GRADUATE STUDENT HANDBOOK

(rev 8/2006)

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Graduate School Forms and instructions for forms are available at:
http://www.colostate.edu/Depts/Grad/FormsPublications.html

This Graduate Student Handbook has been designed to assist graduate students in Electrical and Computer Engineering as they progress towards meeting degree requirements. The Graduate Student Handbook is a supplement to the Colorado State University *Graduate and Professional Bulletin* whose regulations govern all advanced degrees in the University. Students working toward advanced degrees in Electrical and Computer Engineering must meet the graduate school requirements and, hence, should make themselves familiar with the *Graduate and Professional Bulletin.*

Electrical and Computer Engineering Graduate Student Handbook

Introduction

Graduate programs began at Colorado State University in 1891. Graduate programs in Electrical and Computer Engineering leading to Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees were instituted in 1957. The program leading to a Master of Electrical Engineering (M.E.E.) was instituted in 1999 and replaced with the Master of Engineering (M.E.) in 2001. These programs provide broad-based, high-quality education in the rapidly advancing scientific and technological aspects of Electrical and Computer Engineering. The graduate curriculum is structured to provide a wide spectrum of courses leading to a research specialization in an area of interest to the student. Appendix A, listing the Electrical and Computer Engineering faculty and their research interests, should be consulted when seeking an M.S. thesis or Ph.D. dissertation research advisor.

Master of Engineering Program

The Master of Engineering Degree (M.E.) is designed for those who desire a level of education beyond that typically afforded by a BSEE program but who are not interested in pursuing a traditional research oriented M.S. Degree. The M.E. degree is based entirely on coursework and offers considerable flexibility for designing a program of study consisting of courses in electrical and computer engineering in addition to credits in other areas such as business or computer science.

Specific Program Details

- Thirty semester credit hours of coursework.
- No thesis or final report is required.
- No final oral exam is required.
- No GRE examination is required for admission.
- An undergraduate GPA of 3.0 or higher is required for admission to the degree.
- There are no required courses. The program of study can be customized to meet the needs of the student.
- Up to 15 credits of coursework may be taken outside of electrical and computer engineering, subject to approval by the M.E. advisor and the Electrical and Computer Engineering Graduate Committee.
- Up to 6 credit hours of senior level undergraduate electrical engineering courses can be taken at Colorado State University and used towards the degree.
- Up to 6 credits of graduate level coursework can be transferred from other accredited schools.
- A minimum of 21 credits earned at Colorado State must be in 500 or higher level courses.
- No independent study coursework will be accepted.
- No campus residency is required.
- TA and RA positions are not available for students in this program.

Program Requirements

Admission to the M.E. program from the MS program requires the student to have at least a 3.00 GPA in EE courses taken to date (effective Fall 2000).

To graduate with a M.E. degree requires the student to have at least a 3.00 GPA in EE courses taken (effective Spring 2001).

In both above cases, the EE GPA will be calculated based on all EE500 level and above courses taken at Colorado State (with the exception of thesis and independent study credits), no more than 6 credits of EE400 level courses at Colorado State, and no more than 6 credits of EE500 level and above courses from another university.

Associate degrees and Bachelor of Electrical Engineering Technology (BSEET) degrees do not provide adequate background for admission to the M.E. program in Electrical and Computer Engineering.

For information on admission of non-electrical engineering students and for procedures regarding this degree, see the sections below under Master of Science Program.

Master of Science Program

Admission

Faculty in the Department of Electrical and Computer Engineering (ECE) seek to make graduate study a personal experience. Graduate students can tailor their study according to their goals, whether through a research-oriented plan of study involving a thesis, or through a coursework-only plan. Students doing thesis research work very closely with a faculty member, and, to a certain extent, are "hand picked" by the faculty to work on specific research projects. Students planning to work toward the M.S. degree should apply for admission as early as possible, preferably two semesters (including summer) before their intended date of entrance to give the faculty an opportunity to review their application materials.

Admission to the M.S. program generally requires a B.S. degree form an accredited electrical and/or computer engineering program and an undergraduate grade point average (GPA) of 3.50 (A = 4.00) or better (see exceptions below). In addition, the general test of the Graduate Record Examination (GRE) is required. The department may petition to defer this requirement for students with outstanding academic credentials or when there are time constraints. In those cases, the student will be required to take the GRE during his/her first semester at Colorado State University.

Associate degrees and Bachelor of Electrical Engineering Technology (BSEET) degrees do not provide adequate background for admission to the M.S. program in Electrical and Computer Engineering.

Electrical and Computer Engineering Students with a GPA < 3.50

Applications in such cases are considered on a case-by-case basis, but there must be documented indications that the student is capable of maintaining at least a "B" average in graduate courses. Strong letters of recommendation, high GRE scores, good grades in any graduate courses taken beyond the B.S. degree, and significant improvement during the course of undergraduate study are factors that may be considered. If admitted, these students must take courses specified by the student's advisory committee and must earn a grade of "B" or better in each of the first 4 courses taken. Failure to meet this grade requirement will be cause for immediate dismissal from the program. The student's advisory committee may impose additional requirements at its discretion.

Advisor and Advisory Committee

An M.S. advisory committee consists of at least three faculty members, one of whom must be from a department outside of Electrical and Computer Engineering. To a large extent, the success of a graduate student's program can be traced to the choice of advisor and advisory committee; hence some care should be taken in its formulation. The committee provides guidance in prescribing the student's program of study and ensuring that Graduate School requirements and standards are met, and serves as a source of expertise for the student's research studies. The committee is formalized by completion of GS Form 6. This should be submitted prior to completion of 12 credits or the second semester, whichever comes first.

Permanent committee replacements are arranged by filing a GS form 9A. Signatures are required for any member(s) dropped from the committee; additionally, advisor/co-advisor changes require the signatures(s) of the individual(s) added and dropped. This form also requires the signatures of the student, advisor, department head, and graduate school representative.

Whenever a member will be absent for an important function of the committee, or when a member will be absent for a semester or more, a replacement will be designated by the department head with concurrence of the faculty member being replaced. The department head shall designate any eligible replacement by letter to the Graduate School indicating the time period during which the replacement shall serve. At the expiration of the designated time period, the original member shall resume membership.

Program of Study and Coursework

GS Form 6, the Program of Study, must be filed prior to completion of 12 credits or the second semester, whichever comes first. The purpose of the program of study is to ensure the graduate student is working toward well-defined goals approved by his/her advisory committee while meeting departmental and graduate school standards. The Graduate School reviews each GS-6 and determines whether or not the program of study conforms to University policy. Problems are reported to the student and department so that they can be corrected.

Plan A requires a thesis and completion of a minimum of 30 credits. Of this 30, 21 credits must be in regular course work other than independent study or research. No more than 6 credits are allowed at the 400 level. The remaining credits must be 500 level or above.

Plan B requires a minimum of either 32 credits of regular courses other than independent study or research, or 27 credits of regular courses (other than independent study or research) and 3 credits of independent study with the submission of a report. No more than 6 credits are allowed at the 400 level. The remaining credits must be 500 level or above. The Plan A and Plan B options will involve a final examination as described below (see the "Final Examination" section).

Both Plan A and Plan B students may take up to 9 regular course credits outside of the Electrical and Computer Engineering Department.

Under unusual and extenuating circumstances a student may petition the ECE Graduate Committee to change from the Plan A program of study to Plan B. This change must be approved by the student's advisor and must clearly describe the extenuating circumstances involved, in writing, to the Chair of the ECE Graduate Committee. Extenuating circumstances may include, for example, financial exigencies or the advisor leaving the university. Electrical and Computer Engineering Graduate Committee approval will be required prior to the change.

Changes in the GS Form 6

Modifications to the GS Form 6 must be formally approved by the graduate advisor and advisory committee. Courses that have been taken and for which a grade has been received (A through F, I, S or U) may not be removed from the Program of Study. Changes in the program of study should be made with extreme care since the Graduate School makes no additional comprehensive checks until the time of graduation.

Changes to the Program of Study are recorded on the GS Form 25 which is filed during the semester of graduation and prior to the published deadline (approximately 6 weeks after the beginning of the semester). For more information about the GS Form 25 see **Application for Graduation** on page 4.

Transfer Credit

For the Master of Science degree, a minimum of 24 credits must be earned at Colorado State University, 21 of which must be earned after admission to the Graduate School. No more than 6 credits from an institution other than Colorado State may be applied toward the M.S. degree. Students petitioning the advisory committee to transfer credits from another institution must attach a description of the courses taken (course content, text, grade) to their GS Form 6 so that an effective evaluation can be made. Courses accepted for transfer must be at the equivalent of the 500 level or above. Credits earned at institutions not accredited by one of the major regional accrediting agencies are not acceptable for transfer except that the Department may petition the Graduate School to have graduate level courses earned from a foreign institution accepted as transfer credit. Grades in courses accepted for transfer will not be included in calculation of the grade point average. No courses will be accepted for transfer with a grade less than B.

Distance learning students should apply for formal admission to either the Master's Plan A or Plan B or the M.E. program by the time they have completed 9 credits of graduate work.

Final Examination

During the last semester of a graduate student's M.S. program a final examination will be administered by the student's committee.

(A) Plan A: The examination will be an oral defense of the M.S. thesis. Fundamentals from course work may also be covered. Upon completion of the final examination it is the student's responsibility to submit the GS Form 24 (Report of Final Examination Results) to the Graduate School. This form must be received in the Graduate School within TWO working days after the examination results are known.

(B) Plan B (with Independent Study): Students who choose to do 27 credits of regular course work and at least 3 credits of independent study will submit a report on their independent study; evaluation of this report constitutes the M.S. final examination. Upon completion of the final examination it is the student's responsibility to submit the GS Form

24 (Report of Final Examination Results) to the Graduate School. This form must be received in the Graduate School within TWO working days after the examination results are known.

(C) Plan B (Coursework only): No action on the part of the student is required. The Department will handle processing of the GS Form 24. The Final Examination will consist of verification of satisfactory performance in course work.

All examinations are held on the Colorado State University campus and must be scheduled at least one month before the examination date. M.S. Plan A final exams are announced via email to the student's advisory committee, Electrical and Computer Engineering faculty, and graduate students with an email. The online Defense Announcement Form at http://www.engr.colostate.edu/ece/current_students/defense_form.cfm must be completed for department announcements to be made.

Application for Graduation

Before the end of the sixth week of the semester in which the student plans to graduate, or end of the first week of the eight-week summer term, a GS Form 25 and GS Form 25A must be filed with the Graduate School. Any changes to the original GS Form 6 (courses added or dropped) are to be made on this form and approved by the student's advisor and the department head.

Graduate degree candidates must be either enrolled for at least one credit or must register for "CR-ON", *Continuous Registration-On Campus*, (see page 7 for an explanation of "CR", Continuous Registration) during the term (fall, spring, or summer) in which they complete their degree requirements.

Doctor of Philosophy

Admission

Students who have received a Master of Science degree in Electrical and Computer Engineering or equivalent will be considered for admission to the Ph.D. program. No student will be admitted to the program unless they are academically sponsored by a member of the Electrical and Computer Engineering faculty. Applications for the Ph.D. program are accepted any time during the academic year. However, because of the usual need for long-range research support, a prospective student should apply as early as possible. Students who have not yet received a Master of Science degree may be admitted as 72 hour Ph.D. candidates upon approval of a member of the Electrical and Computer Engineering faculty willing to serve as such student's academic sponsor.

The general test of the Graduate Record Examination (GRE) is required for application to the graduate school. The department may petition to defer this requirement for students with outstanding academic credentials or when there are time constraints. In those cases, the student will be required to take the GRE during his/her first semester at Colorado State University.

Advisor/Committee

A Ph.D. graduate committee consists of at least four academic faculty members. At least two members must be from the Electrical and Computer Engineering Department and at least one must be from an outside department. Students are encouraged to include an Electrical and Computer Engineering faculty member from outside his/her major area of specialization. It is recommended that a student's committee have several members with expertise in his/her proposed research field. Industrial participation is encouraged if appropriate, however, only academic faculty may vote at the final examination. The student's graduate committee should be formed during the first semester following admission to the program.

For changes in committee membership a GS Form 9A must be completed. See the appropriate section under "Master of Science Program".

Program of Study

A minimum of 42 semester credits is required beyond the M.S. level. Eighteen of these credits must be in regular graduate course work, other than independent study and research. However students who, as a result of their research, have two or more papers accepted for publication in peer review journals or peer review conference proceedings may petition their Graduate Committee to approve an "Independent Study" course to replace three of the required 18 credits of formal course work. At least 6 credits, exclusive of "Independent Study" credits, must be at the 600 level or above. Courses at the 400 level and below will not be accepted towards the Ph.D. The courses taken for these credits can be in any technical area which is approved by the student's committee subject to the Course Requirements section below. (See also the Ph.D. qualification section).

Students pursuing a 72 credit Ph.D. program will be required to meet the "Program of Study" requirements for both the Ph.D. and M.S. programs of the Department. This includes, 42 credits of regular graduate course work, other than independent study and research. No more than 6 of these credits are allowed at the 400 level and at least 6 must be at the 600 level or above. The remaining 32 credits can be in any technical area which is approved by the student's committee subject to the Course Requirements section below (See also the Ph.D. Qualification section).

The Ph.D. graduate student should arrange a formal meeting with his/her committee to review and approve the program of study which must be reported to the Graduate School using form GS6. Following admission to the Ph.D. degree program, the student must be on campus at Colorado State University for at least two academic year semesters, or two consecutive semesters, one of which may be a summer session, and must earn at least 9 credits during each of these two semesters/sessions.

Changes in the GS Form 6

Modifications to the GS Form 6 must be formally approved by the graduate advisor and department head. Courses which have been taken and for which a grade has been received (A through F, I, S or U) may not be removed from the Program of Study. Changes in the program of study should be made with extreme care since no additional comprehensive checks are made by the Graduate School until the time of graduation.

Changes to the Program of Study are recorded on GS Form 25 which is filed during the semester of graduation and prior to the published deadline (approximately 6 weeks after the beginning of the semester).

Transfer Credit

Up to ten credits may be accepted for transfer if recommended by the student's graduate committee. Students petitioning for acceptance of transfer credit must submit descriptions of the courses taken (content, text, and grade) to the departmental graduate committee with their GS Form 6. Courses accepted for transfer must be at the equivalent of the 500 level or above. Credits earned at institutions not accredited by one of the major regional accrediting agencies are not acceptable for transfer; except that the Department may petition the Graduate School to have graduate level courses earned from a foreign institution accepted as transfer credit. Grades in courses accepted for transfer will not be included in calculation of the grade point average. No courses will be accepted for transfer with a grade less than B. Transfer students must complete a minimum of six credits of formal coursework at the 600 level or above at CSU.

Ph.D. Qualifying Exam

Before the end of the third semester following admission to the Ph.D. program, students will take an oral qualifying examination. The student's advisor, in agreement with his/her committee, will choose one or more "classical" published papers. The student will present an analysis, critique and discussion of the papers, and may be questioned on the contents of the presentation by committee members and others in attendance. The student may also be questioned on coursework. The title of these papers shall be given to the candidate no more than two weeks prior to the scheduled examination. Anyone failing the qualifying exam will have the option of taking a second qualifying examination no more than one semester after the date of the previous exam.

Ph.D. Preliminary Examination

Approximately one year (no less than two semesters) before graduation, a Ph.D. candidate in good standing must take an oral preliminary examination focusing on his/her proposed dissertation research. The purpose of this examination in the Electrical and Computer Engineering Department is to determine if the Ph.D. candidate has achieved sufficient maturity in the program of study to be given final approval for completion of the research. Preliminary examinations must be announced to the Department Graduate Coordinator no less than **two weeks** in advance. Preliminary exams are announced to Electrical and Computer Engineering faculty, graduate students, and committee members through email.

To assist the committee in its evaluation, the student will prepare a dossier containing his/her resume and copies of published reports and papers. In consultation with his/her advisor, the candidate will prepare a clear statement of proposed continuing research activity. One copy of these materials must be delivered to each committee member **one week** prior to the examination.

Based on the examination results, the student's committee will recommend one of the following courses of action:

(A) that he/she be endorsed as a Ph.D. candidate,
(B) that he/she submit to another preliminary examination no sooner than 2 months and no later than 12 months after the first exam, or
(C) that he/she withdraw from the Ph.D. program.

A report of the results of the preliminary examination must be submitted to the Graduate School by the student within two working days of the exam on GS Form 16.

Ph.D. Final Examination

At least **one month** before the final examination the student's advisor will determine the nature and scope of the examination and so inform the student and the committee. In general the format will be that of an oral defense, although the advisor may require an additional written and/or oral examination of any part of a student's program of study. It is the policy of the Department of Electrical and Computer Engineering that the Ph.D. final examination be held on the main campus and that attendees at the final examination be allowed to ask questions.

The online Defense Announcement Form at http://www.engr.colostate.edu/ece/current_students/defense_form.cfm must be completed for department announcements to be made. To provide for faculty and graduate student interaction, the final examination will be announced and distributed to all Electrical and Computer Engineering faculty and graduate students.

In addition to this departmental announcement, and in order to announce the dissertation defense

to the University and public at large, the Graduate School must be notified no less than **two weeks** in advance of the examination on GS Form 23.

The report of the results of the final examination must be submitted to the Graduate School on GS Form 24 by the student within two working days of the exam.

Application for Graduation

Before the end of the sixth week of the term in which the student plans to graduate, or end of the first week of the 8 week term if he/she plans to graduate in the summer semester, he/she must file a GS Form 25 and GS Form 25A with the Graduate School. Any changes to the original GS Form 6 (courses added or dropped) are to be made on this form, which must be signed by the student's advisor and the department head.

Graduate degree candidates must be either enrolled for at least one credit or must register for "CR-ON" (see page 7 for an explanation of "CR", Continuous Registration) during the term (fall, spring, or summer) in which they complete their degree requirements.

Scholastic Standards

To meet the requirements for graduation and to remain in good academic standing, a student must demonstrate acceptable performance in course work after being admitted to a graduate program. This requires a cumulative 3.00 grade point average in all regular course work. Regular course work is defined as courses other than independent or group studies, research courses, open seminars, thesis/dissertation credits, study abroad, U.S. travel, supervised college teaching, student teaching, practicum, internship, field placement, unique title courses offered through the Division of Educational Outreach, and any courses graded pass/fail. Overall a 3.00 grade point average must be maintained in regular and non-regular courses graded
traditionally (A through F). The grade point average in required courses included on the approved program of study (GS Form 6) must also equal at least 3.00.

In addition, good academic standing requires *satisfactory progress* in the overall graduate program. Students' individual graduate advisory committees may render judgments as to whether satisfactory progress is being made toward the degree, taking into account all aspects of academic performance and promise, not necessarily course work alone. A positive judgment is required to remain in good academic standing.

Failure to maintain good academic standing results in being placed on *academic probation*. (New regularly admitted students will not be placed on probation until they have completed 12 credits or two semesters of graduate work, whichever comes fist.) The probationary period extends for one semester beyond the one in which this status is acquired. Students on probation are subject to dismissal by the academic department or the Dean of the Graduate School at the end of the probationary semester unless good academic standing has been regained. This requires adequate improvement in cumulative grade point averages (3.00) and/or satisfactory progress as determined by the student's graduate advisory committee.

A student's graduate advisory committee or an appropriate departmental graduate committee may recommend immediate dismissal upon a finding that the student is making unsatisfactory progress toward the degree and that satisfactory progress cannot reasonably be anticipated. Such a recommendation must be documented in writing with substantive justification for this action in lieu of probation. It must be referred to the Department Head for approval and the Dean of the Graduate School for final action. The student may appeal such an immediate dismissal through the existing Graduate School appeals procedure.

Continuous Registration ("CR")

All graduate students at Colorado State University are required to be continuously registered in the fall and spring semesters throughout their degree programs. This policy applies from the time of the first enrollment through the graduation term. Registration is also required during the summer term if University resources are used. Students may fulfill this requirement by registering for any graduate credit-bearing course. As an alternative, students may opt for Continuous Registration (CR) status. Registration for CR status is accomplished in the same way as registration for courses. Section ID numbers for on-campus (primarily on campus) and off-campus (absent from campus) appear in the class schedule under the CR prefix (CR-ON, *Continuous Registration-On Campus*, and CR-OFF, *Continuous Registration-Off Campus*).

There is no charge for CR-OFF status, but CR-ON students are assessed a $100 fee in the fall and spring semesters of each academic year and $50 during the summer to cover their use of certain University resources. CR-ON students have access to the Library, computer, and research laboratories, or other University facilities as determined appropriate by their advisors or as generally available with payment of part-time student fees.

Graduate Student Responsibilities

Graduate students are responsible for knowing any special expectations and requirements of their department and program and are expected to remain in good academic standing by making satisfactory degree progress and must at all times have an adviser.

Students judged to be making unsatisfactory progress toward a degree or whose work is not of the quality expected by the student's adviser and/or graduate committee may be recommended for academic probation or immediate dismissal from the graduate program (see "Scholastic Standards" in the Graduate and Professional Bulletin) and/or termination of assistantship (see "Assistantships" in the Graduate and Professional Bulletin).

The Dean of the Graduate School will be informed of students who are making unsatisfactory progress.

With regard to meeting graduate school deadlines, ultimate responsibility for a graduate student's program lies with the student. The graduate student's advisor, committee, the graduate school office, the Electrical and Computer Engineering department office, and the Electrical and Computer Engineering graduate committee are all available to help and advise. Several deadlines are critical; for example, failure to file the GS Form 6 before the end of the second semester will prevent the student from registering for further courses. Each semester the Graduate School publishes a list of deadlines which must be met in order to graduate during that term. It is also important that the graduate student provide his/her committee with ample time (at least 2 weeks) to read the student's thesis or dissertation before the final examination. (As a courtesy, two additional copies of the student's thesis should be distributed; one to the Electrical and Computer Engineering graduate committee and one to the Electrical and Computer Engineering faculty at large). Failure to meet this deadline may result in postponement of the final examination. It is the student's responsibility to ensure that appropriate Graduate School forms are properly filled out and submitted on time. M.S. Plan A and Ph.D. students **must** provide a final copy of their thesis and dissertation, respectively, to the department to be bound and kept in the departmental library. The cost of this binding is currently borne by the department.

Graduate Student Appeals Procedure

Graduate students may appeal decisions concerning unsatisfactory performance on graduate preliminary or final examinations, academic probation for reasons of unsatisfactory progress toward the degree other than insufficient grade point average, termination of an assistantship for reasons of unsatisfactory performance, or dismissal from the graduate program.

The Dean of the Graduate School and the Judicial Affairs Officer shall examine the appeal and determine whether the actions are disciplinary or academic.

If deemed to be disciplinary, the Dean of the Graduate School shall refer the complainant to the University Discipline Process.

If deemed to be an academic matter other than a grading decision, the Dean of the Graduate School shall implement the Appeals Procedures as outlined below:

- A review panel, composed of two faculty members and a graduate student, will be appointed;
- The Review Panel will consider the case in detail;
- The Panel will make appropriate recommendations to the Dean of the Graduate School;
- The Dean of the Graduate School and the dean of the college involved shall jointly review the case;
- Following consultation with the Provost/Academic Vice President, the Dean of the Graduate school shall make the final decision.

Graduate Student Representation

In accordance with the By-Laws of the Graduate Student Council, one graduate student representative and one alternate from the Electrical and Computer Engineering Department are elected to the Graduate Student Council (GSC) before the first GSC meeting of the academic year (normally held during the last week of September). The election is organized by the incumbent GSC representative and alternate, and/or the department head. If such an election is not possible, the incumbent representative or the department head may solicit volunteers for the positions. The term of office for the GSC representative is one year beginning with the first GSC meeting of the academic year. As stated in the GSC By-Laws, the responsibilities of the representative and alternate are:

1. To represent his/her department by attending scheduled meetings of the Graduate Student Council. The alternate is responsible for attending the meetings and exercising voting privileges in the absence of the representative.

2. To communicate pertinent information between the Graduate Student Council and the graduate students in his/her department.

3. To represent his/her department in extra-departmental matters as necessary.

4. To gain a thorough understanding of his/her own departmental requirements and procedures.

The GSC meets monthly except for December and the summer months.

Appendix A

Electrical and Computer Engineering
Areas of Faculty Research

Anthony A. Maciejewski, Professor and Head, aam@engr.colostate.edu
Robotics, Computer Graphics, Virtual Reality, Distributed Computing, Remote Sensing
B.S., M.S., Ph.D. (Ohio State University)
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Appendix B

Electrical and Computer Engineering
Graduate Level Courses

EE 404	**Experiments in Optical Electronics** *Concurrent registration in EE441 is required.* Experiments in optical electronics and lasers.	**3 cr.**
EE 411	**Control Systems** Feedback and forward loop control design; frequency and time domain methods; performance and stability requirements.	**4 cr.**
EE 412	**Digital Control and Digital Filters** FIR and IIR digital filter design, analog and digital invariance and direct digital control algorithms, hybrid systems analysis.	**3 cr.**
EE 421	**Telecommunications I** Digital communication (source coding; modulation and detection; channel coding), analog communication (modulation).	**3 cr.**
EE 422	**Telecommunications II** Issues of source coding, detection and estimation, and equalization; introduction of information theory.	**3 cr.**
EE 441	**Optical Electronics** Concepts of modern physics, optical properties of atoms, light sources, lasers, optical detectors, optical cavities and optical fiber transmission.	**3 cr.**
EE 444	**Antennas and Radiation** Retarded potential theory, antenna arrays, long wire antennas, dipoles, aperture antennas, receiving antennas.	**3 cr.**
EE 450	**Digital System Design Laboratory** *Concurrent registration in EE451 is required.* Small digital circuits are designed and simulated using very high speed hardware description language and synthesis tools.	**1 cr.**
EE 451	**Digital System Design** State machines with PLAs as controllers and small computers; timing and race elimination considerations; state and microprogramming implementation.	**3 cr.**
EE 452	**Principles of Digital Computer and Networking** Introduction to digital computing and networking: basic organizations of computers, networks, and computer arithmetics.	**3 cr.**
EE 453	**Digital Systems Testing I** Fault modeling, test generation algorithms, fault simulation, functional testing, design for testability, built-in self-testing	**3 cr.**
EE 454	**Database Computers** computer architecture for database processing. Data filters, associative processors, parallel and distributed computer, text search processors.	**3 cr.**
EE 456	**Computer Networks** Circuit/packet switching, protocols, LAN/MAN, TCP/IP, error correction, ATM, wireless LANS, mobile networks.	**4 cr.**
EE 457	**Optical Information Processing** Introduction to optical systems for signal and information processing with emphasis on Fourier optics.	**3 cr.**

EE 461	**Power Systems I** Design, analysis, and operation of power equipment including ac and dc machinery, transformers, and circuit breakers; power semiconductor devices.	**3 cr.**
EE 471	**Semiconductor Devices** Semiconductor physics, device fabrication technology, analysis of PN junctions, and bipolar and field-effect transistors.	**3 cr.**
EE 472	**MOS Integrated Circuits** MOS transistor theory, design rules, layout design, gate, cell and circuit design, memories, clocking strategies, MOS technologies.	**3 cr.**
EE 512	**Digital Signal Processing** Discrete time signals and systems, digital filter design and implementation, fast algorithms, quantization effects.	**3 cr.**
EE 513	**Digital Image Processing** Image acquisition and display systems, image enhancement, restoration and encoding, image analysis, real-life applications.	**3 cr.**
EE 514	**Applications of Random Processes** Bit-error rates, signal-to-noise power ration, signal detection, signal estimation, Wiener filter, application.	**3 cr.**
EE 520	**Optimization Methods for Control and Communication** Linear and nonlinear optimization theory and methods. Applications in systems, control, and communication.	**3 cr.**
EE 521	**Satellite Communication** Principles of satellite communication systems engineering.	**3 cr.**
EE 524	**Wireless Telecommunications** Physical layer design, including channel modeling, receiver design and performance, and multiple access techniques.	**3 cr.**
EE 525	**Fiber Optic Communications** Optoelectronic and optical components for fiber optics; communications system physical layer issues and examples.	**3 cr.**
EE 534	**Analog Integrated Circuit Design** Design methods for state-of-the-art analog integrated circuits, including CMOS op-amps, comparators, and phase-locked loops.	**3 cr.**
EE 535	**Analog Integrated Circuit Laboratory** *Concurrent registration in EE534 required.* Analog integrated circuits are designed and simulated using modern software tools.	**1 cr.**
EE 546	**Laser Fundamentals and Devices** Amplification of light, laser excitation mechanisms, laser devices, characteristics and design.	**3 cr.**
EE 548	**Microwave Theory and Component Design** Fundamentals and microwave engineering, components, devices, and measurements.	**3 cr.**
EE 549	**Radar Systems and Design** Fundamental ideas of radar operation and basic design of various radar types including current topics.	**3 cr.**

EE 550A-B	**Microprocessor Based Systems** High-performance microprocessors, e.g. 68000 family; intelligent I/O processors. Asyncronous bus, virtual memory, microprocessor in control and multi-user systems. *ONLY Distance Learning students may register for EE550B.*	**A-4 cr.** **B-3 cr.**
EE 554	**Computer Architecture** Current machine architectures such as SIMD, MIMD, and stack machine; overlap pipeline, parallel, and associative processing.	**3 cr.**
EE 555	**Robot Motion Planning** Concepts in geometry and spatial reasoning for the design of autonomous robots.	**3 cr.**
EE 557	**Digital Optical Computing** Optical devices; optical disks, holographic memories; interconnection networks. Optical systems for numerical and non-numerical data processing.	**3 cr.**
EE 562	**Power Electronics I** Switch mode and resonant converters, control using switch averaged dynamic models, modeling of all circuit components including sources, loads, and switches.	**3 cr.**
EE 563	**Power Electronics II** Electrical energy, processing circuits, lightweight power management, and power conversion circuits, emphasizing small signal transfer functions.	**3 cr.**
EE 564	**Resonant Converters** Analysis and design of resonant converters.	**3 cr.**
EE 569	**Micro-Electro-Mechanical Devices** Micor-ELectro-Mecanical processes and applications in sensors, optics, and structures.	**3 cr.**
EE 570	**Compound Materials and Devices** III-V and II-VI alloy semiconductors; bandgap engineering; quantum well heterostructures; HEMT, HBT, and high-performance devices; GaAsICs.	**3 cr.**
EE 571	**VLSI System Design** Design of integrated circuits at the system level including cell design, digital systems, parallel architecture, systolic arrays.	**3 cr.**
EE 574	**Optical Materials and Devices** Semiconductor light emitters and detectors, dielectrics, and light reflection from, and propagation through, anistropic dielectrics.	**3 cr.**
EE 575	**Experiments in VLSI System Design I** *Concurrent registration in EE571 is required.* Course consists of a set of labs that are designed to enhance students' understanding of the materials in EE571.	**1 cr.**
EE 576	**VLSI Processing-Science and Technology I** Physics, chemistry of VLSI processing including plasma, thermal techniques of oxidation, deposition; photolithography; etching; cleaning, process modeling.	**3 cr.**
EE 611	**Nonlinear Control Systems** Controller analysis and design for nonlinear systems	**3 cr.**

EE 612	**Robust Control Systems** Introduction to modern robust control theory techniques for analysis and design of large-scale uncertain multivariable systems.	**3 cr.**
EE 641	**Electromagnetics** Electrostatics, magnetostatics, boundary value problems, EM induction, quasi-statics, Maxwell's equations.	**3 cr.**
EE 642	**Time Harmonic Electromagnetics** Maxwell's equations, radiation, boundary value problem, dyadic Green's functions, scattering theory.	**3 cr.**
EE 650	**Extreme Ultraviolet Soft X-Ray Readiation** Fundamental principles of short wavelength electromagnetic radiation.	**3 cr.**
EE 652	**Estimation and Filtering Theory** Optimal Kalman filter estimators; smoothing and prediction; applications to communications and controls.	**3 cr.**
EE 655	**Multidimensional Digital Signal Processing** Multidimensional signals and systems, 2-D transforms, stability methods, design and implementations, spectral factorization, and image modeling.	**3 cr.**
EE 656	**Neural Networks and Adaptive Systems** Various adaptation rules, neural network paradigms, learning, stability and convergence, applications in signal/image processing and control.	**3 cr.**
EE 657	**Advanced Computer Networks** Computer network architectures, protocols, random access, performance models, priority mechanisms, circuit switching, integrated traffic, ISDN.	**3 cr.**
EE 658	**Internet Engineering** Link technologies, multiple access, hardware and software for internetworks routing, switching flow control, multicast, performance, and applications.	**4 cr.**
EE 660	**Advanced Topics in VLSI Design** VLSI synthesis, optimization, and other issues.	**3 cr.**
EE 666	**Topics in Robotics** Recent advances in robotics, automation, and intelligent systems.	**3 cr.**
EE 670 A-F	**Topics in Architecture/Systems** A) Dataflow. B) Performance evaluation and modeling C) Distributed systems. D) Architecture of advanced systems. E) Computer arithmetic. F) Microarchitecture.	**Variable [1-4 cr.]**
EE 672	**Principles of Semiconductors** Electronic properties of semiconductors' band structure, statistics, transport properties, photoelectronic properties, potential barriers, interfaces.	**3 cr.**
EE 673	**Thin Film Growth** Microstructures of physically vapor-deposited films; thin-film morphological development; atomistic processes of condensation, nucleation, and growth.	**3 cr.**
EE 712	**Topics in Control Theory** Adaptive control of deterministic systems, stochastic control, system identification, and nonlinear systems.	**3 cr.**

EE 721	**Topics in Communication Theory** Detection and estimation theory; radar-sonar problems; nonlinear modulation; information theory; communication systems.	**3 cr.**
EE 742	**Topics in Electromagnetics** Applications in wave propagation and scattering to microwave radar, Doppler radar, meteorological radar applications.	**3 cr.**
EE 744	**Topics in Plasma Dynamics** Kinetic equations, nonlinear theory of waves and instabilities; plasma fluctuation and radiations; plasma diagnostics and plasma heating.	**3 cr.**
EE 752	**Topics in Signal Processing** Adaptive filtering; spectral estimation, sonar/radar signal processing, and detection/classification schemes.	**3 cr.**
EE 773	**Topics in Solid State Electronics** advanced principles of microwave devices, solar cells, theory of solids, or transport in materials.	**3 cr.**
EE 777	**X-Ray Lasers** Fundamentals, design and implementation of soft X-ray lasers and X-ray optics.	**3 cr.**