for courses taken for graduate credit shall be used in the calculation of the current GPA. No more than one grade below B (3.0) in a course taken for graduate credit can be applied toward the degree. If a student receives three grades below B (3.0) in courses taken for graduate credit or taken to fulfill a deficiency requirement, or if a student receives a grade below C (2.0) in a course taken for graduate credit or taken to fulfill a deficiency requirement, then the student will be ineligible to enroll.

Petitions
Any exception to academic policy and regulations or to the degree requirements (e.g. deficiency waiver) must be requested through a written petition. The petition form is available from the CSEE Department Office and on the Web; the completed petition which includes an explanation for the petition should be submitted to the CSEE Department Office. The degree program coordinator or his/her designee will review petitions and communicate the result to the student. It is important that the petition include any necessary documents as attachments for a timely decision.

Ineligibility
Ineligible students may petition the CSEE graduate committee to be re-enrolled. Such petitions will be reviewed by the graduate committee whose ruling is final. An ineligible student will only be approved for further graduate study under the terms of a restrictive probation in the form of a written contract

between the student and the CSEE department. The CSEE department may render a student ineligible regardless of the student's GPA. Such procedures are rare and will involve a recommendation to the dean of the School of Graduate Studies.

Auditing a Course
A graduate student should not take a course for audit if that student plans to take the course for credit. Once a course has been audited by a student, the student cannot take the course for credit later in the program.

A graduate student cannot change a course to audit after the eighth week of the fall and spring semesters or after the fourth week of the summer semester. Changes to audit status must have the permission of the course instructor, as well as be within the allowable period.

Directed Reading Courses
Up to three hours of CS 5597 Directed Readings is allowed toward a master of science. Such a course must be approved in advance (i.e., before the student takes the course) by the students committee and the graduate committee. The following information must be furnished:

- Title of the course.
- Detailed syllabus for the course.
- Textbook and references.
- The manner in which the course will be conducted (i.e. meetings, assignments, etc.).
- The manner in which the students are assessed (i.e. how many exams, presentations, reports, etc.).
- The course which it replaces, if appropriate.
- Name(s) of the instructor(s).
- Name(s) of the student(s).
- Reasons for offering this course in a directed readings format.

Thesis Option
Master's degree candidates in computer science who decide to do the thesis option are required to demonstrate knowledge and maturity in the discipline by completing at least three hours of CS 5599 - Research and Thesis. Students may enroll in more than three hours of CS 5599, however, only three hours may be applied toward the degree. The research program will be defined by the student in conjunction with the student's thesis committee. Under the direction of the thesis adviser, the student will investigate a topic of current interest in computer science and prepare a master's thesis on that topic.

The final requirement for conferral of the M.S. degree is defense of the thesis, where the supervisory committee is the examining body. The thesis must be submitted in complete typewritten form to the adviser and supervisory committee at least six weeks before the date the advanced degree is to be conferred. Also, the supervisory committee must have access to the thesis at least one week before the date of the defense. Students must comply with all rules and regulations governing theses outlined in the general catalog under General Graduate Academic Regulations and Information.

Fast Track Computer Science Program

See the Fast Track section under Computer Science in the undergraduate catalog for information about the Fast Track Computer Science Program.

Master of Science in Electrical Engineering

The University of Missouri-Kansas City has created an exciting and uniquely designed program of graduate study leading to the master of science in electrical engineering. This degree offers several options: thesis or non-thesis, with the latter available with an electric power focus area. In the thesis option, the student has the opportunity to engage in research that builds upon coursework to reach the forefront in the chosen area. This degree option prepares graduates for a wide variety of future opportunities, whether it be in corporate research, product development, management or entrepreneurial endeavors. It also prepares graduates for doctoral studies. The overall goal is to put graduates into a position to be leading technology developers and innovators. The non-thesis option provides the student opportunities to study areas such as wireless communications, signal processing, computer architectures, digital systems, VLSI design, low-power chip design, image processing, computational electromagnetics, antenna theory, computer networking and neural networks. Alternately, the student can select the electric power focus, designed to fit easily into the schedule of full-time working engineers. The curriculum of the focus area is flexible and includes selected business courses such as project management in addition to electrical engineering courses. The specialty has been developed in coordination with industry, engineering firms and utilities. Contact info: (816) 235-**1193**, csee@umkc.edu.

Admission Requirement

Applicants for masters level graduate studies in electrical and computer engineering should have a GPA of at least 3.0 on a 4.0 scale for the last 60 semester hours of relevant undergraduate coursework in electrical engineering and/or computer engineering. However, if that GPA is below 3.0 but more than 2.75, and if other indicators promise success in the program, rules may still allow probationary admission. The department will notify the applicant by letter after careful examination of the application packet. The following documents are required for admission consideration:

1. Application for admission.
2. Official transcripts of all college coursework.
3. Graduate engineering supplemental application.
4. Official results of the Graduate Record Exam (GRE) general test. The applicant must score in at least the 75th percentile on the quantitative portion of the GRE. Admission to our degree programs is competitive and a higher score is recommended.
5. (For international students only) A minimum test score of TOEFL 550/ CBT 213 is needed. International students must also place in the top 25 percent of his or her graduating class.
6. Three letters of recommendation for students with a GPA less than 3.0 for the last 60 hours of undergraduate work.

Note: High GRE verbal and quantitative scores and strong letters of recommendation may compensate for lower TOEFL scores and GPAs.

Acceptance or Denial
After thoroughly considering an applicants record, one of the following actions will be taken:

Normal Acceptance
The student is accepted unconditionally.

Normal Acceptance with Pre-program Requirements
This category applies to an otherwise qualified applicant who has a bachelor of science degree from an approved program, but not in electrical engineering, computer engineering, or a similarly named engineering discipline. The student will be notified in writing of any make-up requirements specified by the masters committee.

Probationary Acceptance
Applicants with marginal credentials may be admitted conditionally. They will have to receive a B or better in each course in the first 12 hours of graduate coursework. In addition, make-up requirements may be set forth by the masters committee.

Non-Acceptance
The student is not admitted. The student will be notified in writing of the admission denial. The letter may specify under what conditions a future application would be more favorably considered.

Advising

Initially, the student will be advised by the academic adviser assigned to them during the first semester of enrollment. In order to enroll in any course, the student must have the signature of the adviser.

In the semester that results in 12 hours of credit toward the master's degree, the student should decide between a thesis option and a non-thesis option. If the student decides on a non-thesis option, he or she should consult with his or her adviser. If the student decides on a thesis option, he or she should seek a thesis adviser, who then also becomes the academic adviser. The thesis adviser must be a full member of the graduate faculty and, in collaboration with the student, will then appoint two other graduate or associate graduate faculty members to be on the student's thesis/supervisory committee. This committee may consist of more than three members, but the majority of committee members must have full graduate faculty status.

Student Learning Outcomes

Upon graduating, students have demonstrated that they can apply the core technologies from their chosen areas within electrical engineering. They will have developed an analytical mindset and understand the limitations of current theories and technologies. They are able to design a system under realistic constraints, which they are able to implement using modern tools and techniques. They will also have had an opportunity to take in-depth course work in the area of computer engineering, digital signal processing, computational electromagnetics and antenna theory, telecommunications and computer networking.

Degree Requirement

To earn a master of science in electrical engineering, the student must satisfy the general degree requirements and complete coursework that fulfills the requirements according to the thesis or non-thesis option. The specific requirements for the power engineering focus area are listed seperately.

Specific Requirements for the Thesis Option:

1. Complete a minimum of three hours and a maximum of six hours ECE 5599 Research.
2. Pass a final examination, which is an oral defense of the thesis.
3. Satisfy all common requirements (see below).

Specific Requirements for the Non-Thesis Option:

1. The following courses do not count toward this degree option: ECE 5599, ECE 5600 or ECE 5690.
2. Satisfy all common requirements (see below).

Common Requirements and Limitations for both Thesis Option and Non-Thesis Option:
(Note that the specific requirements for the power engineering focus area are listed seperately.)

1. At least 30 credit hours of 400-, 5500- or 5600-level coursework, completed within the past six years.
2. At least 21 hours of 5500/5600-level coursework.
3. At least 24 hours of ECE course work, see also below.
4. At least one three-hour course, at the 5500/5600-level, in each of three different concentration areas, with at least two of the areas in ECE; a list concentration areas with their courses is provided below.
5. Up to three credit hours of ECE 5597 Directed Readings and ECE 5697 Advanced Directed Readings, are allowed.
6. The following courses can be used to satisfy degree requirements and can be counted as equivalent to ECE courses: CS 5511, CS 5513, CS 5514, CS 5517, CS 5520, CS 5522 and CS 5594.
7. No more than six credit hours of transferable graduate coursework from another institution or from other degree programs within UMKC, as approved by the students graduate faculty adviser.
8. The courses ECE 402WI, ECE 403WI, ECE 493R, ECE 494R (or their equivalents) do not count for graduate credit.

Specific Requirements and Limitations for the Electric Power Focus:

1. At least 30 credit hours of 400-, 5500- or 5600-level coursework, completed within the past six years.
2. At least 21 hours of 5500/5600-level coursework.
3. At least 18 hours of ECE course work, with at least 12 hours of ECE course work in the power concentration.
4. At least one three-hour course, at the 5500/5600-level, in each of three different concentration areas, with at least two of the areas in ECE.
5. Up to three hours of ECE 5597 Directed Readings and ECE 5697 Advanced Directed Readings, is allowed.
6. The following courses can be used to satisfy the power focus requirements. (Note: the course ECE 5567 is currently being developed and will be added to the catalog as soon as it has been approved.) ECE 460, ECE 466, ECE 468, ECE 470, ECE 472, ECE 5536, ECE 5567, ECE 5568, ECE 5590AE, ECE 5590MC, ECE 5660, ECE 5664, ECE 5670, ECE 5672, BA 5519 and BA 5532.
7. The following courses can be used to satisfy degree requirements and can be counted as equivalent to ECE courses: CS 5511, CS 5513, CS 5514, CS 5517, CS 5520, CS 5522 and CS 5594.
8. The following courses do not count toward this degree option: ECE 5599, ECE 5600 or ECE 5690.
9. No more than six (6) credit hours of transferable graduate coursework from another institution or from other degree programs within UMKC, as approved by the students graduate faculty adviser.
10. The courses ECE 402WI, ECE 403, ECE 461, ECE 493R, ECE 494R (or their equivalents) do not count for graduate credit.

Concentration Areas
The faculty provide research and concentration area coursework in:

- Communication and information processing (signal and image processing, electro-optical systems, neural networks).
- Computers and digital systems (computer arithmetic, computer architecture and computer and digital systems).
- Wireless communications (system design, propagation modeling, antenna design, wireless networking, electromagnetic modeling).
- Power (electromechanical conversion I, electromechanical conversion II, power system I, power system II, electrical power distribution systems, reliability of electric power systems, economics of power systems, power systems stability, lightning and switching surges in power systems, application of power electronics in power systems, power systems relaying, direct current power systems, contracts and law for engineers and microcomputer control of power generation systems).
- Computer networking

Starting the Program
When accepted into the program, the students first contact is with the electrical engineering principal graduate adviser. At this initial meeting, a review will be made of the students status in the program and the student will be required to provide a tentative program of study within the first semester. Such a program should reflect the prerequisite courses that have been prescribed and that may have to be taken prior to taking courses for graduate credit.

The most immediate concern is for the courses to be taken in the first semester. The principal graduate adviser will help the student select those initial courses. Within the first semester, the student will be assigned an academic adviser who will be the primary contact for the student until the student graduates under the non-thesis option. If the student decides to follow the thesis option, a thesis adviser will replace the academic adviser. In either case, it is the responsibility of the student to devise, after consultation with their advisers, a program of study using the degree requirements worksheet and the course planning worksheet. This should be submitted to the graduate officer, usually by the end of the second semester.

The masters committee is in charge of handling procedural issues related to the M.S. program in electrical engineering. Any request for exception to the rules should be handled as described below related to petitioning procedures.

Program of Study
A graduate degree indicates mastery of a coherent program in a chosen field and the ability to engage in creative projects in that specialty. The program of study is vital in assuring the completion of a formal program of study designed to ensure the mastery of specified knowledge and skills.

Forms for the program of study specification may be obtained from the graduate officer. It is required that the program be approved by the students graduate thesis adviser and filed by the graduate officer in the semester in which the student will complete 12 credit hours toward the degree. This is usually during the second semester of enrollment.

Once a program of study has been approved by the principal graduate adviser and filed with the graduate officer, it is the students responsibility to ensure that all curricular requirements and prerequisites are satisfied and changes in the program are submitted to the students thesis/supervisory committee via the thesis adviser for approval.

Any changes to the program of study must have the approval of the adviser, the thesis/supervisory committee and the principal graduate adviser. It is not expected that more than four courses will change from the original program of study. If more than four courses are changed, then a new program of study should be filed.

Academic Loads
A graduate student enrolled in the fall or spring semester for nine or more credit hours is considered full time. A graduate student enrolled in the summer semester for five or more credit hours is considered full time. Any student enrolled in less than the above number of hours is considered part time. A students academic load may be restricted as deemed fit by the students graduate adviser or the masters committee. International students will be required to take an English Proficiency Test administered by the International Student Affairs Office. Performance on the test may result in recommendations that the student take one or more English language courses during the first semester. It is strongly recommended that the student abide by those recommendations.

Students holding graduate teaching assistantships and graduate research assistantships should take a minimum of six credit hours during each of the fall and spring semesters, and a minimum of three credit hours during the summer session. However, GTA/GRAs who have completed all coursework and who are working on research need only to enroll in one credit hour. International students must abide by the requirements of the U.S. Immigration Service and should consult the International Student Affairs Office regarding this matter.

Enrollment Policies
To remain in good standing, the student must enroll for at least one semester during each calendar year until all the courses in the program of study are completed. After this time, the student must be continuously enrolled each fall and spring semester until the degree is awarded. The student must be enrolled in the semester in which the degree will be received. Students working as graduate assistants during the summer must be enrolled during the summer semester. Failure to follow the above policies will result in a need to apply for new admission to the program under the degree requirements in effect at the time of re-admission.

Academic Standing
The student must maintain at least a 3.0 GPA every semester. Deficiency courses, if any, must be passed with a B (3.0) or higher. A 400-level course in which the student receives a grade lower than B (3.0) shall not be used to satisfy the degree requirements. Similarly, a 5500/5600-level course in which the student receives a grade lower than C (2.0) shall not be used to satisfy the degree requirements. However, all grades for courses taken for graduate credit shall be used in the calculation of the current GPA. No more than one grade below B (3.0) in a course taken for graduate credit shall be applied toward the degree. If a student receives three grades below B (3.0) in courses taken for graduate credit or taken to fulfill a deficiency requirement, or if a student receives a grade below C (2.0) in a course taken for graduate credit or taken to fulfill a deficiency requirement, then this student will be ineligible to enroll.

Petitions
Any exception to academic policy and regulations or to the degree requirements (e.g. deficiency waiver) must be requested through a written petition. The petition form is available from the CSEE Department Office and on the Web. The completed petition that includes an explanation for the petition should be submitted to the CSEE Department Office. The degree program coordinator or his/her designee will review such petitions and will communicate the result to the student. It is important that the petition include any necessary documents as attachments for a timely decision.

Ineligibility
Ineligible students may petition the CSEE graduate committee to be re-enrolled. Such petitions will be reviewed by the graduate committee whose ruling is final. An ineligible student will only be approved for further graduate study under the terms of a restrictive probation taking the form of a written contract between the student and the CSEE department. The CSEE department may render a student ineligible regardless of the student's grade-point average. Such procedures are rare, and will involve a recommendation to the dean of the School of Graduate Studies.

Auditing a Course
SCE graduate students should not take a course for audit if they plan to take the course for credit. Once a course has been audited by a student, that student cannot take the course for credit later in the program.

SCE graduate students cannot change a course to audit after the eighth week of the fall and spring semesters or after the fourth week of the summer semester. Changes to audit status must have the permission of the course instructor, as well as be within the allowable period.

Directed Reading Courses
Up to three hours of ECE 5597 Directed Readings and ECE 5697 Advanced Directed Readings, is allowed toward the master of science in electrical engineering. Such a course must be approved in advance (i.e., before the student takes the course) by the students thesis/supervisory committee and the graduate committee. The following information must be furnished:

- Title of the course.
- Detailed syllabus for the course.
- Textbook and references.
- The manner in which the course will be conducted (i.e. meetings, assignments, etc.).
- The manner in which the students are assessed (i.e. how many exams, presentations, reports, etc.).
- The course which it replaces, if appropriate.
- Name(s) of the instructor(s).
- Name(s) of the student(s.)
- Reasons for offering this course in a directed readings format.

Thesis Option
The Comprehensive Final Examination is required of all candidates for the master of science degree under the thesis option. It is arranged by the graduate faculty adviser. It is to be conducted prior to the deadline date established by the Graduate School for the semester of intended graduation. Prior to the date of the examination, each member of the committee is furnished a copy of the candidates final thesis for review and discussion at the time of the final examination.

If pursuing the thesis option, the thesis must be submitted in complete typewritten form to the adviser and supervisory committee at least six weeks before the date the advanced degree is to be conferred. Also, the supervisory committee must have access to the thesis at least one week before the date of the defense. Students must comply with all rules and regulations governing theses outlined in the general catalog under General Graduate Academic Regulations and Information.

Fast Track Electrical Engineering Program

See the Fast Track section under Electrical and Computer Engineering in the undergraduate catalog for information about the Fast Track Electrical Engineering Program.

Doctoral Studies in Computer Science and Electrical Engineering

The Department of Computer Science Electrical Engineering also participates in the Interdisciplinary Ph.D. program of the University of Missouri-Kansas City. This program is administered through the School of Graduate Studies at the University of Missouri-Kansas City and requires a student to select both a coordinating discipline and a co-discipline. Many doctoral students choose both coordinating and co-disciplines in our department or the School of Computing and Engineering, but other disciplines can be taken as well. Three such disciplines are housed in our department:

- Computer Science
- Electrical and Computer Engineering
- Telecommunication and Computer Networking

These were formerly known as computer networking, software architecture and telecommunications networking. See the School of Graduate Studies section of this catalog for details about the Interdisciplinary Ph.D. program.

Financial Assistance
Graduate teaching assistantships and graduate research assistantships are available to prospective doctoral students, but are highly competitive. Currently, most full-time Ph.D. students in the CSEE department are supported either as graduate teaching assistants or as graduate research assistants.

Doctoral students already in the program are eligible to apply for several fellowships available from the School of Graduate Studies. Check the School of Graduate Studies Web site at www.umkc.edu/sgs/financial.asp for additional information.

Computer Science (CS) Courses

5510 Information Theory (3). Representation, transmission and transformation of information, information compression and protection, generation, storage, processing and transmission of information. Prerequisite: BS in Computer Science, Engineering, or Mathematics.

5511 Advanced Telecommunications Networks (3). Efficient source coding and channel coding techniques, principles of switching, digital transmission over microwave, copper and optical media, T-carrier and SONET systems, traffic consideration in telecommunications networks, network synchronization, control and management, ATM concepts. Prerequisite(s): CS 394R and CS 411.

5513 Digital Cellular Communications (3). Principles of microwave communications, performance metrics, mobile communications and cellular topology, co-channel and adjacent channel interference, fading and shadowing, various types of diversity, TDMA, FDMA and CDMA and other techniques for channel assignment, cellular network architectures, design considerations, PCN concepts. Prerequisite CS 411.

5514 Optical Fiber Communications (3). Fiber optic cable and its characteristics, optical sources and transmitters, optical detectors and receivers, optical components such as couplers and connectors, WDM and OFDM techniques, modulation and transmission of information over optical fibers, design of optical networks, single and multihop fiber LANs, optical carrier systems. Prerequisite: CS 411.

5514A Optical Networking (3). Components of optical networks such as OADM, OXC, optical switches, DWDM, and their functions and interactions. Design, analysis and routing over all-optical networks to include waveband, wavelength and lightpath routing. Prerequisite: CS411

5517 Digital Switching: Techniques And Architectures (3). Integration of transmission and switching, single and multistage switching principles, space and time division switching, conventional switch architectures such as 4ESS, integration of circuit and packet switching, ATM switching and design considerations, ATM switch architectures, evaluation and comparison, future trends. Prerequisite(s): CS 394R and CS 411.

5520 Network Architecture I (3). Principles, protocols, and architectures of data networks, internetworking, routing, layering, and addressing, with specific investigation of the Internet Protocol (IP), Mobile IP, Multiprotocol Label Switching (MPLS), IP over Asynchronous Transfer Mode (ATM) networks, and virtual private networks. Prerequisite: CS 420 or CS 421, CS 431.

5521 Network Architecture II (3). Principles, protocols and architectural issues of computer networks for transport layer and above, with specific emphasis on TCP/IP for best-effort services as well as for emerging multi-media services. Prerequisite: CS520

5522 Computer Network Design And Analysis (3). Topological design, capacity and flow assignment problem-modeling and algorithms, and their analysis, issues in network control. Prerequisite(s): CS 352, CS 394R, CS 421.

5524 Protocol Design (3). Protocols as formal algorithms, architectural definition, protocol specification languages and models and their translation to implementation languages, overview of verification methods, symbolic execution. Prerequisite: CS 421.

5526 Network Routing (3). Algorithms, protocols and analysis for network routing. Routing in different networks such as circuit-switched networks, Internet, broadband networks, and transmission networks are covered. Prerequisites: CS520 and CS522.

5528 Local Area Networks: Analysis And Design (3). Definition of local area networks (LAN), LAN architecture and protocols, topology, transmission media, channel access protocols, modeling, simulation and performance evaluation of LANs, considerations in design and implementation, examples. Prerequisite: CS 421 and 494R.

5531 Advanced Operating Systems (3). Components of an operating system, scheduling/routing mechanisms, process control blocks, design and test various operating system components. Prerequisite: CS 431.

5532 Discrete Event Simulation (3). Review of statistical distributions, generation of pseudorandom variates and stochastic processes, basic queueing systems such as M/M/m and Jackson Networks, simulation project. Prerequisite: CS 5594.

5551 Advanced Software Engineering (3). Current concepts in software architecture and design, comparative analysis for design, object-oriented software design, software quality criteria for evaluation of software design. Introduction to metrics, project management and managerial ethics. Prerequisite: CS 451.

5552 Advanced Data Structures (3). Formal modeling including specification and deviation of abstract data types, completeness issues in the design of data types and data structures, implementation of data structures from a formal data type specification, verification of abstractto concrete data mapping. Prerequisite(s): CS291 and CS 352.

5552A Formal Software Specification (3). Formal modeling including specification and deviation of abstract data types, completeness issues in the design of data types and data structures, implementation of data structures from a formal data type specification, verification of abstract to concrete data mapping. Prerequisite(s): CS291 and CS 352.

5554 Software Tools And Programming Environments (3). Taxonomy of software tools and environments, generic software tool architecture, interface techniques for users, intra-system and stand-alone systems, integration of heterogeneous systems components. Prerequisite: CS 451.

5556 Human Factors In Computer Systems (3). Design of "user friendly" man-machine interface, survey of recent psychological studies in man-machine interaction, user interface design, instrumentation and testing, analytic models of man-machine interaction. Prerequisite: CS 451.

5560 Knowledge Discovery And Management (3). This course teaches students fundamental theory and practice in the field of knowledge discovery and management and also provides them with hands-on experience through application development. Prerequisites: CS 5551, and either CS 461 or CS 464 Offered: Every Winter

5561 Advanced Artificial Intelligence (3). AI systems and their languages, implementations and applications, case studies of various expert systems, current research topics in AI, logic programming using PROLOG. Prerequisite: CS 461.

5564 Inference Techniques And Knowledge Representation (3). Inference Techniques is an in-depth course of logic and automatic theorem proving, intended for Computer Science graduate students, with particular importance to those students interested in Artificial Intelligence. The main areas of study will be concerned with the principals and techniques used for automatic theorem proving. An overview of the representation of knowledge and logic, a detailed appreciation of theorem proving methods, and implementation techniques will be provided in the course. The course will provide background for further study in varying fields of A.I. Prerequisite: CS 461 or consent of instructor.

5566 Introduction To Bioinformatics (3). This course introduces students to the field of Bioinformatics with a focus on understanding the motivation and computer science behind existing Bioinformatic resources, as well as learning the skills to design and implement new ideas. Offered: Every Fall Prerequisites: CS 352 and a course/background in Biology (Genomics or etaModels preferred.)

5567 Machine Learning In Bioinformatics (3). This course introduces students to the field of Machine Learing algorithms that are used in Bioinformatics, illustrated by several examples of applications to various problems. Offered: Every Winter Prerequisites: CS 352, CS394R and a course/background in Biology (Genomics or MetaModels preferred.)

5570 Architecture Of Database Management Systems (3). Covers in detail, architecture of centralized database systems, database processing, management of concurrent transactions, query processing, query optimization, data models, database recovery, datawarehousing, workflow, World Wide Web and Database performance, and reviews the architecture of some commercial centralized database systems. Prerequisites: CS470 and CS431, or consent of instructor.

5572 Mobile Computing (3). This course covers in detail the architecture of mobile and wireless network. It discusses and develops reveland concepts and algorithms for building mobile database systems (MDS), which is necessary for managing information on the air and E-commerce. This course is offered once a year. Prerequisite: CS 5570 Offered: Every Fall

5575 Advanced Computer Graphics (3). Review of transformations, 3D viewing, curve fitting in 3D, generation of surfaces, hidden surface elimination, scan-line coherence, rigid solid representation, shading, color theory. Prerequisite: CS 475.

5581 Parallel Computer Architecture I (3). Parallelism in computer architecture, pipelined processors, array processors and multi-processor systems, algorithms for SISD, SIMD, MISD and MIMD organizations, vectorization, pipelining algorithms. Prerequisite: CS 481.

5590 Special Topics (1-3). Selected topics in specific areas of computer science. May be repeated for credit when the topic varies.

5590AB Special Topics (1-3).

5590AC Special Topics (1-3).

5590BI Special Topics (1-3).

5590CA Special Topics (1-3).

5590CD Special Topics (1-3).

5590DA Special Topics (1-3).

5590DM Special Topics (1-3).

5590KB Special Topics (1-3).

5590MB Special Topics (1-3).

5590NM Special Topics (1-3).

5590O Special Topics (1-3).

5590OP Special Topics (1-3).

5590OS Special Topics (1-3).

5590PC Special Topics In Computer Science (1-3).

5590SK Special Topics Computer Science (1-3).

5590WW Special Topics (1-3).

5590XX Special Topics (1-3).

5591 Concurrency Models (3). Concurrency control constructs, P/V primitives, cobegin/coend, monitors, message transmission, rendezvous systems, underlying mathematics of concurrent systems, Petri Nets, liveness (deadlock), reachability, boundedness, invariants, system modeling. Prerequisite: CS 431 and 493.

5592 Design And Analysis Of Algorithms (3). Combinatorial analysis, searching and sorting, shortest path algorithms, spanning trees, search and traversal techniques, backtracking, branch and bound, heuristics, algebraic simplification and transformation. Prerequisite: CS 352.

5594 Introduction To Queueing Theory (3). Review of statistics and probability, stochastic processes, Markov Processes, the basic Poisson process, equilibrium conditions, M/M/1 system with variations local and global balance in networks of queues, open and closed networks. Prerequisite: CS 494R.

5595 Mathematical Foundations Of Computer Science (3). Study of the theory, and algorithmic techniques, of the fields of graph theory, combinatorics and number theory, as they relate to their application in the field of computer science. Prerequisite: CS 352 and CS 494R, or Consent of Instructor.

5596A Computer Security I: Cryptology (3). Study of theory, and algorithmic techniques, of the fields of number theory and cryptology, as they are applied in the general area of computer and network security. Prerequisites: CS291.

5596B Computer Security II: Applications (3). Application of the algorithmic techniques learned in CS 596A to provide suitable security countermeasures to the variety of security threats across the spectrum of computing. Prerequisite: CS 596A.

5597 Directed Readings (1-3). Readings in an area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration.

5598 Research Seminar (1-3). Graduate research based on intensive readings from the current research literature under the direction of a faculty member. Arrangements must be made prior to registration.

5599 Research And Thesis (1-6). A project investigation leading to a thesis, or written report under the direction of a faculty member. A prospectus must be accepted prior to registration.

5622 Advanced Network Analysis (3). Design and analysis of data networks, comparative analysis of capacity and flow strategies, time-delay/cost trade offs, concentration and buffering in store and forward networks, random access techniques, pure, slotted and reservation type Aloha schemes, carrier sense multiple access. Prerequisite: CS 5522.

5623 Network Simulation And Modeling (3). Simulation and modeling of network topologies and protocols, evaluation of the physical layer, data-link layer, network layer routing algorithms, local and long-haul networks. Prerequisite: CS 522 and 532.

5651 Distributed Computing For Software Systems (3). Formal descriptions of problems encountered in distributed computing for architecture. Parameters to formal requirements, operating system support, communications support, process synchronization, and system verification, distinctions between real time and concurrent time. The nature of life cycles, project organization and use of automated tools. Prerequisites: CS 5551, CS 5531 OR CS 5570.

5670 Architecture Of Distributed Database Systems (3). Detailed study of distributed database systems architecture, in-depth study of distributed transaction management, distributed concurrency control and recovery

algorithms, database distribution, distributed query optimization and analysis of database system design, and intelligent network databases. Prerequisites: CS 5570 or consent of instructor.

5690 Advanced Special Topics (1-3). A lecture course presenting advanced research level topics. Prerequisite: Ph.D candidacy or consent of instructor. On demand. This course is intended to allow faculty and visiting scholars to offer special courses in selected research areas.

5694 Advanced Queueing Theory (3). Non-Markovian systems such as M/G/1, G/M/1 and G/G/1, solutions of networks of non-Markovian nodes, queueing network approximate solution techniques. Prerequisite: CS 5594.

5697 Directed Readings (1-3). Readings in an area selected by the doctoral student in consultation with a doctoral faculty member. Arrangements must be made prior to registration.

5698 Advanced Research Seminar (1-3). Advanced research by a group of doctoral students based on intensive readings from the current research literature under the direction of one or more doctoral faculty. Original research results of each student are exchanged by presentations and group discussion. Arrangements must be made prior to registration.

5699A Research And Dissertation Research In Computer Science (1-12). Doctoral research in computer science.

5899 Required Grad Enrollment (1).

Electrical and Computer Engineering (ECE) Courses

5501AP Special Topics In Electrical Engineering (1-4).

5501NN Special Topics In Electrical Engineering (1-4).

5512 Microwave Remote Sensing (3). Basic principles of remote sensing including scattering, absorption, transmission, and reflection of microwave energy. Basic radiative transfer theory. Microwave remote sensing systems including altimeters, scatterometers, radiometers, & synthetic-aperture systems. Principle applications of remote sensing systems including imaging, atmospheric sounding, oceanographic monitoring, ice-sheet dynamics, etc. Prerequisite: ECE 414.

5516 Computer Networks (3). Concepts and goals of computer networking, structure of computer networks, OSI model and layers, network control, analysis, design and management, data communication techniques including fiber optics, WAN, MAN and LAN architecture and protocols, internetworking, case studies and hand-on studying the performance by analytic modeling and computer simulation. Prerequisite: ECE 424 or instructor's consent.

5528 Digital Hardware Systems Design (3). Characteristics and parameters of various hardware subsystem including main memory, auxiliary memory, arithmetic units, card equipment, etc., and principles of organization into efficient system. Prerequisite: ECE 428.

5530 Digital Electronics (3). Electronic hardware aspects of digital systems. Includes state-of-the-art information on integrated-circuit logic devices and their applications. Prerequisite: ECE 435 or instructor's consent.

5532 Biomedical Instrumentation (3). Biomedical objectives, physical and engineering principles; optimal equipment design and actual performance of biomedical instrumentation; considers practical instrumentation problem solutions and unsolved problems. Prerequisite: ECE 330 and instructor's consent.

5535 Hdl-Based Digital Systems Design (3). This course covers hardware design techniques using a Hardware Description Language (HDL). It also discusses several digital system design methodologies, including structural specifications of hardware, HDL-based simulations and testbenches. Courses focus on the synthesis methodologies for use-defined primitives (UPD), data types, operators, Verilog constructs multiplexed datapaths, buses, bus drivers, FSMs, assignments, case, functions, tasks, named events and rapid protyping techniques with Verlog HDL, ASICs and FPGAs. Prerequisites: ECE 226 (Logic Design) or consent of instructor.

5536 Power Electronics II (3). Circuit concepts and analysis techniques for transistor switching regulators, thyristor choppers, transistor inverters, self-commutated thyristor investers and cycloconverters. Prerequisite: ECE 436.

5568 Economics Of Power Systems (3). Transmission loss formula coefficients, incremental costs and losses, economic scheduling of generation, and applications. Prerequisite: ECE 466 and ECE 467.

5572 Antennas & Propagation For Wireless Systems (3). This course introduces the mathematical aspects of the basic antenna parameters such as vector potential, gain, directivity, impedance, radiation patterns, and develops a comprehensive theory of antenna arrays including the effects of mutual coupling. In-depth modeling studies for wire, aperture and mircrstrip antennas, is presented; diffraction of plane electromagnetic (TE and TM) waves by perfectly conducting half-planes and wedges- applications to site-specific propagation path modeling in wireless systems. Prerequisites: ECE 412 and ECE 341 (or their equivalents) and written communication skills; must have a knowledge of MATLAB, C or C++ for computational work. Recommended: Prior or concurrent enrollment in PHYS 5500.

5579 Digital Signal Processing In Telecommunications (3). Applications of digital signal processing in telecommunications systems; oversampling and quantization, Delta-Sigma modulation, linear predictive speech coding, adaptive filtering, echo canceller, adaptive receivers and equalizers for wireless communication, digital cellular, CDMA. Prerequisites: ECE 474 and ECE 480.

5580 Advanced Digital Signal Processing (3). Topics in digital signal analysis and filtering, including hardware implementation, speech synthesis and recognition, multi-dimensional transforms, random-signal concepts, design methods and computer aids to analysis and design. Prerequisite: ECE 480.

5586 Pattern Recognition (3). Decision functions, distance measures, minimum distance classifiers, hard clustering methods, fuzzy clustering methods, statistical pattern recognition methods, Bayesian classifiers, error probabilities, estimation of density functions, perceptrons, least-mean-square algorithms, feature selection, dimensionality reduction and syntactic pattern recognition. Prerequisites: CS 394R or MATH 436, course in high-level programming language, some matrix theory and linear algebra or instructor's consent.

5588 Communication Theory I (3). Generalized communication systems, signal processing, signals as random processes, optimum receivers. Prerequisite: A statistics course, ECE 478, and CS 394R

5590 Special Topics In Electirical And Computer Engineering (1-4).

5590AE Special Topics In Electirical And Computer Engineering (1-4).

5590B Special Topics In Electrical And Computer Engineering (1-4).

5590BB Special Topics in Electrical and Computer Engineering (1-4).

5590BE Special Topics In Electirical And Computer Engineering (1-4).

5590BP Special Topics In Electirical And Computer Engineering (1-4).

5590C Special Topics In Electrical And Computer Engineering (1-4).

5590CA Special Topics In Electirical And Computer Engineering (1-4).

5590CD Special Topics In Electirical And Computer Engineering (1-4).

5590CL Special Topics In Electirical And Computer Engineering (1-4).

5590CS Special Topics In Electirical And Computer Engineering (1-4).

5590DC Special Topics In Electirical And Computer Engineering (1-4).

5590DE Special Topics (1-4).

5590DS Special Topics In Electirical And Computer Engineering (1-4).

5590ER Special Topics In Electirical And Computer Engineering (1-4).

5590ES Special Topics In Electirical And Computer Engineering (1-4).

5590IP Special Topics In Electirical And Computer Engineering (1-4).

5590MC Special Topics In Electirical And Computer Engineering (1-4).

5590NA Special Topics In Electirical And Computer Engineering (1-4).

5590NN Special Topics In Electirical And Computer Engineering (1-4).

5590NR Special Topics In Electirical And Computer Engineering (1-4).

5590ON Special Topics In Electirical And Computer Engineering (1-4).

5590PG Special Topics In Electirical And Computer Engineering (1-4).

5590PL Special Topics In Electirical And Computer Engineering (1-4).

5590PR Special Topics In Electirical And Computer Engineering (1-4).

5590PS Special Topics in Electrical and Computer Engineering (1-4). Special Topics in Electrical and Computer Engineering.

5590RD Special Topics In Electirical And Computer Engineering (1-4).

5590T Special Topics In Electirical And Computer Engineering (1-4).

5590WW Special Topics ECE (1-4).

5590XX Special Topics In Electirical And Computer Engineering (1-4).

5597 Directed Readings (1-3). Readings in an electrical and computer engineering areas selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration. Prerequisite: Permission of instructor

5598 Research Seminar (1-3). Graduate research and/or readings in an electrical and computer engineering area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration. Prerequisite: Permission of instructor

5599 Research (1-6). Independent investigation in field of electrical engineering to be presented in the form of a thesis.

5600 Problems (2-5). Supervised investigation in electrical engineering to be presented in form of report.

5606 Electromagnetic Scattering And Antenna Theory (3). Dyadic analysis; integral equations and Green's functions; field theorems-uniqueness, induction equivalence, reciprocity; image and Babinet's Principles; applications to antennas; method of stationary phase and applications to aperture antennas; array antennas and mutual coupling analysis; method of moments; asymptotic techniques and applications to EM scattering from wedges, sylinders, and spheres; RF propogation path loss modeling and conformal antennas. Prerequisite: ECE 412 is required and Physics 500 is recommended.

5616 Parallel And Distributed Processing (3). Covers the fundamental issues involved in designing and writing programs for simultaneous execution. Semaphores and monitor constructs are covered to provide a basis for critical section programming. Expansion of these concepts provide a basis for the analysis and design of control systems for multiprocessor devices and computer networks. Prerequisites: A suitable systems programming course or instructors consent.

5617 Neural Network Based Computing System (3). The course will consider computing systems based on neural networks and learning models, along with implementations and applications of such systems. Prerequisite: Instructor's consent.

5618 Artificial Intelligence (3). Concepts, theories, and models pertaining to neural nets, pattern recognition, learning systems, and programmed problem solving. Prerequisite: Instructor's consent.

5619 Theory Of Automata (3). Sequential machines: Turing machines; deterministic and stochastic automata; applications of automata. Prerequisite: instructor's consent.

5624 Digital Software Systems Design (3). Characteristics and parameters of various software subsystem including assemblers, compilers, utility programs, special programming packages, interpreters, and operating systems; and principles of organization into efficient systems. Prerequisite: ECE 524.

5635 Vlsi Systems Design (3). Course discuss design of the MOSFETs (nFETs and pFETs), and high speed CMOS cascades in VLSI. It also covers the design of various arithmetic circuits, different fast adders, memories, and chip-level physical designs requirements in the VLSI subsystems are also the focus of this course. It uses Verilog HDL/VHDL as a tool to design VLSI systems. Prerequisites: ECE 535 or knowledge of VHDL or instructor's consents

5642 Advanced Integrated Circuits (3). Fundamentals of advanced integrated circuit design; diffusion, ion implantation and epitaxy; MOS and bipolar techniques; survey of current LSI design, fabrication and testing.

5644 Liapunov And Related Nonlinear Methods In Automatic Control (3). A study of nonlinear methods in automatic control including phase plane analysis, describing function techniques, basic definitions and theorems of Liapunov, methods of generating Liapunov functions, applications of Liapunov's methods, and Popov's methods. Prerequisite: ECE 544.

5645 Optimal Control Theory (3). Analysis and design of dynamic systems using optimal control theory parameter optimization, dynamic optimization, computational methods, differential games. Prerequisite: ECE 544.

5646 Stochastic Optimal Estimation And Control (3). Surveys random process theory; stochastic control and optimization; estimation and filtering based on Kalman-Bucy techniques; stochastic stability; adaptive and learning control systems. Prerequisite: ECE 544.

5660 Power-Systems Stability (3). Performance of synchronous machines under transient conditions, power system stability, system fault computations using symmetrical components; computer solutions of power system problems.

5661 Solid State Energy Conversion (3). Solid state direct energy conversion; and design of thermoelectric generators and heat pumps.

5662 Power Electronic Drives (3). Advanced study of dc and ac motor drives controlled by power electronic methods, including phase controlled rectifier de chopper, cycloconvertyer, variable frequency inverters. Prerequisite: ECE 536 or consent of instructor. Recommended: ECE 544 and ECE 562.

5664 Lightning And Switching Surges In Power Systems (3). Overvoltage, switching surge and lightning effects of a power system. Use of grounding and lightning arresters. Effects of surges off and on machines. Prerequisites: ECE 466 and ECE 467, or equivalent.

5668 Advanced Computer Methods In Power System Analysis (3). Power system matrices. Sparse matrix methods. Advanced load flow analysis techniques and concepts. Contingency analysis. State estimation. Prerequisites: ECE 466K and strong background in FORTRAN or C.

5670 Direct Current Power Systems (3). Characteristic and performance analysis of DC transmission lines and associated conversion systems.

5672 Power Systems Relaying (3). Theory of relaying systems for power system protection, improvement of power system stability. Relay coordination; performance of relays during transient swings and out-of-step conditions. Prerequisite: ECE 466.

5674 Machine Intelligence (3). Formal languages in relation to natural language processing; formal languages, graphs, and image processing; formal logic and automated theorem proving; natural language processing; aspects of problem solving and heuristic programming.

5675 Introduction To The Modeling And Management Of Uncertainty (3). Theoretical and practical issues in the modeling and management of uncertainty. Topics include probabilistic uncertainty, belief theory and fuzzy set theory. Applications to computer vision, pattern recognition and expert systems.

5676 Advanced Electric Circuit Analysis (3). Specialized study of mathematical analysis as applied to solutions of circuit networks with fixed and variable parameters.

5677 Network Synthesis (3). Surveys linear active and nonreciprocal circuit elements, realizability conditions, methods for synthesizing active networks, and practical applications. Prerequisite: ECE 676.

5680 Digital And Sample-Data Systems (3). Introduces sampling and quantization, design of digital and sample-data systems, digital filters, adaptive sampling and quantization. Prerequisite: ECE 480.

5681 Applications Of Transforms (3). Applications of Laplace and other transform methods of solution of circuit and field problems.

5682 Coding Theory II (3). Further study of error-correcting codes; ring and cyclic codes, linear switching circuits, burst error codes, codes for arithmetic units, etc. Prerequisite: ECE 579.

5684 Computer Vision (3). Image processing methods for segmentation, object representation, scene description and scene interpretation. Prerequisite: ECE 484 or consent of instructor.

5688 Communication Theory II (3). Probability theory of analog and digital communication in the presence of random process noise. Encoding systems, detection systems, optimum receivers. Prerequisite: 472.

5690 Advanced Topics In Electrical And Computer Engineering (1-4).

5690EM Advanced Topics In Electrical And Computer Engineering (1-4).

5690ET Advanced Topics In Electrical And Computer Engineering (1-4).

5697 Advanced Directed Readings (1-5). Advanced readings in an electrical and computer engineering area selected by the graduate student in consultation with a faculty member. Arrangements must be made prior to registration. Prerequisite: Permission of instructor Offered: Every semester

5698 Advanced Research Seminar (1-5). Advanced Graduate research and/or readings in an electrical and computer engineering area selected by the doctoral student in consultation with a faculty member. Arrangements must be made prior to registration. Prerequisite: Permission of instructor Offered: Every semester

5699 Dissertation Research (1-9). Doctoral Dissertation