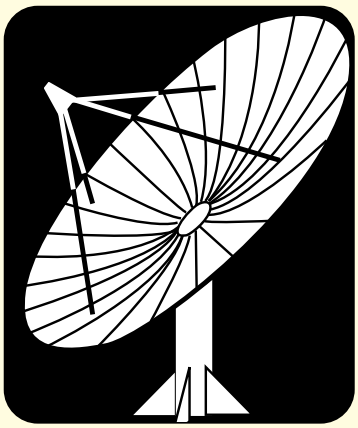

ENGINEERING— ELECTRICAL & ELECTRONIC

BACHELOR OF SCIENCE
MASTER OF SCIENCE

PROGRAM DESCRIPTION

Electrical Engineering (power distribution, motors, generators) and Electronic Engineering (integrated circuits, digital and analog hardware, electromagnetic fields, communications, controls) require the understanding and application of electrical, electronic and magnetic phenomena.

The Department offers a comprehensive program leading to a BS degree in Electrical and Electronic Engineering. Students receive thorough grounding in mathematics, physics, chemistry, computer science, and engineering science during their first four semesters. Engineering design and applications are stressed in upper division courses. Prospective students are urged to discuss their plans as early as possible with their high school or community college counselor and the EEE Department Chair, who will advise students individually.

In cooperation with the Department of Computer Science, a separate major in Computer Engineering is offered. Students deciding between Electrical and Electronic Engineering and Computer Engineering as majors should also refer to the Computer Engineering section of this catalog.

The Department offers a master's degree program in Electrical and Electronic Engineering, with specialties in control systems, power systems, communications, and digital systems, microwaves, circuits and devices, intelligent machines, and signals and systems.

The unique master's degree in Biomedical Engineering (see separate catalog section) is administered through this department.

FACULTY

S.K. Ramesh, *Department Chair*

John Balachandra; Jean-Pierre Bayard; Ronald Becker; Steve de Haas; Cynthia Desmond; Katherine Ferrara; Turan Gonen; Mahlon Heller; B. P. Lathi; Miroslav Markovic; Charles Nelson; John Oldenburg; S. K. Ramesh; James Simes; Warren Smith; Karl E. Stoffers; Suresh Vadhva; Salah Yousif

Shelley Hedberg, *Department Secretary*
Department Office, ECS-3018, 278-6873

FEATURES

The BS degree in Electrical & Electronic Engineering is accredited by the Engineering Accreditation Commission of the Accreditation Board of Engineering & Technology.

Students should join our student chapter of the Institute of Electrical and Electronic Engineers. The chapter sponsors field trips and professional meetings on campus.

The Electric Power Education Institute, housed within the department and supported by local industry, provides scholarships for students interested in power. It also provides short courses for local industry.

Students should consider summer employment in a professional office or an industry related to Electrical & Electronic Engineering. The School's Career Development Center will assist in securing summer employment with local industry.

The Department of Electrical and Electronic Engineering encourages students to participate in the University's Cooperative Education Program. They will then complete one or two six-month periods of full-time, off-campus work in their field during their upper division years. Employment with private industry or government agencies is arranged by the University's Cooperative Education Program office. Students are paid by the employer. Participating students must enroll in EEE 195A-D, but units earned for Co-op work cannot be used to satisfy the requirements for a major. Students who satisfactorily complete two work periods are awarded a certificate. The Co-op experience will enhance the student's employment prospects after graduation. Interested students should apply in the Cooperative Education Program office, LSN-2008. 278-7234.

CAREER POSSIBILITIES

Controls Engineer • Design Engineer • Research Engineer • Test Engineer • Biomedical Engineer • Product Design Engineer • Applications Engineer • Systems Engineer • Project Engineer • Product Engineer • Communication Engineer • Power Engineer • Computer Engineer • Electronic Engineer

MAJOR REQUIREMENTS • BS

Total units required for BS: 134
Total units required for Major: 50
Total units required for Pre-major: 48
Courses in parentheses are prerequisites.

A. Required Lower Division Courses (Pre-major)

Lower division requirements are essentially common for Civil, Electrical and Electronic, and Mechanical Engineering

1. First Semester Freshman Year (18 units)

(5)	CHEM 1A*	General Chemistry
(3)	CSC 25	Introduction to C Programming
(4)	MATH 30*	Calculus I
(6)	General Education courses	

2. Second Semester Freshman Year (17 units)

(4)	MATH 31*	Calculus II (MATH 30)
(4)	PHYS 11A*	General Physics: Mechanics (MATH 30, 31)
(3)	General Education course	
(3)	General Education course	
(3)	General Education course	

3. First Semester Sophomore Year (17 units)

(3)	ENGR 30	Analytic Mechanics: Statics (PHYS 11A, MATH 31)
(3)	ENGR 45	Engineering Materials (PHYS 11A, CHEM 1A)
(4)	MATH 32	Calculus III (MATH 31)
(4)	PHYS 11C*	General Physics: Electricity & Magnetism, Modern Physics (PHYS 11A, MATH 31)
(3)	General Education course	

4. Second Semester Sophomore Year (17 units)

(4)	CPE 64	Introduction to Logic Design
(3)	ENGR 17	Introductory Circuit Analysis (MATH 45, PHYS 11C)
(3)	MATH 45	Differential Equations for Science & Engineering (MATH 31)
(4)	PHYS 11B*	General Physics: Heat, Light, Sound (PHYS 11A, MATH 31)
(3)	General Education course	

* Indicates course which can also be used to meet General Education (GE) requirements. The designation "General Education course" denotes a course which meets GE requirements other than those which also serve as prerequisites to courses in the major. Students are expected to satisfy the requirements of the Accreditation Board for Engineering and Technology (ABET) as well as the University's GE requirements. Consult the Department Chair for specific GE requirements. Students should take ENGL 1A as early as possible since it is required for admission to the upper division.

A second year foreign language course (2A or equivalent) may also satisfy the 3 units of GE when the course is being taken to comply with the CSUS foreign language requirement. Students should consult with an advisor for exact GE eligibility of these courses.

Note: Courses may be interchanged between semesters to accommodate the student's schedule, as long as prerequisites are observed.

B. Required Upper Division Courses (Major)

Students are not permitted to enroll in upper division courses until they have completed all lower division requirements in **Section A** and have filed a change of major form for Electrical and Electronic Engineering. It is imperative that students take the University's Writing Proficiency Examination (WPE) during the first semester of the junior year as it is a prerequisite to all laboratory courses after EEE 117.

1. First Semester Junior Year (17 units)

(4)	CPE 184	Introduction to Microprocessors (CPE 64)
(3)	EEE 117	Network Analysis (ENGR 17)
(1)	EEE 117L	Network Analysis Lab (Corequisite: EEE 117)
(4)	EEE 161	Applied Electromagnetism (MATH 32, 45, PHYS 11C; ENGR 17 and CSC 25 or 3 units of Fortran or Pascal)
(3)	ENGR 110	Analytic Mechanics: Dynamics (ENGR 30; MATH 32, 45)
(2)	ENGR 140	Engineering Economics (ENGR 30)

2. Second Semester Junior Year (18 units)

(3)	EEE 118	Electronic Devices & Circuits (EEE 117, 117L, WPE. Corequisite: EEE 118L)
(1)	EEE 118L	Electronic Devices & Circuits Lab (Corequisite: EEE 118)
(3)	EEE 130	Electromechanical Conversion (EEE 117)
(3)	EEE 180	Signals & Systems (EEE 117, MATH 45)
(2)	ENGR 115	Statistics for Engineers (MATH 31)
(3)	ENGL 20	Expository Writing (ENGL 1A)
(3)	General Education course	

3. First Semester Senior Year (15 units)

(3)	EEE 184	Introduction to Feedback Systems (EEE 180, 118)
(3)	EEE 185	Modern Communication Systems (EEE 180, Corequisite: ENGR 115)
(2)	EEE 190A**	Electrical Engineering Design (EEE 117, 130; 141, 142 or 144; Writing Proficiency Exam, GE Oral Communications requirement) **OR**
	EEE 190B**	Electronic Engineering Design (EEE 118, 161, 180; Writing Proficiency Exam, GE Oral Communications requirement)
(1)	EEE Elective Lab	
(3)	EEE Elective Lecture	
(3)	General Education course	

4. Second Semester Senior Year (15 units)

(2)	EEE 191A**	Electrical Senior Design Project (EEE 190A) **OR**
	EEE 191B **	Electronic Senior Design Project (EEE 190B)
(3)	EEE Design Elective	
(3)	EEE Design Elective	
(1)	EEE Elective Lab	
(3)	General Education course	
(3)	General Education course	

** Students interested in electric power take EEE 190A and 191A. All other students take EEE 190B and 191B.

Design Elective Lectures

BME 120	Electronic Instrumentation
CPE 153	VLSI Design
CPE 166	Advanced Logic Design
CPE 186	Computer Hardware Design
EEE 120	Electronic Instrumentation
EEE 135	Power System Relay Protection
EEE 141	Power System Analysis
EEE 142	Energy Systems Control
EEE 144	Electric Power Distribution
EEE 145	High Voltage Engineering
EEE 146	Power Electronics Controlled Drives
EEE 147	Power Electronics
EEE 154	Communication Circuits Design
EEE 155	Application of Integrated Circuits
EEE 164	Introduction to Antennas
EEE 165	Introduction to Optical Engineering
EEE 181	Introduction to Digital Signal Processing
EEE 183	Digital Communication System Design
EEE 187	Robotics
EEE 196	Experimental Offerings in Electrical & Electronic Engineering (see Department Chair for current offerings)

Other Elective Lectures

CPE 175	Data Communication Systems
EEE 151	Digital Electronic Devices
EEE 162	Applied Wave Propagation
EEE 166	Physical Electronics
PHYS 106	Introduction to Modern Physics
PHYS 130	Acoustics

Elective Laboratories

BME 120	Electronic Instrumentation
CPE 166	Advanced Logic Design
CPE 187	Microprocessor Design Laboratory
EEE 120	Electronic Instrumentation
EEE 131	Electromechanics Laboratory
EEE 143	Power Systems Laboratory
EEE 157	Integrated Circuits Laboratory
EEE 163	Traveling Waves Laboratory
EEE 167	Electro-Optical Engineering Lab
EEE 186	Communication Systems Laboratory
EEE 187	Robotics
EEE 189	Controls Laboratory
EEE 196	Experimental Offerings in Electrical & Electronic Engineering (see Department Chair for current offerings)

Note: Other upper division courses in Engineering, Computer Science, Mathematics, and Science may be selected as elective lectures with **prior** approval of the student's advisor.

GRADUATE PROGRAM

The Master of Science degree program in Electrical and Electronic Engineering is designed to provide students with advanced study in a variety of electrical and electronic engineering topics, to provide an opportunity for students to conduct independent research and to broaden their professional scope. Students may focus their studies on communication systems, control systems, digital systems and microprocessors, fields and waves, power systems, or signal processing. Coordinated courses are offered in advanced microprocessors, electromagnetic theory and microwaves, lasers and fiber optics, systems and control, networks, and communication systems. Other coordinated courses facilitate the study of estimation and stochastic control, advanced communications and signal processing, large interconnected power systems, power systems reliability and planning, and advanced design and organization of digital computer systems.

The program is sufficiently flexible to allow students to conduct special independent studies of problems of current interest. Each student plans a program of study in consultation with the departmental graduate coordinator and his/her thesis or project advisor and works closely with these faculty advisors.

The Electrical and Electronic Engineering graduate program consists of studies adapted to the needs and interests of the practicing engineer, and the department has a strong relationship with the local engineering community. Students of the program have access to the department laboratories and facilities and to the university computer services.

Admission Requirements

Admission as a classified graduate student in Electrical and Electronic Engineering requires:

- a BS in Electrical and Electronic Engineering or equivalent **and**
- at least a 3.0 GPA in the last 60 units of the BS in Electrical and Electronic Engineering or equivalent **and**
- at least a 3.25 GPA in the Electrical and Electronic Engineering major or equivalent major

Under special circumstances, a student who does not satisfy the Admission Requirements may be admitted as a *conditionally classified* graduate student. Deficiencies will be specified in the acceptance letter to the student and must be removed by the student before the student can become a *classified* graduate student.

A student registered as an *unclassified* graduate student should carefully note that graduate courses taken as an *unclassified* graduate or as an *open university* student cannot be used to improve the student's grade point average for admittance to the EEE graduate program. Only undergraduate EEE courses can be taken or retaken to improve the GPA of the student for admittance to the EEE Graduate Program.

Admission Procedures

Applications are accepted as long as room for new students exists. However, students are strongly urged to apply by April 1 for the following Fall or October 1 for the following Spring. All prospective graduate students, including CSUS graduates, must file the following with the Graduate Center:

- an application for graduate admission
- two sets of official transcripts from all colleges and universities attended, *other than CSUS.*

At the same time, students not meeting the above Admission Requirements should submit to the EEE Graduate Coordinator two letters of recommendation, Graduate Record Examination scores, and/or other evidence of their potential for successful graduate study in this program.

Approximately six weeks after receipt of all items listed above, a decision regarding admission will be mailed to the applicant.

Advancement to Candidacy

Each student must file an application for Advancement to Candidacy with the Graduate Center indicating a proposed program of graduate study for the completion of the MSEE. This procedure should begin as soon as the *classified* graduate student has:

- removed any deficiencies in Admission Requirements, **and**
- completed a minimum of 12 units in the graduate program with a minimum 3.0 GPA; at least nine units of the 12 units must be EEE 200 level courses, **and**
- filed the Advancement to Candidacy Form with the Graduate Center; the student must be advanced to candidacy prior to registering for EEE 500.

Advancement to Candidacy forms are available in the Graduate Center and in the Electrical and Electronic Engineering Department. The completed form, with appropriate approval signatures, is then returned to the Graduate Center for approval.

Degree Requirements

The Master of Science in Electrical and Electronic Engineering requires completion of 30 units of coursework with a minimum 3.0 GPA. Specific degree requirements are:

A. Required Core Courses (10 units)

(1) EEE 201 Research Methodology (graduate standing)
(3) EEE 241 Linear Systems Analysis (EEE 180 or equivalent)
(3) EEE 243 Applied Stochastic Processes (ENGR 115)
(3) One of the following:
- EEE 211 Microwave Engineering I (EEE 161)
- EEE 222 Electronic Neural Networks
- EEE 233 Advanced Digital Signal Processing (EEE 181, CPE 184; or equivalent)
- EEE 247 Optimal LQG Control (EEE 241)
- EEE 250 Analysis of Faulted Power Systems (EEE 130 or equivalent)
- EEE 260 Statistical Theory of Communication (EEE 185)
- EEE 285 Micro-Computer System Design I (CPE 184 or 185)

B. Electives (15-18 units)

(15-18) Select units from the following fields of study and other areas, in consultation with the Graduate Coordinator. A maximum of 6 units of undergraduate technical electives in EEE may be applied to this requirement, if approved by the Graduate Coordinator and if they have not been used to satisfy the BS program requirements or MSEE admission requirements.

1. Microwaves, Circuits and Devices
- EEE 211 Microwave Engineering I (EEE 161)
- EEE 212 Microwave Engineering II (EEE 211)
- EEE 213 Microwave Devices & Circuits (EEE 162)
- EEE 215 Lasers (EEE 180, 161; or permission of instructor)

2. Intelligent Machines/Robotics
- EEE 221 Machine Vision
- EEE 222 Electronic Neural Networks
- EEE 225 Advanced Robot Control (EEE 184; or equivalent)
- EEE 242 Statistical Signal Processing

3. Control
- EEE 246 Direct Digital Control (EEE 184 or equivalent)
- EEE 247 Optimal LQG Control (EEE 241)
- EEE 248 Adaptive Filtering & Control (EEE 241)
- EEE 249 Advanced Topics in Control & Systems

4. Communications
- EEE 234 Communication Circuits (EEE 118, 185)
- EEE 260 Statistical Theory of Communication (EEE 185)
- EEE 261 Information Theory, Coding & Detection (EEE 185)
- EEE 267 Fiber Optic Communications (EEE 185 or permission of instructor)

5. Power
- EEE 250 Analysis of Faulted Power Systems (EEE 130 or equivalent)
- EEE 251 Power System Economics & Dispatch (EEE 141 or equivalent)
- EEE 252 Power System Reliability & Planning (EEE 142 or equivalent)
- EEE 253 Power System Stability
- EEE 254 Large Interconnected Power Systems (EEE 142)
- EEE 259 Advanced Topics in Power Systems (EEE 142)
- EEE 296 Experimental Offerings in Electrical & Electronic Engineering (see Department Chair for current offerings)

6. Computer Engineering
- CSC 242 Computer-Aided Design Methodology for Computer Systems (CSC 205)
- CSC 275 Advanced Data Communication Systems (CSC 175, 205, or CPE 175)
- EEE 273 Hierarchical Digital Design Methodology (CPE 64 or equivalent)
- EEE 280 Advanced Computer Architecture (CSC 205)
- EEE 285 Micro-Computer System Design I (CPE 184 or 185)
- EEE 286 Micro-Computer System Design II (EEE 285 or CPE 186)
- EEE 296 Experimental Offerings in Electrical & Electronic Engineering (see Department Chair for current offerings)

7. Signals and Systems
- EEE 221 Machine Vision
- EEE 232 Small Signal Amplifiers (EEE 155)
- EEE 233 Advanced Digital Signal Processing (EEE 181, CPE 184; or equivalent)

C. Culminating Requirement (2-5 units)

(2-5) EEE 500A Culminating Experience

Note: *The student cannot register for the Culminating Experience until the student has passed the Writing Proficiency Exam (WPE), and has been advanced to candidacy*. Prior to registering for EEE 500, the student must choose Plan A, Master Thesis (5 units), or Plan B, Master's Project (2 units), by submitting a Proposed Topic Form with the Department Office. In subsequent semesters, students will enroll in RCE 599, Continuous Enrollment, after qualifications for enrollment have been verified. As soon as possible after the student has registered for EEE 500, it is expected that the student will select a Committee appropriate to the chosen plan of study. The Thesis Committee is to consist of the

student's Thesis Advisor, who is the Chairperson of the student's Thesis Committee, and two other faculty members. The Project Committee is to consist of the student's Project Advisor, who is the Chairperson of the student's Project Committee, and one other faculty member. The Committee members selected by the student must be approved by the EEE Department Graduate Coordinator.

The Thesis (Plan A) must be orally presented and defended, approved by the student's Thesis Committee, and approved by the EEE Graduate Coordinator prior to submittal of the Thesis to the Graduate Center. The Project (Plan B) is to culminate in a report and a device or simulation which is to be demonstrated to the student's Project Committee. The Project Report must be approved by the student's Project Committee and approved by the EEE Graduate Coordinator prior to submittal of the Project Report to the Graduate Center.

LOWER DIVISION COURSES

90. Introduction to Electronic Messages. Provides an elementary introduction to the scientific and engineering basis of information and communication technology for non-engineering majors. The main topics are electric power sources, frequency spectrum, analog and digital signals, characterization of human faculties (eyes, ears, speech) in engineering terms and signal transmission through wires and space. **Prerequisite:** One year of high school science, algebra and trigonometry. 3 units.

UPPER DIVISION COURSES

All courses that have a laboratory component may require students to purchase an electronic component fee card or to purchase the parts elsewhere.

117. Network Analysis. Review of Sinusoidal steady state, phasors, complex power, three phase power, mutual inductance, series and parallel resonance. Introduction to application of Laplace transforms in network analysis, transfer functions, Bode plots, Fourier series, two-port circuits. **Prerequisite:** ENGR. 17. **Corequisites:** CPE 64 and EEE 117L. 3 units.

117L. Networks Analysis Laboratory. Introduces fundamental laboratory techniques while demonstrating the concepts introduced in the EEE 117 lecture. The computer simulation language "P-SPICE" is introduced and applied. Laboratory three hours. **Corequisite:** EEE 117. 1 unit.

118. Electronic Devices and Circuits. Semiconductor physics of diodes, bipolar transistors and junction and MOS field effect transistors. Bias circuits, amplifiers, cutoff and saturation. Small signal analysis, input and output impedance, and frequency response. Power amplifier and operational amplifier circuits. **Prerequisites:** EEE 117, 117L, Writing Proficiency Examination. **Corequisite:** EEE 118L. 3 units.

118L. Electronic Devices and Circuits Laboratory. Emphasizes the concepts introduced in the EEE 118 lecture and shows the student how to include the various design tradeoffs. The selection of components to meet design objectives is stressed. Course continues with the use of "P-SPICE" and introduces GPIB equipment. Laboratory three hours. **Corequisite:** EEE 118. 1 unit.

120. Electronic Instrumentation. Junior-level course introducing electronic instrumentation design and systems concepts using examples from both biomedical engineering and other engineering application areas. Lecture/discussion covers the areas of systems design, electronic circuit analysis and design, analog and digital recording systems, sensors for transducers, signal conditioning, statistical methods, selected transducer/measurement system design examples and electrical safety design considerations and device testing. The laboratory features experience with time and frequency domain measuring instruments; transducers for displacement, force, light intensity, ionic current, temperature, pressure, and flow; analog signal conditioning and analog/digital conversion; use of National Instruments LabVIEW software for virtual instrument design. Course is cross-listed as BME 120 and may be taken only once for credit. Lecture three hours, laboratory three hours. **Prerequisite:** ENGR 17. 4 units.

130. Electromechanical Conversion. Magnetic circuits and principles of electromechanical energy conversion, DC machines, state equations, terminal characteristics, transformers, AC machines, terminal characteristics of synchronous machines, stability considerations. Induction machine theory. Introduction to energy sources including conventional and nuclear power plants. **Prerequisite:** EEE 117. 3 units.

131. Electromechanics Laboratory. Direct current motor and generator characteristics, three phase synchronous motor and synchronous generator characteristics, single phase power transformer short circuit and no-load tests, frequency changer tests and tests on DC and AC machine models, potential and current transformers. **Prerequisite:** EEE 117. **Corequisites:** EEE 130, Writing Proficiency Examination. 1 unit.

135. Power System Relay Protection. Principles of relay techniques (classical and solid state), current and potential transformers and their application in relaying technique, overcurrent, differential, impedance, frequency, overvoltage and undervoltage relays, relay protection of overhead and underground power lines, generators, transformers, motors, buses and computer applications in relay protection. **Prerequisite:** EEE 130. 3 units.

141. Power System Analysis. Characteristics of power system components; power system planning; transmission line parameters and the steady-state performance of transmission lines; disturbance of the normal operating conditions, symmetrical components and sequence impedances; analysis of balanced and imbalanced faults; and a brief review of protection systems. **Prerequisite:** EEE 130. 3 units.

142. Energy Systems Control and Optimization. Energy systems and ecology, load flow studies, sensitivity; optimum allocation and dispatching; optimal dynamic system control; modern stability studies. **Prerequisite:** EEE 130. 3 units.

143. Power System Laboratory. Fundamentals of power system instruments. Experimental study of three-phase circuits, synchronous generators, transformers and power transmission lines. Simulation of power system dynamics and transients by computer. **Prerequisites:** EEE 130, Writing Proficiency Examination. **Corequisite:** EEE 141. 1 unit.

144. Electric Power Distribution. Operation and design of utility and industrial distribution systems including distribution system planning; load characteristics; application of distribution transformers; design of subtransmission lines, distribution substations, primary systems, secondary systems; application of capacitors; voltage regulation and reliability. **Prerequisite:** EEE 130. 3 units.

145. High Voltage Engineering. This course discusses high voltage power equipment to give the student a basic understanding of the special needs of high voltage equipment and system design. The design of high voltage cable systems with respect to ionization and the Townsend criteria, and insulations for transmission lines is introduced. High voltage generation, insulation coordination, over voltage protection, and analysis of surges is developed. **Prerequisite:** EEE 130. 3 units.

146. Power Electronics Controlled Drives. Course will review thyristors, controlled rectifiers, DC choppers and inverters and pulse width modulation methods including space vector method. Control of DC drives and methods of control of induction synchronious motors including flux-vector methods and computer simulations will be studied. **Prerequisites:** EEE 118, 130. 3 units.

147. Power Electronics. Power semiconductors diodes, thyristors, and converters and their characteristics will be introduced. Silicon controlled rectifier circuits, both single and three phase, will be studied. AC voltage controllers, choppers and inverters modelling, analysis and their switching characteristics will be studied. Applications in UPS systems, reactive power control and power supplies will be briefly introduced and studied. **Prerequisite:** EEE 118. 3 units.

151. Digital Electronic Devices. This course introduces semiconductor physics with applications to junction diodes, bipolar transistors, and field effect transistors. The use of these devices in transistor-transistor logic, bipolar current mode digital logic, FET digital logic, RAM cells and ROM circuits is considered. **Prerequisite:** CPE 64. 3 units.

154. Communication Circuits Design. Design techniques for solid-state transmitter and receiver circuits: RF amplifiers, sine wave oscillators, phase-locked loops, mixers, IF filters, detectors, linear power amplifiers, tuned power amplifiers. **Prerequisites:** EEE 118, 185. 3 units.

155. Application of Integrated Circuits. Step-by-step development of linear and digital ICs. Methods of interconnecting ICs to form complete analog and digital systems. Compensation techniques for operational amplifiers. Applications of operational amplifiers to filtering, switching, sensing, timing, and A to D and D to A converters. **Prerequisite:** EEE 118. 3 units.

157. Integrated Circuits Laboratory. Design, testing, and building practical electronic circuits and systems using operational amplifiers and integrated circuits. Individual and group projects. **Prerequisites:** EEE 117, Writing Proficiency Exam. **Corequisite:** EEE 155. 1 unit.

161. Applied Electromagnetism. Laws of electromagnetism by Gauss, Faraday, Ampere, Coulomb and Ohm are applied to conductors, semiconductors, insulators including the atmosphere, batteries, magnets, elementary generators and plasmas. Circuit parameters of various configurations. Generalization to Maxwell's equations and the relation to transverse electromagnetic waves. **Prerequisites:** MATH 32, 45, PHYS 11C; ENGR 17 and CSC 25 (or 3 units of Fortran or Pascal) 4 units.

162. Applied Wave Propagation. One-dimensional wave equation in electromagnetics and acoustics. Wave velocity, wavelength and directivity. Poynting vector and sound intensity. Low and high frequency equivalent circuits of transmission lines. Impedance, attenuation and standing wave measurements on transmission lines with losses and negligible loss. Rectangular and circular hollow waveguides. Optical Waveguides. **Prerequisites:** EEE 117, 161. 3 units.

163. Traveling Waves Laboratory. Selected experiments in the transmission and reflection of waves in coaxial lines and waveguides. Antenna impedance and pattern measurements. Laboratory three hours. **Prerequisites:** EEE 117, Writing Proficiency Examination. **Corequisite:** EEE 162. 1 unit.

164. Introduction to Antennas. Application of potential functions to obtain fields of infinitesimal dipoles, long antennas, and arrays. Radiation resistance and gain. Aperture antennas and Babinet's principle. Mutual impedance effects. High gain and broadband antennas. **Prerequisite:** EEE 161. 3 units.

165. Introduction To Optical Engineering. Generation, propagation and detection of light. Fresnel equations, Snell's law, diffraction, polarization and interference. Operating principles of LED's, lasers, photodiodes and optical fibers. Introduction to optical communications systems, integrated optical devices, and optical instrumentation. **Prerequisites:** EEE 161, 180. **Corequisite:** EEE 185. 3 units.

166. Physical Electronics. Semiconductor physics, atomic models and crystal structures. Quantum theory, energy bands, motion of charge carriers, minority/majority carrier profiles and pn junctions. Manufacturing processes for and operating characteristics of diodes, bipolar transistors and field effect devices. **Prerequisites:** EEE 118, 161. 3 units.

167. Electro-Optical Engineering Lab. Course provides senior level undergraduates with hands-on experience in optical engineering and design . Experiments involving laser characteristics, spectral radiometry, diffraction, polarization, modulation of light, holography and spatial filtering will be performed. Laboratory three hours. **Prerequisites:** EEE 161, 180, Writing Proficiency Exam. **Corequisite:** EEE 165. 1 unit.

180. Signals and Systems. Rigorous development of the fundamental relationships governing time-domain and frequency-domain analysis of linear continuous-time and discrete-time systems. Topics include Fourier, Laplace and z-transforms, sampling theorem, modulation, system stability, and digital filters. **Prerequisite:** EEE 117. 3 units.

181. Introduction to Digital Signal Processing. Course focuses on the application of linear systems theory to design and analysis of digital signal processing systems. Discrete systems, the z transform, and discrete Fourier transform are reviewed. Design of infinite impulse response filters, finite impulse response filters, and digital spectral analysis systems is presented. Computer simulation is used to study the performance of filters and spectral analysis systems. Signal processing architectures are introduced. Lecture three hours. **Prerequisites:** EEE 180, and CPE 64 or equivalent. 3 units.

183. Digital Communication System Design. Review of fundamentals, probability, information, effects of channel, sampling, PCM, and Delta modulation. Problems with synchronization. Digital modulation of carrier amplitude, frequency or phase. Design trade offs. **Prerequisite:** EEE 185. 3 units.

184. Introduction to Feedback Systems. Feedback analysis methods including signal flowgraphs, Bode diagrams, and root locus are introduced. System stability tests and design techniques via Nyquist and Routh are derived. System type, frequency response, and signal following error are discussed. Included are application of feedback concepts to the design of typical systems such as electro-mechanical servos, feedback amplifiers, op-amps, and phase locked loops. **Prerequisites:** EEE 180, 118. 3 units.

185. Modern Communication Systems. Review of signal and system analysis, sampling theorem and Nyquist's criteria for pulse shaping, signal distortion over a channel, study of digital and analog communication systems, line coding, signal to noise ratios, performance comparison of various communication systems. **Prerequisite:** EEE 180. **Corequisite:** ENGR 115. 3 units.

186. Communication Systems Laboratory. Experimental study of modulation and demodulation in AM, FM, and digital communication systems, A/D and D/A conversion, measurement of power spectra, noise characterization in frequency domain. **Prerequisites:** EEE 117, Writing Proficiency Exam. **Corequisite:** EEE 185. 1 unit.

187. Robotics. Lecture introduces principles of robotics and design of robot systems. Course includes robot architectures, sensing position/velocity, digital circuit noise, actuator and path control, robot coordinate systems, kinematics, differential motion, computer vision/architectures, and artificial intelligence. Laboratory will apply lecture theory in design experiments utilizing five degree-of-freedom robots, an industrial robot, and vision systems. **Prerequisites:** EEE 180 or equivalent, or permission of instructor. 4 units.

189. Controls Laboratory. Study of linear and nonlinear control problems on analog and digital computers. Examples of analysis and compensation for closed loop systems. **Prerequisites:** EEE 117, Writing Proficiency Exam. **Corequisite:** EEE 184. 1 unit.

190A. Electrical Engineering Design. Concentrates on the planning, research and design aspects of electric power systems, including generation, transmission and distribution systems. Emphasis is placed on design philosophies, problem definition, research, project planning, written and oral communication skills, teamwork, development of specifications and effective utilization of available resources. Lecture one hour, laboratory three hours. **Prerequisites:** Writing Proficiency Exam, GE Oral Communication requirement, EEE 117, 130; and EEE 141, 142, or 144. 2 units.

190B. Electronic Engineering Design. Concentrates on the planning and design of electronic engineering devices, systems and software. Emphasis is placed on design philosophies, problem definition, project planning and budgeting, written and oral communication skills, teamwork, development of specifications, utilization of computer aided design systems, and effective utilization of available resources. Lecture one hour, laboratory three hours. **Prerequisites:** Writing Proficiency Exam, GE Oral Communication requirement, EEE 118, 161, 180. 2 units.

191A. Electrical Senior Design Project. A continuation of 190A. Students are expected to continue the power engineering design project begun in EEE 190A. Under some circumstances they may be allowed to work on a separate project. Final results of the project report will be presented orally to the class and invited faculty in a publicized seminar. Lecture one hour, laboratory three hours. **Prerequisite:** EEE 190A. 2 units.

191B. Electronic Senior Design Project. Concentrates on design projects begun by design teams in EEE 190B. The hardware will be completed, tested for the meeting of specifications and other requirements, and redesigned if necessary. Required software will be written, debugged and incorporated in a written report. The final results of the team project will be presented orally to the class and invited faculty in a publicized seminar. Lecture one hour, laboratory three hours. **Prerequisite:** EEE 190B. 2 units.

195. Fieldwork in Electrical and Electronic Engineering. Supervised work experience in Electrical and Electronic Engineering with public agencies or firms in the industry. Admission to course requires approval of a petition by the supervising faculty member and department chair. May be repeated for credit. Graded Credit/No Credit. 1-3 units.

195A-D. Professional Practice. Supervised employment in a professional engineering or computer science environment. Placement arranged through the School of Engineering and Computer Science. Requires satisfactory completion of the work assignment and a written report. **Note:** Units earned cannot be used to satisfy major requirements. **Prerequisite:** permission of instructor. Graded Credit/No Credit. 1-12 units.

196. Experimental Offerings in Electrical and Electronic Engineering. Proseminars devoted to subject matter not adequately covered elsewhere in the curriculum may be scheduled in response to proposals from faculty and students. May be repeated for credit with permission of advisor. 1-4 units.

199. Special Problems. Individual projects or directed reading. **Note:** open only to students who appear qualified for independent work. Approval of the faculty sponsor and the academic advisor must be obtained before registering. May be repeated for credit. Graded Credit/No Credit. 1-3 units.

GRADUATE COURSES

In addition to those graduate courses previously listed under the general title of engineering, the following courses are of special interest to the electrical and electronic engineering student. **Note:** it is required that all students enrolled in 200-level EEE courses be classified or conditionally classified graduate students, or have permission of the instructor.

201. Research Methodology. Research methodology, problem formulation and problem solving. Collective and individual study of selected issues and problems relating to fields of study in the EEE Graduate Program. Orientation to the requirements for Master's Thesis or Project in Electrical Engineering. **Prerequisite:** fully classified graduate standing. Graded Credit/No Credit. 1 unit.

211. Microwave Engineering I. Review of Maxwell's equations. Radiation, propagation and scattering of waves in unbounded systems. Transmission line theory; quarter-wave, binomial and Chebyshev transformers; single and double-stub tuning; microstrip and stripline design. Modes in waveguides of various geometries; waveguide excitations, discontinuities and junctions. Applications of scatter (S-parameters) and ABCD matrices to microwave network theory. **Prerequisite:** EEE 161. 3 units.

212. Microwave Engineering II. Passive microwave components; power dividers, couplers and hybrids. Microwave filter design, periodic structures, image parameter and insertion loss methods for designing filters. Design of ferromagnetic components, isolators, phase shifters and circulators. Noise in microwave circuits. **Prerequisite:** EEE 211. 3 units.

213. Microwave Devices and Circuits. Theory and application of electromagnetic radiation at microwave frequencies; study of microwave impedance and power measurement and characteristics of microwave circuit components, and electronic devices. **Prerequisite:** EEE 162. 3 units.

215. Lasers. Review of electromagnetic theory. Ray tracing in an optical system, Gaussian beam propagation. Resonant optical cavities, study of excitation and lasing mechanisms in gas and semiconductor lasers. General characteristics and design of CW, Q switched and traveling wave lasers. **Prerequisite:** EEE 180, and 161 or permission of instructor. 3 units.

221. Machine Vision. This course introduces the student to fundamental digital imaging processing concepts and their application to the fields of robotics, automation, and signal processing. Topics include: digital image filters, two dimensional transforms, boundary descriptors, Hough transform, automated visual inspection techniques, vision for robot control, 3-D vision, and hardware architectures to support vision. 3 units.

222. Electronic Neural Networks. Current neural network architectures and electronic implementation of neural networks are presented. Basics of fuzzy logic is covered. Application software will be used to simulate training. Testing of various neural net architectures. Learning strategies such as back-propagation, Kohonen, Hopfield and Hamming algorithms will be explored. A final project requires the student to design, train and test a neural network for electronic implementation that solves a specific practical problem. 3 units.

225. Advanced Robot Control. Introduction to robot kinematics and dynamics followed by a comprehensive treatment of robot control. Topics include: independent joint control, multivariable control, force control, feedback linearization, real-time parameter estimation, and model-reference adaptive control. **Prerequisites:** EEE 184, or equivalent. 3 units.

232. Small-Signal Amplifiers. Analysis and design of lowpass, wideband amplifiers for analog integrated circuits, including differential, cascade, level shift, and gain cell stages. Advanced high frequency analysis techniques. Band width optimization and optimum high frequency coupling of discrete and integrated stages. **Prerequisite:** EEE 155. 3 units.

233. Advanced Digital Signal Processing. Advanced signal processing topics include: multirate signal processing, adaptive filter design and analysis, spatial filtering and the application of FIR filter theory to beamforming. Applications of digital signal processing in communication systems, radar systems, and imaging systems are covered. Hardware and software topics, including current products and the incorporation of VLSI are included. Lecture. **Prerequisites:** EEE 181, CPE 184; or equivalent. 3 units.

234. Communication Circuits. Analysis and design of circuits used in analog communication systems; high frequency tuned amplifiers, broadband transformers, RF oscillators, phase-locked loops, frequency synthesizers, power amplifiers, modulators and demodulators. Study of noise sources and noise minimization methods. **Prerequisites:** EEE 118, 185. 3 units.

241. Linear Systems Analysis. Applications of complex variable theory to Fourier, Laplace and z-transforms. Review of linear algebra. State variables for continuous and discrete systems. Credit cannot be obtained for both EEE 241, and either ENGR 201 and 202. **Prerequisite:** EEE 180 or equivalent. 3 units.

242. Statistical Signal Processing. This course introduces the student to modern statistical approaches for solving electronic system noise problems. A few of the topics covered are: Stochastic processes, Wiener and Kalman filters, linear prediction, lattice predictors and singular-value decomposition. 3 units.

243. Applied Stochastic Processes. Introduction to sequence of random variables and multivariable distributions; models of stochastic processes; stationary stochastic processes and their applications; Markov processes, Markov chains, continuous Markov chains; renewal processes; birth-death processes; time-series applications in stochastic processes in filtering, reliability and forecasting, prediction and control. **Prerequisite:** ENGR 115. 3 units.

244. Electrical Engineering Computational Methods and Applications. Computational methods for solving problems in engineering analysis. Topics include variational methods, finite-difference analysis, optimization methods and matrix methods. Course focuses predominantly on applications of the methods, and students are required to solve real-world engineering problems on the computer. 3 units.

246. Direct Digital Control. Fundamentals of discrete systems, z-transforms, and system stability. Methods of direct digital control applied to proportional integral and differential controllers, motor control, plant controllers, power electronics controllers and stepper motors, and principles of adaptive control. Not offered every semester. **Prerequisite:** EEE 184 or equivalent. 3 units.

247. Optimal LQG Control. Dynamic Optimization by maximum principle and dynamic programming. Deterministic optimal control using linear quadratic (LQ) criteria. Spectral factorization and LQG/LTR design. Kalman filter and stochastic optimal control using linear quadratic Gaussian (LQG) criteria. Linear optimal estimator and observer design. Both continuous-time and discrete-time control systems will be treated. **Prerequisite:** EEE 241. 3 units.

248. Adaptive Filtering and Control. Parameter estimation and system identification. Adaptive prediction and control of deterministic systems. Parameter estimation of stochastic systems. Adaptive filtering and control of stochastic systems. Adaptive observers and adaptive pole assignment. Both MRAC and self-tuning regulators will be treated. **Prerequisite:** EEE 241. 3 units.

249. Advanced Topics in Control and Systems. Topics from recent advances in control, systems and robotics control selected from IEEE Journals and related professional publications. 3 units.

250. Analysis of Faulted Power Systems. Computation of phase and sequence impedances for transmission lines, machines, and transformers; sequence capacitance of transmission lines; applications of symmetrical components; changes in symmetry; analysis of simultaneous faults by two-port network theory and matrix transformations; analytical simplification for shunt and series faults; solution of the generalized fault diagrams; computer solution methods using the admittance and impedance matrices. **Prerequisite:** EEE 130 or equivalent. 3 units.

251. Power System Economics and Dispatch. Study of a number of engineering and economic matters involved in planning, operating, and controlling power generation and transmission systems in electric utilities. Effects of hydro and nuclear plants on system economics. Economic and environmental constraints. Theoretical developments and computer methods in determining economic operation of interconnected power systems with emphasis on digital computers. **Prerequisite:** EEE 141 or equivalent. 3 units.

252. Power System Reliability and Planning. Power system economics, generation, transmission and distribution reliability. Production costing and generation planning, transmission planning. **Prerequisite:** EEE 142 or equivalent. 3 units.

253. Power System Stability. Course involves theory, design, analysis and computer projects dealing with stability of electric power systems. Topics include the classical, one-axis/two-axis representation of the synchronous machine; dynamic, steady state and transient ability, equal area criterion, multimachine system analysis, exciter modeling, voltage regulators and related topics relevant to a power systems engineer. 3 units.

254. Large Interconnected Power Systems. Computer control, optimization and organization of large power systems. Loan and frequency control, voltage control, large load flow and contingency studies. Introduction to state estimation and load forecasting. **Prerequisite:** EEE 142. 3 units.

259. Advanced Topics in Power Systems. Topics from recent advances in Electrical Power Engineering selected from IEEE Journal on "Power Systems" and "Power Systems Delivery." **Prerequisite:** EEE 142. 3 units.

260. Statistical Theory of Communication. Review of Fourier analysis and theory of probability, random processes, optimum filtering, performance of analog and digital communication systems in the presence of noise, system optimization. **Prerequisite:** EEE 185. 3 units.

261. Information Theory, Coding, and Detection. Signal space concepts, optimum M-ary communication systems, MAP estimation of continuous waveform parameters, information theory, coding. **Prerequisite:** EEE 185. 3 units.

267. Fiber Optic Communications. Fundamentals of modern lightwave communication systems, sources detectors and optical fibers. Study of dispersion in Step Index, Graded Index and Single Mode Optical Fibers. Intensity Modulated Direct Detection systems (IMDD) and Coherent Fiber Optic Systems (COFOCS). Performance evaluation and design considerations. Wavelength division multiplexing, Local Area Networks, optical amplifiers and photonic switching. **Prerequisite:** EEE 185 or permission of instructor. 3 units.

273. Hierarchical Digital Design Methodology. A hierarchical digital design course that includes: State machine design, Programmable Logic Devices, digital simulation techniques, digital interface, design with ASIC (Application Specific Integrated Circuits), programmable Gate Arrays, and designing with GaAs high speed logic devices. Problems with EMI, RFI and EMC will be presented along with design guidelines. Lecture three hours. **Prerequisite:** CPE 64 or equivalent. 3 units.

280. Advanced Computer Architecture. Course introduces computer classification schemes, structures of uni- and multiprocessor systems, parallelism in uniprocessor systems, design and performance analysis of pipelined and array processors; survey and analysis of interconnection networks and parallel memory organizations; programming issues of multiprocessor systems; and fault tolerant computing and design for testability. Cross-listed as CSC 280, only one of these courses may be counted for credit. **Prerequisite:** CSC 205 or permission of instructor. 3 units.

285. Micro-Computer System Design I. Course focuses on: design of the microprocessor based computer system, study of bus structures, interrupt schemes, memory interfacing, timing, bus arbitration, system architecture, data communications, introduction to multiprocessor systems, and software development. **Prerequisite:** CPE 184 or 185. 3 units.

286. Micro-Computer System Design II. This course includes: 32-bit Microprocessor Architectures, design of 32-bit computer systems, memory and peripheral interfacing, DMA and MMU controllers, coprocessor and multi-microprocessor systems, electromagnetic interference, methods of eliminating interference, shielding grounding, balancing, filtering, isolation, separation, orientation, cancellation techniques and cable design. **Prerequisite:** CPE 186 or EEE 285. 3 units.

296. Experimental Offerings in Electrical and Electronic Engineering. Proseminars devoted to subject matter not adequately covered elsewhere in the curriculum may be scheduled in response to proposals from faculty or students. May be repeated for credit with permission of advisor. 1-4 units.

299. Special Problems. Open to qualified students who wish to pursue problems of their own choice. Projects must have approval and supervision of a faculty advisor. Graded Credit/No Credit. 1-3 units.

500. Culminating Experience. Completion of a thesis or project. Credit given upon successful completion of one of the following plans: Plan A: Master's Thesis. 5 units; Plan B: Master's Project. 2 units. Open only to graduate students who have advanced to candidacy and have secured the permission of the graduate coordinator and completion of a Proposed Topic Form. **Prerequisite:** WPE. Graded Credit/No Credit.