Graduate Advising Handbook for Electrical Engineering

Degree Code 438

Department of Electrical Engineering

College of Engineering and Computer Science

Wright State University

Dayton, OH 45435

TABLE OF CONTENTS

1. PURPOSE

The Department of Electrical Engineering offers a program of study leading to a Master of Science in Engineering Degree with a major in electrical engineering. The program permits concentration of study in specific areas of electrical engineering such as stochastic analysis, communication theory, digital signal processing, control theory, electromagnetic simulation, power electronics and integrated circuits. Most classes are offered after 4:00 p.m. to serve the educational needs of the practicing engineering professional as well as the full-time student. This document addresses questions that frequently arise in the advising process.

2. THE ELECTRICAL ENGINEERING DEPARTMENT

2.1 Programs. The department is one of four in the College of Engineering and Computer Science and offers three degree programs. At the undergraduate level is an ABET accredited Bachelor of Science in Electrical Engineering program and an Engineering Physics program which is offered jointly with the Department of Physics. At the graduate level the department offers a Master of Science in Engineering degree with a major in Electrical Engineering. The M.S.E. program is the focus of this document. The college offers a Ph.D. in Engineering. A student may choose to focus on doctoral studies in an electrical engineering area.

2.2 Points of Contact. The department's administrative offices are located in 311 Russ Center. The EE Graduate Program Director and advisor is Dr. Lang Hong (email: lang.hong@wright.edu). The mailing address is: Department of Electrical Engineering, Wright State University, Dayton, OH 45435. The telephone number is 937-775-5037, the fax number is 937-775-3936 and our web site is www. wright.edu/ee.

2.3 Faculty. The department has seventeen faculty members conducting research and offering courses in the electrical engineering body of knowledge. Information on each faculty member is listed below:

Elliott Brown, Professor, Ph. D., and Ohio Research Scholar Chair, California Institute of Technology, 1985. Research interests include: mm-wave and THz mixers made from semiconductor hot-electron bolometers and magnetically-quantized photoconductors. 109 University Park, 775-4903, 425 RC, 775-5063, Elliott.Brown@wright.edu**.**

Henry Chen, Professor, Ph.D., Minnesota, 1989. Research interests include: very large scale integrated circuit design, built-in self-test design, test generation and scheduling, reduced instruction set, computer architecture and fault tolerant computing. 325 Russ Center, 775-5056; henry.chen@wright.edu.

Kuan-Lun Chu, Assistant Professor, Ph.D., University of Illinois at Urbana-Champaign, 2007. Research interests include: micro fuel cells, alternative energy systems and micro-electro-mechanical systems. 338 Russ Center, 775-4491, kuan-lun.chu@wright.edu.

John Emmert (Marty), Associate Professor, Ph.D., University of Cincinnati, 1999. Research interests include: physical design automation for VLSI, VLSI systems, physical VLSI design, reconfigurable systems, digital CD, VHSIC hardware description language (VHDL), verilog, digital design, VLSI interconnections, analog integrated circuit design, signal processing,digital control systems, 415 RC, 775-5023, marty.emmert@wright.edu.

Fred Garber, Associate Professor, Ph.D., Illinois, 1983. Research interests include: communication systems, target recognition, information theory, and pattern theory. 312 Russ Center, 775-5033, fred.garber@wright.edu.

Russell Hannen, Associate Professor Emeritus, Ph.D., Ohio State, 1969. Research interests include: electric car technology. 022 Russ Center, 775-5183.

Lang Hong, Professor, Ph.D., Tennessee, 1989. Research interests include: computer vision, image processing and pattern recognition, robotic sensing and control, multisensor systems, stochastic systems, system modeling and estimation, and multitarget tracking. 329 Russ Center, 775-5053, lang.hong@wright.edu.

Marian Kazimierczuk, Professor, Ph.D., Warsaw Technical, 1978. Research interests include: radio frequency and power electronics, semiconductor device modeling, circuit theory and computer-aided design. 418 Russ Center; 775-5059, marian.kazimierczuk@wright.edu.

Pradeep Misra, Associate Professor, Ph.D., Concordia, 1987. Research interests include: multivariable control theory, robotics and applied numerical analysis. 424 Russ Center, 775-5062, pradeep.misra@wright.edu.

Kuldip Rattan, Professor, Ph.D., Kentucky, 1975. Research interests include: control theory, robotics, microprocessor applications and bioengineering. 108 Russ Center, 775-5052, kuldip.rattan@wright.edu.

Saiyu Ren, Professor, Ph. D., Wright State University, 2008. Research interests include: RF and mixed signal integrated circuit design with applications to wireless transceivers, communications and signal processing. 328 Russ Center, 775-5051, saiyu.ren@wright.edu.

Brian Rigling, Associate Professor, Ph.D., Ohio State University, 2003. Research interests include: sensors, signal processing, communications, and synthetic aperature radar. 313 Russ Center, 775-5100, brian.rigling@wright.edu.

Arnab Shaw, Professor, Ph.D., Rhode Island, 1987. Research interests include: estimation theory, spectrum estimation and neural network based speech processing. 427 Russ Center, 775-5064, arnab.shaw@wright.edu.

Raymond Siferd, Professor Emeritus, Ph.D., Air Force Institute of Technology, 1977. Research interests include: very large scale integrated circuit design, signal processing and analog integrated circuit design. 324 Russ Center, 775-5058, ray.siferd@wright.edu.

Zhiqiang Wu, Associate Professor, Ph.D., Colorado State University, 2002. Research interests include: 3G cellular, CDMA systems, multicarrier architectures, and frequency domain processing. 421 Russ Center, 775-5060, zhiqiang.wu@wright.edu.

Xiaodong Zhang, Assistant Professor, Ph.D., University of Cincinnati, 2001. Research interests include: intelligent control, integrated health management, distributed and cooperative control and smart adaptive systems. 335 Russ Center, 775-4463, xiaodong.zhang@wright.edu.

Yan Zhuang, Assistant Professor, Ph.D., Johannes Kepler University, Linz, Austria, 2000. Research interests include: RF/microwave technology, magnetic materials, nano-composite materials, high speed si-based electronics, MEMs/NEMs, micro aerial vehicle and sensors. 421 Russ Center, 775-4556, yan.zhuang@wright.edu.

Kefu Xue, Associate Professor and Chair, Ph.D., Pennsylvania State, 1987. Research interests include: digital image processing, computer vision and special purpose architecture for signal processing. 311 Russ Center. 775-5037, kefu.xue@wright.edu.

2.4 Facilities. Access to modern equipment, instrumentation, and computer systems similar to those used by industry is a critical part of an engineering education. Laboratories specifically dedicated to student and faculty research exist in the areas of robotics, heat transfer, fluid dynamics, microprocessors, mechanical vibrations, signal processing, analog and digital electronics, microwave devices, VLSI design, materials testing, materials processing, electron microscopy, augmentative communications diagnostic ultrasonics, medical imaging, man-machine displays, and visual displays. Students have access to a wide range of computer systems interconnected by local and wide-area networks. Access is available to numerous SUN, DEC, and Silicon Graphics file servers and workstations, as well as X-windowing terminals and personal computers. Access is also available to the Ohio Supercomputer via the Ohio Academic and Research Network (OARNET).

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3. ADMINISTRATIVE ISSUES

3.1 Admission. Applications for admission are to be submitted to the School of Graduate Studies which has the responsibility for administering graduate programs at Wright State University. Upon completion of an admission package (which must include official transcripts of all post high school education), it is forwarded to the EE Department for review and recommendation. International students need additional information in a complete admission package (including a TOEFL score minimum-550, computerized testing score-minimum 213, internet based test score-minimum 79 and financial information). International students' admission packages are sent to the International Student Admissions Office before forwarding to the EE Department for review and recommendation.

Department personnel review admission packages for recommending admission status. Recommendation categories include regular, conditional and not admitted.

A GRE exam is not required for students who have graduated from an ABET accredited institution. Non-ABET program graduates must have a minimum of an 850 combined (verbal and quantitative) GRE score.

A student may be admitted to the program on a regular status with a bachelor's degree in electrical engineering or related area and an undergraduate grade point average (GPA) of 2.9 on a 4.0 scale.

A student may be admitted to the program on a conditional status when the undergraduate cumulative GPA is less than but at least 2.7. The condition of admission is usually the achievement of a GPA of 3.0 or better in the first 12 credit hours of graduate courses specified by a department advisor.

A student with an undergraduate academic deficiency may petition for admission after demonstrating the ability to perform well in graduate courses taken in a non-degree status.

Departmental admission recommendations are sent to the Office of the Dean of the College of Engineering and Computer Science for recording and then forwarded to the School of Graduate Studies for action.

Academic Honesty Policy (College of Engineering Policy # 1011)

1. The college will always impose the most severe penalty possible within the university's policy on academic dishonesty.

2. The college will permanently dismiss any of its majors found guilty of two acts of academic dishonesty.

3.2 Degree Requirements. The general requirements of the School of Graduate Studies for a Master of Science Degree are set forth in the Graduate Catalog. Specific departmental requirements for the Master of Science in Engineering with a major in Electrical Engineering follow:

1. The student must complete at least 45 graduate credit hours (numbered 600 or above) in a Program of Study approved by the Graduate Program Director.
2. A minimum of six credit hours of approved math courses or math related credits is required. Students must earn a grade of B or higher. Choose from:
   - EE 701 Linear Systems I
   - EE 702 Linear Systems II
   - EGR 703 Computational Engineering Analysis
   - EE 761 Random Processes
   - *Or* any 600-700 level math (MTH) or statistics (STT)
3. Of the 45 required credit hours, a minimum of 33 credits must have an EE prefix (taken at Wright State University).
4. Of the 45 required credit hours, a minimum of 24 credit hours must be courses numbered 700 level or higher. Of the 700+ level courses, at least 16 credit hours must have an EE prefix.

In any given quarter, a minimum of one half (50%) of your total registered credit hours must have an EE prefix.

With the first MS degree from an undergraduate ABET accredited school, the second masters degree at WSU requires 33 credit hours of which at least 23 credits must have an EE prefix and 24 credits must be numbered 700 or above. Math is not required for a second MS degree.

A student may choose to conduct a thesis research and write and defend a thesis under the guidance of a faculty member. Once a faculty advisor has been determined, the student will be required to submit a thesis application form. Additionally, the student will be required to meet with his or her full thesis committee prior to registering for his or her 7th thesis credit. At this meeting the committee will sign off on continuation of the student's thesis project, or request changes to the research that should be made before the final thesis defense. Twelve credit hours of

thesis (EE 899) will be used to partially satisfy the degree requirement of 45 credit hours. These 12 thesis credits may also be used to partially satisfy the requirements for 24 credits numbered 700 or above. A maximum of 12 credit hours of graduate **non degree** credit may be applied toward a MSE in the Electrical Engineering program.

3.3 Graduation. Each student must submit an application to receive a master's degree. Application forms may be obtained at the School of Graduate Studies office located in E344 Student Union. The application deadline is usually *one month before the graduation quarter begins.* Specific cutoff dates are published in the quarterly class schedule (newsprint). Should the first graduation attempt be unsuccessful, students must re-apply for a degree on each successive attempt. Under extreme circumstances, a student may petition the Department for support of a late application for Graduation through the first week of the quarter.

Wright State holds two commencement ceremonies each year, at the end of spring and fall quarters. Students may participate in the ceremony held at the end of the graduation quarter, or in the event that there is no ceremony at the end of the quarter, after the graduation quarter.

Degree confirmation in the form of a diploma and an official transcript of grades is usually mailed within 30 days of the graduation date to the last official address.

3.4 Course Numbering. Courses numbered 700 and above are intended to be taken only by graduate students. Courses numbered 600 and above are co-listed in the undergraduate catalog with a corresponding 400 number and may be attended by graduate and undergraduate students. Note that a student cannot take the same course for undergraduate and graduate credit. For example, EE 419 taken for credit as an undergraduate student cannot then be taken as EE 619 for graduate credit. Graduate students can expect to perform additional study when compared to the undergraduate student when enrolled in a course numbered 600 or above. Courses numbered 500 and above are co-listed in the undergraduate catalog. These courses are usually not used to satisfy any requirement for the Master of Science in Engineering degree with a major in Electrical Engineering.

3.5 Course Scheduling. Most classes are offered after 4:00 p.m. to serve the need of practicing engineering professionals as well as the full-time student. A class schedule is published in newsprint format well in advance of the starting date for each quarter to facilitate early registration. These schedules are available in the department's administrative office and around the university.

3.6 Selected Guidelines. The Policies and Procedures Manual for Graduate Studies contains the body of guidelines that govern graduate programs. Similarly, the EE faculty has developed some departmental guidelines to address issues that arise repeatedly. A few of those guidelines are listed below in a "frequently asked question" format.

3.6.1 ***What if I earn poor grades?*** You may either keep the grade or replace the grade. Up to nine credits of "C" may be applied toward the degree as long as the cumulative GPA remains at or above 3.00 (see Manual para. 6.32). D grade credits may not be used toward the 45. Alternatively, for a maximum of two courses, graduate students may repeat once any course previously taken for which the grade received was below a "B". The hours and points for the new grade earned will replace the hours and points for the initial attempt for the cumulative GPA calculation (see manual para. 5.20).

3.6.2 ***How many credits may I transfer?*** Up to 12 graduate quarter credits earned at a regionally accredited academic institution may be transferred to a student's graduate academic record. Acceptance of these credits is subject to approval by the department's Graduate Program Director and the School of Graduate Studies.

An approved Program of Study must be on file at the School of Graduate Studies before transfer credits may be posted.

Only courses offered by the Math Department at another institution may be counted toward the EE department's math requirement. Engineering courses such as Linear Systems will not transfer as a math course.

3.6.3 ***How may I earn credit for independent study?*** Two course titles enable independent study by a student well along in his or her studies under the guidance of a faculty member. They are Special Problems (EE 890) and Thesis (EE 899). Up to *four* credit hours of EE 890 credit may be applied toward the degree. These credits may be earned in one quarter or spread over two consecutive quarters. Independent study credits are graded on a pass/fail basis.

Some students may choose to learn the formal research process by performing thesis research under the guidance of a faculty member. Up to *twelve* credit hours of EE 899 credit may be applied toward the degree. These credits are typically spread over three or more quarters and culminate in writing a thesis and defending it in a public forum. Thesis work is graded on a pass or no pass basis and the grade is not included when calculating the cumulative GPA.

A student desiring to perform independent study should complete an independent study contract form which may be obtained in the

department's administrative office. That "contract" should define the work to be accomplished and must be approved by the faculty member and chair prior to registering for credit.

3.6.4 ***How many courses should I take?*** A full time graduate student carries 8 to 16 credit hours. Less than eight credits classify a graduate student as part-time. Typically, students who work full time take one 3 or 4 credit hour class per quarter. Full time students typically register for 2 or 3 classes.

Please note that there are certain times when graduate students must carry a minimum credit hour load. For example, international students must have full time status (8 credits minimum). Engineering students with assistantships must carry 8 credit hours per quarter. Check with your graduate advisor if you have any questions about your particular circumstances.

3.6.5 ***May I drop a course?*** The online quarterly class schedule lists specific dates by which a course must be formally dropped to eliminate earning a grade

3.6.6 ***Where may I find a graduate studies catalog?*** School of Graduate Studies Office in E 344 Student Union.

3.6.7 ***May I take coursework outside the Electrical Engineering Department?*** The set of MSE(EE) degree requirements state that at least 30 of 45 credits must have an EE prefix. It follows that with advisor approval, a program of study may be devised to include graduate courses from other engineering departments. To promote program integrity, it is expected that a degree candidate will maintain the majority of EE credits earned in the cumulative credit total. This requires that the student should have at least as many graduate EE credits as non EE credits at any time while completing the program.

3.6.8 ***May I take courses through the Dayton Area Graduate Studies Institute (DAGSI)?*** DAGSI is a consortium of graduate schools from which you may take select courses.

You may take courses from the Air Force Institute of Technology (AFIT) and the University of Dayton (UD), which are partner schools in DAGSI.

You may register for courses from these institutions, providing that they are **UNIQUE** courses that are not offered by Wright State University. You will need to get approval for registration from your graduate advisor.

Ph.D. students may waive the DAGSI course tuition by means of the "ENHANCEMENT SCHOLARSHIP." Students must fill out an application and submit it to the Ph.D. program advisor for approval.

4. CURRICULUM

4.1 Program of Study. A program of study may be tailored to meet the needs of the student. There are no course requirements beyond the graduation requirements listed in section 3.2 above. Students in consultation with an advisor, may select areas of concentration from groupings of department courses, prerequisite courses to the groupings, other courses in the college, an array of mathematics related courses and any transfer credits to build a coherent, formal program of study. The program of study must be documented on a department form, approved by the Graduate Program Director and, in combination with a department degree certification, provides the supporting documentation for awarding the degree. It is useful to complete a program of study early in the program to provide an efficient path to the degree and a memorandum of agreement between the student and the department for the specific degree requirements. The program of study may be amended as circumstances change.

4.2 Areas of concentration. Students may choose to concentrate study in areas where the faculty is strong. To assist in this endeavor, selected courses are grouped by faculty member around their areas of expertise. Each grouping is listed below with the associated faculty members, course number, course credit hours, short title and prerequisite courses. Individual course descriptions may be found following this section.

Electronics
Dr. Kazimierczuk

Course Title		Prerequisite
EE 644-4	Linear Integrated Circuits	EE 631 & 632*
EE 649-4	Pulse and Digital Circuits	EE 631 & 632*
EE 741-4	Power Semiconductor Devices	EE 631 & 632*
EE 742-4	Power Electronics II	EE 741
EE 743-4	Power Electronics III	EE 742
EE 758-4	CMOS Analog Integrated Circuit Design	EE 631 & 632*
EE 759-4	CMOS RF Integrated Circuits	EE 758
EE 880-4	RF Power Amps	

Integrated Circuit Design
Drs. Emmert, Chen, Siferd and Ren

Course Title		Prerequisite
EE 654-4	VLSI Design	EE 631 & 632 & 651*
EE 662-4	Digital IC Design with PLDs & FPGAs	EE 651
EE 659-4	IC Design Synthesis with VHDL	CEG 220 & EE 260*
EE 752-4	VLSI Subsystem Design	EE 654
EE 753-4	VLSI Design Synthesis & Optimization	EE 654
EE 754-4	VLSI Testing & Design for Testability	EE 654
EE 758-4	CMOS Analog Integrated Circuit Design	EE 631 & 632*
EE 759-4	CMOS RF	EE 758

Signal and Image Processing
Drs. Shaw, Hong, Garber, Xue, and Rigling

Course Title		Prerequisite
EE 636-4	DSP with Implementation	EE 322 CEG 220*
EE 637-4	Modern Signal Processing	EE 322*
EE 710-4	Digital Signal Processing	EE 701
EE 715-4	Digital Image Processing	EE 710
EE 716-4	Kalman Filters & Applied Estimation	EE 702 & 761
EE 717-4	Multisensor Integration	EE 702 & 761
EE 718-4	Multitarget Tracking & Data Association	EE 702 & 761
EE 761-4	Random Processes	Fourier Theory
EE 762-3	Detection, Esti. & Optimal Filter Thy.	EE 761
EE 763-3	Classical & Modern Spectral Analysis	EE 762

Electromagnetic, RF and MEMS Devices
Drs. Zhuang, Chu, Petkie, and Riechers

Course Title		Prerequisite
EE 610-4	Introduction to MEMS	
EE 646-4	Microwave Circuit Design	EE 546
EE 708-4	Advanced MEMS	EE 610
EE 746-4	EM Simulation Methods I: FDTD	EE 546
EE 747-4	EM Simulation Methods II: MoM	EE 546

Wireless Communications Systems
Drs. Garber, Shaw, and Wu

Course Title		Prerequisite
EE 621-4	Communication Theory	Linear Systems
EE 673-4	Wireless Communication	EE 621*
EE 678-3	Coding Theory (Math)	MTH 253 or 355
EE 680-4	Modern Digital Communication	
EE 735-4	Wireless Communication I	EE 761
EE 736-4	Wireless Communication II	EE 735
EE 737-4	Spread Spectrum Systems	EE 321& 421*
EE 740-4	Information & Coding Theory	EE 761

Control and Robotics
Drs. Hong, Misra, Rattan, and Zhang

Course Title		Prerequisite
EE 615-3	Control Systems II	EE 613 & 614*
EE 617-3	Digital Control Theory+ 620 (Lab)	EE 522 & 615
EE 619-4	Intro to Fuzzy Logic Control	EE 613 & 614*
EE 656-4	Introduction to Robotics	MTH 253/CEG 220*
EE 720-3	Advanced Digital Control	EE 617 & 702
EE 725-3	Principles of Modern Control Theory	EE 615 & 616, 702
EE 756-4	Robotics I	EE 656

*Or an undergraduate equivalent.

4.3 EE Graduate Course Descriptions

610-4 ..... Introduction to MEMS
This course covers the history, design, and fabrication of micro-electro-mechanical systems (MEMS), and the basic operating theory of selected MEMS transducers. Typical fabrication methods covered include surface micromachining, bulk micromachining and micromolding.

613-3 ..... Control Systems I
An introductory course providing students with a general control background. Major topics include block diagrams and signal-flow graphs, electromechanical modeling, time response, root locus and introduction to design. Prerequisites: ME 213 and EE 321; Corequisite: EE 614.

614-1 ..... Control Systems I Laboratory
Application and testing of control systems theory with electromechanical systems. Prerequisite or corequisite: EE 613.

615-3 ..... Control Systems II
Using Control Systems I background, this course concentrates on controller design in both the time and frequency domains, using Nyquist, Bode, root locus and state variable techniques. Digital control concepts are introduced. Prerequisites: EE 322, EE 613 & EE 614; Corequisite: EE 616.

616-1 ..... Control Systems II Laboratory
Application and testing of control systems theory with electromechanical systems. Prerequisite: EE 613 and EE 614; Prerequisite or corequisite: EE 615.

617-3 ..... Digital Control Systems
Sampled spectra and aliasing, analysis and design of digital control systems using root locus and transform techniques; discrete equivalents of continuous controller and quantization effects. Prerequisites: EE 322 and EE 615.

618-4 ..... Control Systems Design
A project-oriented design course, integrating design methodology with the principles of controller design developed in previous courses. Topics include project planning, system specs, documentation, design reviews, written and oral reports, system test. Prerequisites: EE 617 and EE 620.

619-4 ..... Introduction to Intelligent Control Systems
Foundations and philosophy of fuzzy logic and applications to control theory. Relationship between classical PID control and fuzzy rule-based control. Techniques for rule construction and adaptive fuzzy logic controllers. Case studies of fuzzy logic control applications. Prerequisites: EE 613 and EE 614.

620-1 ..... Digital Control Systems Laboratory
Sampling, temperature control, position control on a microprocessor-based system, PLC implementation, quantization error computational delay, frequency response. Prerequisites: CEG 611, EE 614, EE 616; corequisite: EE 617.

621-4 ..... Communication Theory
Analysis of communication systems using the Fourier transform and the convolution integral. Discussion of Nyquist's sampling theorem and an introduction to binary pulse code modulation (PCM). Various analog (AM, SSB, WBFM) and digital (BPSK, AK, FSR) modulation techniques are also discussed and analyzed. Prerequisite: EE 321.

631-3 ..... Electronic Circuits
Theory and application of basic engineering electronics developed for discrete and integrated circuits. Topics include bipolar and field effect transistor amplifier analysis and design, frequency response, multistage and feedback amplifiers. Prerequisites: EE 321 and EE 331; Corequisites: EE 303, EE 304 and EE 632.

632-1 ..... Electronic Circuits Laboratory
Design of single and multiple stage amplifier circuits, feedback amplifiers, circuits to meet frequency response specifications and output stages; Prerequisite: EE 331 and 332; Corequisite: EE 631.

636-4 ..... Digital Signal Processing
Introduction to the principles and applications of digital signal processing (DSP) from the design and implementation perspective. Major topics include analog-to-digital/digital-to-analog converters and digital filters, Fourier analysis algorithms and real-time applications all implemented on a TMS320C30 floating point DSP chip. Prerequisite: EE 322, CEG 220 or CS 240.

637-4 ..... Modern Signal Processing
Introduction to advanced digital signal processing design concepts. Foucus on time and frequency domain algorithms. Methods include multi-rate signal processing. Filter banks, time-frequency analysis and wavelets. Examples taken from audio processing. Prerequisite: EE 322.

640-4 ..... Introduction to Nanoscience and Nanotechnology
Topics include introduction to quantum mechanics, fabrication, characterization, materials, electronic properties, optical properties, magnetic properties, devices, MEMS and NEMS. Prerequisites: PHY 240 and PHY 242 and PHY 244.

642-4 ..... Transmission Lines, Waveguides & Radiating Systems
Plane waves in free space and matter. Transmission line equations and application of Smith chart. Wave propagation in rectangular waveguides. Introduction to radiating systems including dipole and loop antennas. Rudimentary design of typical systems containing transmission lines, waveguides and antennas. Prerequisite: EE 345.

644-4 ..... Linear Integrated Circuits
Theory and applications of linear integrated circuits. Topics include ideal and real operational amplifiers, frequency response and compensation, active filters, comparators and waveform generators; 3 hours lecture, 2 hours lab. Prerequisites: EE 631 and 632.

646-4 ..... Microwave Circuit Design Project
Review of Smith chart, introduction to microstrip lines, impedance matching, power gain equations, stability considerations, design methods for amplifiers & oscillators. CAD (Touchstone software by EEsof) is utilized. Prerequisite: EE 346.

647-4 ..... Antenna Theory and Design
Linear dipole antennas, antenna arrays, thin-wire antennas, moment method analysis examples (vee dipole, folded dipole, etc.), broadband and frequency-independent antennas. Computer-aided design and analysis of wire antennas, feed networks and antenna arrays using antenna CAD software. Prerequisite: EE 346.

651-4 ..... Digital Systems Design
(Also listed as CEG 560) Design of digital systems. Topics include digital arithmetic, register-level design, memory devices and their logic, and controller and processor design; 3 hours lecture, 2 hours lab. Prerequisite: EE 260.

654-4 ..... VLSI Design
(Also listed as CEG 654) Introduction to VLSI system design. Topics include CMOS devices and circuit design techniques, basic building blocks for CMOS design, fabrication processing and design rules, chip planning and layout, system timing and power dissipation, simulation for VLSI design, and signal processing with VLSI; 3 hours lecture, 2 hours laboratory. Prerequisites: EE 631, EE 632 & EE 651.

655-4 ..... Electronic Circuits Design Project
A project-oriented design course, integrating design methodology with the principles of integrated circuit design, developed in previous courses. The focus of the course is an integrated circuit design project including the topics of project selection, planning and management, system specification, docu-

mentation, design reviews, written and oral reports, and testing; 2 hours lecture, 4 hours lab. Prerequisite: EE 654.

656-4 .....Introduction to Robotics
(Also listed as CEG 656, ME 656.) Introduction to the mathematics**,** programming, and control of robots. Topics include coordinate systems and transformations, manipulator kinematics and inverse kinematics, trajectory planning, Jacobians and control. Prerequisites: Proficiency in Pascal, C or FORTRAN programming.

659-4 .....Integrated Circuit Design Synthesis with VHDL
(Also listed as CEG 659) Application of VHSIC hardware description language (VHDL) to the design, analysis, multilevel simulation and synthesis of digital integrated circuits. A commercial set of CAD tools (Mentor Graphics) will be used in the laboratory portion of the course. Prerequisites: CEG 220 and EE 260.

662-4 ..... Digital Integrated Circuit Design with PLDs & FPGAs
(Also listed as CEG 658) Design and application of digital integrated circuits using programmable logic devices (PLDs) and field programmable gate arrays (FPGAs). A commercial set of CAD tools (Mentor Graphics and Xilinx) will be used in the laboratory portion of the course. Prerequisite: EE 651

670-4 ..... Introduction to Sensors
An overview of basic sensor technology to provide the engineering student with practical working knowledge of sensors. Course will include basic sensor operating principles, basic electronics and measurement principles. Prerequisites: EE 303 or PHY 315.

673-4 .....Communication Systems Design
The concepts of probability and random processes are introduced and used to specify and analyze communication systems. A complete noise study of the AM and FM analog modems is made. The matched filter is introduced and the following binary modems are considered: PSK, ASK, and FSK; 3 hours lecture, 2 hours lab. Prerequisite: EE 621.

675-4 ..... Introduction to Radar Systems
Introductory study of the radar equation, antenna patterns, target cross sections and system losses, radar measurements, pulse Doppler and coherent techniques, detection probability and signal-to-noise ratio, sidelobe clutter, synthetic arrays, and pulse compression techniques. Prerequisite: EE 322.

676-4 .....Wireless Communication II
This course introduces advanced wireless communication techniques. Topics include: spreading spectrum technology and CDMA, multi-user detection and interference cancellation, multi-carrier transmission and ultra-wideband transmission technology, cognitive radio and dynamic spectrum access. Prerequisite: EE 473 and EE 474.

678-3 .....Coding Theory
(Also listed as MTH 656 and CEG 678). Introduction to the essentials of error-correcting codes, the study of methods for efficient and accurate transfer of information. Topics to be covered include basic concepts, perfect and related codes, cyclic codes and BCH codes. Prerequisites: MTH 253 or 355 (or equivalent)

701-4 .....Linear Systems I
(Also listed as EGR 701 and BMS 705). Signal representation, orthonormal bases, generalized Fourier series. Description of linear, discrete and continuous systems. Systems analysis via classical equations, convolution, and transform methods. Prerequisite: EE 321.

702-3 .....Linear Systems II
(Also listed as BMS 706). State variable representations of continuous and discrete systems. Linear vector spaces and similarity transformations, eigenanalysis, time and transform domain solutions of linear state equations; controllability, observability and stability of linear systems. Prerequisite: EE 701.

EGR 703-4 .....Computational Engineering Analysis
The course is designed to expose the students to practical and efficient computational techniques that are routinely encountered in modeling, simulation and analysis of engineering problems. Prerequisites: programming**,** linear algebra, differential equations.

708-4 ..... Advanced MEMS
Classical and advanced micro-sensing and actuation methods. Analytical and finite element methods utilized in investigating MEMS with computed results compared to published experimental data and findings.

710-4 ..... Digital Signal Processing
Data acquisition and quantization, unitary transforms, circular convolution, Hilbert transform, FIR/IIR filter design and realization, analysis of finite-precision numerical effects, spectral estimation, cepstrum analysis. Prerequisite: EE 701.

711-3 .....Multidimensional Digital Signal Processing
Topics of EE 710 extended to multidimensional system and signals. Provides the theoretical and applied basis for analysis and synthesis of discrete systems and operations used in digital images, transducer arrays, and other multidimensional signals. Prerequisite: EE 710.

715-4 .....Digital Image Processing
Image representation, sampling/quantization, spatial/frequency concepts, image enhancement, color image theory, unitary image transforms, image data compression, image models, image coding, image restoration, feature extraction and description, computer implementation of concepts and algorithms introduced. Prerequisite: EE 710.

716-4 .....Kalman Filters and Applied Estimation

Least square estimation, minimum mean square error estimation, maximum likelihood estimation, maximum a posteriori estimation, consistency testing, Kalman filters, extended Kalman filters, iterated extended Kalman filters, alpha-beta-gamma filters, adaptive estimation, Monte Carlo simulation and case studies. Prerequisites: EE 702 and EE 761.

717-4 ..... Multisensor/Data Integration
Multisensor/data integration. Sensor characteristics, management, modeling and coordination. Statistical, Bayesian and Fisher, weighted least-square, dynamic distributed and centralized, rule-based and adaptive sensor fusion. Dempster-Shafer technique. Fusion by Markov random fields. Neural network and fuzzy logic applications. Prerequisites: EE 702 and 761.

718-4 ..... Multitarget Tracking and Data Association
Multitarget tracking and data association. Linear and non-linear state estimation. Maneuvering targets. Single target and multitarget tracking in clutter. Joint probabilistic data association filter. Multiple hypothesis and distributed multitarget tracking. Track-to-track fusion. Prerequisites: EE 702 & 761.

720-3 ..... Advanced Digital Control
Analysis and design of digital control systems using the state approach, multirate digital control systems, digital state observer and microprocessor control. Prerequisites: EE 617 and EE 702.

725-3 ..... Principles of Modern Control Theory
Calculus of variations for continuous processes. Euler-Lagrange equations and the use of Lagrange multipliers; Pontryagin's maximum principle, Hamilton-Jacobi theory; and application to control examples. Prerequisites: EE 615 and EE 616.

733-4 ..... Modern Radar Theory
Application of probability an random process to the performance characterization of range/Doppler radar. Development of the concepts of resolution, S/N, ambiguity function, and pulse compression, and their applications to radar systems design. Consideration is also given to coherent imaging radar. Prerequisites: EE 621, 675, STT 363 or equivalent.

735-4 ..... Wireless Communications I
Wireless Generations (1G, 2G, and 3G) and Standards, Wireless LAN's (Bluetooth), the Cellular Concept – channel allocation and hand-off strategies, capacity of Cellular systems – Cell Splitting, Sectoring, Trunking and Grade of Service. Matched Filters and basic detection Theory, Analog and Digital Modulation techniques used in commercial Wireless systems – FM, DPSK, QPSK, /4-QPSK, OPSK, MSK, GMSK and OFDM. M-ary modulation, Multiple-access techniques, Path loss in wireless channels, Large Scale and Small Scale Path Loss – Rayleigh and Rician Fading; Multipath and Doppler, Computer simulation of digital communication techniques, Computer Simulation of fading channels. Prerequisite: EE 761 or equivalent.

736-4 ..... Wireless Communications II
Fading Counteraction including ISI mitigation and Adaptive Equalization, Diversity, Coding and Interleaving for error correction, Speech Coding, Multiplexing and Multiple Access techniques including TDMA, FDMA, and CDMA; OFDM, CDMA, Wireless Networking, Packet Radio, Wireless LAN's including Bluetooth. Prerequisite: EE 735.

738-4 ..... Analysis and Simulation of Communication Networks
Analysis and simulation of networks, including both LANs and WANs. Dependence of network throughput, latency, average delay, robustness on network protocol, routing, flow control, and traffic dynamics as modeled by queuing theory. Required design project based on COMNETIII software. Prerequisite: EE 521, STT 363 or equivalent.

740-4 ..... Information and Coding Theory
Development of communication channel model and use of information theory as means of quantifying that model. Investigation of various error correcting and detecting codes. The popular Viterbi coding algorithm is also considered. Prerequisite: EE 761.

741-4 ..... Power Semiconductor Devices
General-purpose, fast-recovery, and Schottky diodes, performance parameters: power BJTs, MOSFETs, and MOSFITs, static and dynamic characteristics, drivers, pulse transformers, and optocouples; thyristor characteristics, SCR, GTO parameters; cooling, snubbers, voltage and current protection, varistors. Prerequisites: EE 631 and EE 634.

742-4 ..... Power Electronics
AC-to-DC converters, natural and forced thyristor commutations, controlled rectifiers, power factor improvements, static AC and DC switches, AC voltage controllers, output harmonic reduction, DC choppers, characteristics of DC-to-AC inverters, PWM and FM control. Prerequisite: EE 741.

743-4 ..... Power Electronics III
Power factor correction under nonlinear load conditions, harmonic reduction, utility line disturbances, uninterruptible power supplies, international standards on electromagnetic pollution, low-frequency inverters, residential and industrial applications of power electronics, and characteristics of electric energy storage components. Prerequisite: EE 742.

746-4 ..... Electromagnetic Simulation Methods I: FDTD
Direct solution of Maxwell's differential equations in the time domain using the finite-difference time-domain (FDTD) method. Absorbing boundary conditions and waveguide or plane wave excitation methods. Application to the solution of problems relevant to radiation, radar cross-section (or scattering) and microwave circuit design (3 hours lecture plus projects). Prerequisites: EE 545, 546 or equivalent.

747-4 ..... Electromagnetic Simulation Methods II: MoM
Wave equation and integral formulations for electromagnetic (EM) problems. Method of moments (MoM) and its implementation. Application to one- and

two-dimensional EM problems. Comparison with the finite element method. 3 hours lecture plus projects. Prerequisites: Equivalent of EE 545 and 546.

752-4 ..... VLSI Subsystem Design
(Also listed as CEG 752) CMOS VLSI subsystems, including data path operators, counters, multipliers, memory elements, and programmable logic arrays. VLSI circuits for FIR and IIR filters. VLSI circuits for digital data exchange systems. 3 hours lecture, 2 hours lab. Prerequisite: EE/CEG 654.

753-4 .....VLSI Design Synthesis and Optimization
(Also listed as CEG 753) VLSI Architectural-level synthesis and optimization including data-path synthesis, control-units synthesis, scheduling, and resource sharing. Logic-level synthesis and optimization including two-level and multilevel combinational logic optimization and sequential logic optimization. 3 hours lecture, 2 hours lab. Prerequisite: EE/CEG 654.

754-4 .....VLSI Testing and Design for Testability
(Also listed as CEG 754.) Design for testability of VLSI circuits. Topics include importance of testing, conventional test methods, built-in test, CAD tools for evaluating testability, test pattern generators and compressors. Prerequisite: EE/CEG 654 or EE/CEG 752.

755-4 .....Low Power VLSI and System on a Chip
Low power Very Large Scale Integrated Circuit (VLSI) and system level design with System on a Chip (SOC) integration and test between analog and digital cores.

756-4 .....Robotics I
(Also listed as CEG 756 and ME 756). This course is a detailed study of the dynamics and control of robotic systems and robot programming languages and systems. Material covered includes rigid-body dynamics; linear, nonlinear, adaptive and force control of manipulators and robot programming languages. Prerequisite: EE 656.

758-4 .....CMOS Analog Integrated Circuit Design
(Also listed as CEG 758.) Introduction to the techniques, limitations, and problems in the design of CMOS analog integrated circuits. Topics include CMOS analog circuit modeling and device characterization, analog CMOS subcircuits, CMOS amplifiers, comparators, CMOS operational amplifiers; 3 hours lecture, 2 hours lab. Prerequisite: EE 631 and 632.

759-4 ..... CMOS Radio Frequency Integrated Circuit Design
Introduction to the design of Radio Frequency Integrated Circuits using CMOS technology. Topics include noise sources in RF Integrated Circuits, low noise RF amplifiers, RF mixers, RF oscillators and synthesizers and phase lock loops.

761-4 .....Analytical Techniques of Stochastic Analysis
Probability and random variables, distributions and density functions, random processes, strict-sense and wide-sense stationarity, autocorrelation and power spectral density, ergodicity, response of linear systems with stochastic inputs, discrete linear models, Gaussian processes. Prerequisite: Fourier Theory.

762-3 ..... Detection, Estimation and Optimal Filter Theory
Binary detection with single/multiple observations, linear minimum mean-square error filtering; Wiener and Kalman filters, MLE and MAP estimators, histogram, tests of hypotheses, regression analysis, model-free and model-based parameter estimation of random processes. Prerequisite: EE 761.

763-3 .....Classical and Modern Spectral Analysis
Linear and matrix algebra, periodogram and Blackman-Tukey estimators, moving average, autoregressive, and autoregressive moving-average methods, fast techniques, statistics of estimators, model order selection, minimum variance and high-resolution techniques. Prerequisite: EE 761.

831-3 .....Robust Controls
Study of several important topics from recent research in robust control design. Topics include review of LQR and state feedback designs; Kharitonov's theorem; Barmish's theorem; Wei-Yedavalli's theorem; edge theory; and elements of H1 control. Prerequisites: EE 615, EE 616 and EE 702.

880-1-4 .....Special Topics
Special topics in advanced engineering. Titles vary.

890-1-4 ..... Special Problems
Special problems in advanced engineering topics. Independent Study. Titles vary.

891-4 .....Ph.D. Seminar

898-1-5 ..... Ph.D. Dissertation

899-1-5 ..... M.S. Thesis

5. FINANCIAL AID

5.1 Graduate Teaching Assistantships (GTAs). The department has seven to nine graduate teaching assistantships to assist professors in teaching laboratories and other academic duties. The terms of department supported GTA will be limited to six quarters (cumulatively) for each student. Fractional departmental GTA appointments can be awarded coupled with Graduate Research Assistantship (GRA) funded by his/her advisor. The GTA/GRA appointments include tuition remission and a stipend in return for 20 hours work per week. The GTA/GRAs are required to follow the thesis option for the MSE degree. However, preference for the award of GTA/GRA is given to Ph.D. students. Recommendation from a faculty member of EE department is necessary to apply for open GTA/GRA positions.

5.2 Graduate Research Assistantships (GRAs). Individual professors employ graduate students to assist them in fulfilling the re-

quirements of research contracts or grants the professors have secured. Candidates are usually chosen based on skills demonstrated in Wright State courses. The research assistant is expected to follow the thesis option for the master's degree. Students should discuss GRA opportunities with individual professors.

5.3 Dayton Area Graduate Studies Institute (DAGSI) Scholarships. The DAGSI awards tuition remission scholarships on a competitive basis to engineering graduate students. Application and program information are available at www.dagsi.org.

5.4 Co-operative Education. The Office of Student Employment maintains a listing of employers interested in hiring co-op students. Students desiring part-time work under a co-op student arrangement should contact the College of Computer Science and Engineering liaison officer in the Career Services Office at E334 Student Union. International students must obtain approval for any off-campus co-op work from International Programs Office personnel.

5.5 Hourly Employment. Many departments hire students on an hourly basis to accomplish varied tasks. For example, the EE Department hires a few students to assist professors in grading homework. The Office of Student Employment in E334 Student Union serves as a central posting agency for these opportunities. Interested persons should check the student employment bulletin board as well as inquire at individual department offices.